DISCOVER THE COSMOS CONFERENCE

e-Infrastructure for an Engaging Science Classroom

AUGUST 2-4, 2013, VOLOS, GREECE

PROCEEDINGS

DISCOVER THE COSMOS   GLOBAL HANDS-ON UNIVERSE   ELLINOGERMANIKI AGOGI

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e-Infrastructure for an Engaging Science Classroom

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Contents

Welcome to the Discover the COSMOS Conference

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1. Introduction

It has been noted by various reports that during recent years, there has been an alarming decline in young people's interest for science studies and mathematics. Since it is believed that the traditional teaching methods often fail to foster positive attitudes towards learning science, the European Commission has made intensive efforts to promote science education in schools though new methods based on the inquiry based techniques: questions, search and answers. This is coupled to hands-on experience, playful learning accompanied by laboratory exercises and examples.

"Discover the COSMOS"[1] is such a project which brings into synergy resources from high energy, astronomy and space physics to promote e-Science in Europe. Event analysis tools from the ATLAS experiments at the Large Hadron Collider of CERN -such as the "Hunt for the Higgs" application- as well as time slices in various robotic telescopes around the world and the related software to process the images, are all available as educational scenarios for both the students and the educators.

Discover the COSMOS proposes a reversal of science teaching in school from deductive lectures to the inquiry-based approach which raises the interest and curiosity of the students. The Inquiry Based Science Education (IBSE) is effective with all kinds of students from the weakest to the most able and is fully compatible with the ambition of excellence. Moreover IBSE is beneficial to promoting girls' interest and participation in science activities. Finally, IBSE and traditional deductive approaches are not mutually exclusive and should be combined in any science classroom to accommodate different levels of knowledge and age group preferences.

2. The Discover the COSMOS project

The "Discover the COSMOS"[1] project started on 1st September 2011, for two years and belongs to EU's coordination actions. It is coordinated by the author of this article and has fifteen partners from Europe and US (Table I), experts in the fields of astronomy, particle and space physics as well as in the field of science education research. It aims to demonstrate innovative ways to involve teachers and students in eScience through the use of existing e-infrastructures in order to trigger young people's interest in science and in following scientific careers.

1 Discover the COSMOS" FP7-Coordination action RI-283487.

More precisely its objectives were:

• Select a series of eScience initiatives that successfully introduce the scientific methodology in school science education, by utilizing existing research infrastructures of frontier research institutions enriched with online tools (data analysis tools, simulators & games) and web-interactive educational material.

• Coordinate the organization of these initiatives under a common educational approach and develop the Discover the COSMOS Demonstrators which are being exploited and widely used from the educational communities in Europe and beyond.

• Implement the Discover the COSMOS Demonstrators at large scale in Europe, and organize a series of activities which introduce students and teachers to eScience through the use of real scientific instruments (robotic telescopes, accelerators and particle detectors).

• Create virtual learning communities of educators, students and researchers and involve them in the IBSE.

Table 1. Consortium: The Partners members of the Discover the COSMOS consortium

1	Institute of Accelerating Systems and Applications (IASA)	Greece
2	CERN	Switzerland
3	Institut d'Astrophysique de Paris (IAP)	France
4	University of Coimbra (UoC)	Portugal
5	University of Glamorgan (UoG)	United Kingdom
6	Cambridge University (CAM)	United Kingdom
7	Liverpool John Moores University (LJMU)	United Kingdom
8	Technical University of Dresden (TUD)	Germany
9	University of Birmingham (UoB)	United Kingdom
10	Ellinogermaniki Agogi (EA)	Greece
11	Núcleo Interactivo de Astronomia (NUCLIO)	Portugal
12	Science View	Greece
13	Ministry of Education, Arts and Culture (BMUKK)	Austria
14	Universidad Complutense de Madrid (UCM)	Spain
15	Lawrence Berkeley National Laboratory (LBNL)	USA

At the first stages of the project a work plan of a pedagogically structured inquiry-based approach that promoted school and research centers collaboration was adopted. Based on it, a series of eScience activities, that are offering access to a unique scientific resources and tools, were selected to act as pilot cases. Obviously the usage of these resources by teachers and students provides an innovative way to easily expand greatly the limitations of classroom instruction. The resources were then enriched with the necessary pedagogical framework (connections to the curriculum, organization at different levels of complexity, pedagogical and technical support, teachers' training activities) in order to create a large number (over one hundred) of Discover the COSMOS Demonstrators. The demonstrators can be found on the project's portal[2] and are classified in as structured way and searchable according to subject (with keywords), age group, duration, degree of difficulty etc using metadata files. The portal besides being the unique repository of the demonstrators, includes material previously included at "COSMOS"[3] as well as "The Learning with ATLAS@CERN"[4] portals/databases. Over 81,000 educational objects are organized either in the form of educational content or educational scenarios (lesson plans).

This way the Discover the COSMOS portal brings together resources, virtual experiments and online labs from the fields of Astronomy, Space and High Energy Physics (HEP). The HEP resources include real data from CERN's major experiments, ATLAS[5] and CMS[6].

The HEP analysis tool called "HYPATIA: HYbrid Pupil's Analysis Tool for Interaction in ATLAS"[7] which has been developed for the project and extensively used by it in school activities, will be summarized in the talk of S.Vourakis.

The portal offers access to a network of six robotic telescopes as well, in which the teacher can schedule time slots for observation. In addition several software packages which were developed by the partners over the years to be used in order to analyse the astronomical mages will be presented in the conference. They can be found in the astronomy tool-box of the portal. The "Sun for all"[8] scientific archive alone includes over 30.000 Sun images captured the last 80 years.

The consortium has been implementing the Discover the COSMOS Demonstrators in schools and teachers training centers in Greece, Switzerland, France, Portugal, United Kingdom, Germany, Austria, Spain and US. The necessary guidance and support were provided to teachers and students during the pilots. Additionally, national and international contests for teachers and students were launched and international training seminars, as well as summer and winter schools took place in the framework of the project to effectively support the widespread of the above activities in the participating countries and beyond. Using all the variety of communication and social networking tools, a community of practitioners for transferring the pilot implementations to the real introduction of eScience in school settings has quickly scaled-up.

Furthermore, in order to further enlarge the community hundreds of continuous dissemination and clustering activities took place. Using as main vehicles the CERN outreach programme, the Global Hands On Universe initiative and the Galileo Teachers Training Programme, the consortium is promoting the project work at many countries beyond Europe. Only through the Galileo teachers' community[9], the consortium has access to 16,000 teachers in 100 countries including Latin America and Asia!

Finally the impact of the performed activities is being validated using a standardized approach provided by the Austrian Ministry of Education who operates a devoted Department for assessing the impact of innovations in the classroom. The VALNET evaluation framework which is used offers the tools to identify different multicultural dimensions of the educational approaches. The results will be presented during the conference. The goal of the project was to have an active community of 5,000 teachers and 10,000 students using its portal.

3. Acknowledgements

The coordinator wishes to thank the Ellinogermaniki Agogi School for its perfect organization of the concluding conference and in particular Dr. S. Sotiriou for his expert help and contribution during the whole duration of the project.

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[5] http://atlas.ch/

[6] http://cms.web.cern.ch/

[7] http://hypatia.iasa.gr/

[8] http://www.mat.uc.pt/sun4all/

[9] http://www.galileoteachers.org/

Global Hands-On Universe: A Universe of Learning, Inspiration, and Discoveries: Developing Ideas On How to Have Deeper Impact

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Abstract

Over the past decade, the Global Hands-On Universe (GHOU) collaboration has helped develop, coordinate, and disseminate powerful tools of learning to a wide range of schools, from primary schools to secondary schools to colleges to after-school and informal science centers. GHOU has been adopted at various levels in over 100 nations, making GHOU one of the larger international educations systems. Now we endeavour to go deeper into these national educational systems, and understand how to build local support and teacher community-building mechanisms for this century.

Keywords

Astronomy education, science education, hands-on learning

1. Introduction

GHOU has successfully developed much of the infrastructure necessary for hands-on learning using real astronomy tools and data. Over the past decade, with contributions from many nations, we have built the pieces of the GHOU educational system so it can be used by member nations, including software, websites, discovery campaigns (such as the International Asteroid Search Campaign), planetarium software, and use of web resources (telescope networks, etc.). Along the way, we have organized GHOU as a non-profit non-governmental organization (NGO), which relies on member nations for democratic governance, and endeavours to equalize access and use of the astronomy data and educational systems for all.

Now that we have come this far, we begin to face the challenge of going deeper into the educational systems, deeper into teachers' and students' lives, and keep enabling their usage and mastery of great tools, content, inspiration, and learning value of astronomy as captured by GHOU.

It is clear that most educational systems in the world are challenged by the fact that many students do not learn to like science and math from their in-classroom schoolwork, that they are not learning deeply, and that our schools often produce students who are not good at undertaking careers in science and math. Hence, we feel these students are severely hampered in their capabilities to take care of our planet and enrich earth for the next generation. This is a fundamental disservice of our society to the future and to our children.

GHOU has a growing base of evidence we do successfully change students attitude about math and science, that we do tech them skills for the future, and that we do help them learn more. We describe some of this data below, although this is by no means an exhaustive survey, but exemplary of some programs, and often replicated in many GHOU programs.

2. Some Accomplishments to Date:

GHOU, working as a Global collaboration, has succeeded very well in developing, testing, implementing, training teachers, and using many of the essential tools to enable the whole GHOU system to succeed. This is a complicated project – without most of the components below, GHOU would function at a fraction of its power, if at all. Here are some of the resources now working and generally freely available with no cost to the users:

2.1. Salsa J Image Processing

Developed by FHOU with funding from the European Commission, Salsa J is a wonder of the world! It does all of the scientific and data analysis we need in GHOU activities, and it also provides a stable platform for improvements and additions. Its longevity and sustainability is helped in as much as it is based on "Image J" image processing software, from the United States National Institute of Health. (some GHOU teachers indeed use Salsa J to measure and look at biological images!).

2.2. Stellarium Planetarium Software (www.stellarium.org):

Developed in France and then brought to GHOU's attention and shared by EUHOU, Stellarium is a well-maintained, beautiful, and powerful planetarium program. This software can undertake many important studies, help plan observations, undertake lessons and activities such as studying parallax or measuring the speed of light via the Roemer experiment…

2.3. Global Hands-on Universe Association (www.globalhou.net):

GHOU is a legally incorporated non-profit Association, registered in Portugal with by-laws, boards, leaders, etc. Regular meetings are held at the annual GHOU conference, and the GHOU Association is actively engaged in a fundraising campaign that endeavours to grow GHOU, support is Global efforts, and other activities.

2.4. Amazing Curricula and Activities:

GHOU collaborators from a number of nations have contributed outstanding curricula and activities for students and teachers. Most of these activities use real data, promote deep conceptual thinking and learning, are hugely fun and inspiring, use beautiful images, use data from real telescopes, and help students learn more and be more inspired and engaged in their learning!

2.5. IASC – the GHOU Asteroid Search:

Over the past few years, a large number of schools are now discovering asteroids, thanks to the International Asteroid Search Campaign, which is affiliated with and grew from GHOU. There is now a main belt asteroid – Asteroid Madisonville High – that was discovered and named after a GHOU school (see below).

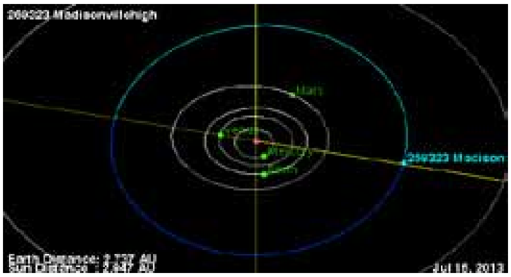

***Figure 1**: Orbital Diagram for Asteroid Madisonville High, July 15, 2013.*

2.6. GTTP -- Amazing Teacher Training Workshops all over the World:

Through the good works of many people in this room and their world-wide network of collaborators, GHOU and GTTP have trained an extraordinary number of teachers around the world – 20,000 in 100 nations! Teachers in developing nations, industrialized nations, and other nations all have undertaken GTTP workshops. These workshops are usually very successful, and routinely teachers in the workshops remark that these workshops are the best they have ever been in, and we have given them many ideas for their own classroom usage of GHOU.

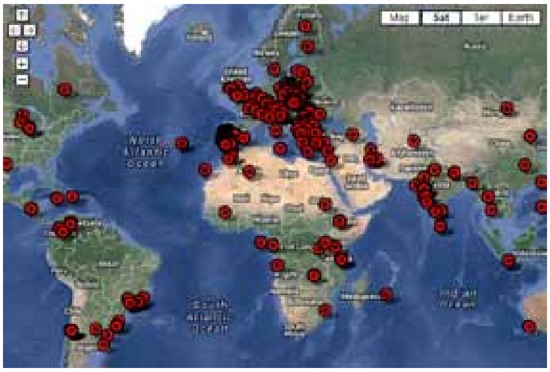

***Figure 2:** Examples of Implementations GTTP/GHOU by Teachers around the world (not complete)*

2.7. Telescope Networks:

GHOU now has routine access to a number of great telescopes, including INO in Arizona, telescopes in Australia, the Faulkes Telescopes, and now GHOU is an official member/telescope contributor to SkyNet (see http://skynet.unc.edu). We make tremendously good use of such telescopes, and we bring a deserving audience to these worthy collaborators with their fine telescopes.

2.8. Engaging and Powerful Hands-On Activities and Fun and Instructive Things to Learn With GHOU:

GHOU members have developed an extraordinary number of piloted and tested hands-on activities that promote deep learning about fundamental science. For example, in Berkeley we have developed and extensively piloted an activity that teaches the correct scale size of the solar system, using Salsa J, real images, paper tape, and cut out planets. Students learn how to use proportion and scale, and also learn the true scale size of our solar system, which is almost never learned by students anywhere on Planet Earth.

3. Some Results

3.1 Engagement

We know that students prefer HOU to other types of sciences taught. Early measurements in successful HOU classrooms clearly showed deeper engagement in HOU topics s compared to other science topic.

Students Like HOU Better Data: Students are on task and active learners and would consider careers in science and technology:

Fig. 3: *Students Like HOU Better than Other Sciences*

3.2 Acquisition of Key Skills for the Future

In studies of acquisition of skills, students who undertook GHOU activities (in this case in the Universe Quest after-school program in the United States) learned key technologies of the future. The figure below shows some of these results.

Figure 4: *Students acquisition of key technology skills through GHOU*

3.3 Learning Science and Math Better

Whenever GHOU teachers use true inquiry based learning, and techniques that help students build their own conceptual frameworks and understanding, we find students can understand math and science better. An example from a GHOU after school session that endeavoured to teach math integrated with astronomy yielded positive results on pre-post-tests of simple problems of proportionality and scale.

Figure 5: *Students acquisition of key math skills through GHOU*

4. Possible Ways for GHOU to Grow

4.1 Deeper Involvement in Classrooms and Teacher's Lives and Creation of On-going Learning Communities

In the United States, there seems to be a growing consensus that to help U.S. teachers implement new ideas, some support and on-going stimulation and help is needed beyond the multiple day summer or weekend workshops. That is, often in GHOU, teachers engage very well in the workshop, love our materials, get excited about astrophysics, but then sometimes have a hard time including GHOU materials in their teaching. We are proposing to potential GHOU funders that we begin to pilot, say in five eager nations, a system where teachers take summer or weekend workshops, and then come to Saturday morning workshops once a month. These teachers would receive classroom visits by the lead GHOU teacher in their region, coaching, ideas, materials, and on-going support to make teaching a collaborative effort. Each of these systems would have a reliable (and paid) organizer, new materials, perhaps some parts of the workshop broadcast over the Internet nationally or internationally, cookies, coffee, and lunches, and intend to build relationships and collaborations and impetus for classroom growth as a community. We have been told that this system is wanted in the Unites States and in Chile, and we hope to find other nations who will participate in our pilot. We are seeking financial resources for this work, for the local organizers, the cookies and coffee and lunches, and other items for teachers to take home that would build some enthusiasms for these workshops.

4.2 Training another 20,000 Teachers around the World over the Next Three Years

Since we know we can train teachers and have succeeded at reaching 20,000 teachers already, endeavouring to reach another 20,000 over three years seems to be a reasonable goal. Particular emphasis will be put on ways to recruit new teachers, who would use our materials in classrooms,

Reaching 20,000 teachers would require an average of 200 new teachers from each of our 100 GHOU nations, so at least two to three workshops a year must be undertaken in each nation, which is not a trivial number.

5. Conclusions

With very little centralized funding, Global HOU has accomplished large amounts. Now it is appropriate that we attain some centralized funding so we can ramp up recruitment, accountability, and other measures of success and engagement, and enable GHOU to keep changing the world for the better.

Building Blocks of our Future

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Abstract

Training teachers on the use of cutting edge e-infrastructures, fostering the integration of inquiry resources are just some of the tools we have at hand to build the future of our specie. Empowering teachers with the means to achieve this is a bigger mission, today even more than it ever was. As human beings we should all be concerned with the future of education. Are we preparing a generation that will make a difference or are we just keeping the status quo? Are we prepared to put "Big Data" in the hands of students that are uninterested in science? Are we confident that we are doing our best to support the teachers in our community? Is the economic crisis really our bigger concern or are we facing the biggest crisis in the educational system? Are we preparing students for the future using today's vision or yesterday's pedagogy? In this talk I want to highlight important points that should be the priority of all successful communities.

Keywords

teacher training, astronomy, eInfrastructure, eScience, inquiry learning,

1. Introduction

In moments where the world face big crisis we can evaluate the true values and the essence behind different world policies. A common characteristic of obvious cuts in public expenses always line up to give the strongest hits in culture, science and education. These are the obvious solutions of people whose science literacy is very low and whose vision has a very short horizon. Investing in science and education is equivalent to building a strong and free community, capable of handling their challenges together and never losing the important perspective: We are all human beings, living our short lives in a tiny piece of this enormous cosmos. If ever we are to survive as specie we need strength of will to make the difference and start building the future today.

2. The Galileo Teacher Training Program: A living legacy of IYA2009

The Galileo Teacher Training Program (GTTP) (Fig 1), was born during the International Year of Astronomy 2009. It successfully named representatives in over 100 nations and has now reached over 20 000 teachers worldwide. It is proven to be a strong and sustainable legacy of this important ephemeris. The institution supporting this effort at a global level and the one from which the GTTP methodology was imported is the Global Hands-on Universe Association (GHOU).

Figure 1. *The Galileo Teacher Training Program logo*

The core of this program is the creation of a 24/7 support network to educators from all over the world and provide them with innovative tools for inspirational science teaching. The strategy used by early adopters of this model was to put scientific data in the hands of students and build their scientific literacy while doing real research in school. During the initial years of the project back in 1994, 2 high school students, Melody Spence e Heather Tartara (Fig 2), under the supervision of their teacher Tim Spuck, discovered a Supernova (SN 1994I).

Figure 2. *Melody Spence and Heather Tartara, the discoverers of SN 1994I, while working under the supervision of their teacher, Tim Spuck.*

This discovery set the tone of the program that from then on started bringing real research to the fingertips of students from all over the world. Learning assumed a completely new taste.

3. Traveling to the past?!?!

Reading the previous paragraph would make you think, wow this works in schools since 1994? So why aren't we using it? Well, that is actually a very good question. Perhaps the word money will ring a bell. In many countries the student centred model is gaining terrain and schools being remodelled completely in order to embrace this promising model [1], but the vast majority still prefers to use the traditional teaching mode, which is the one that ensures the highest ratio students/teacher and therefore the favourite model for economies worldwide.

At a first glance it seems like a reasonable choice. It is equivalent to make good use of our resources, or is it? Let's think a little bit. Students all over the world are getting less and less interested in science; they feel that entering a classroom is like travelling to the past without all the fun. That means that the average literacy about those subjects is dropping, which will eventually prevent future investors to make wise choices about important issues like climate change, health and education. Feeling a victim of this system yet? Well, you should. There is a reason why we are continuously threatening the conditions for us to be in this pale blue dot. Perhaps, critical thinkers and a science literate society wouldn't give birth to monsters that,, as Carl Sagan [2] used to say, feast by being "momentary masters of a fraction of a dot".

4. We all have different fingerprints!!

We know that all human beings are different from each other. Each and every one of us has their own fingerprint, personality, character, style, etc. Yet, in order to be considered successful in school we need to perform in accordance to standard criteria that tries to measure us all, as alike creatures. In a magnificent TED talk, by the renowned author, Sir Ken Robinson [3], it is argued that schools are killing creativity. Inspired by personal experiences and profound reflexion the speaker narrates some interesting episodes that recurrently happen in schools all over the world. A general reflexion is needed to access what is a good definition of a successful student with a brilliant career for the future. Taking into consideration that we are preparing new generations to handle our planet and define the direction of our specie as a whole; do we really mean to name successful only the students that make it to the academic world?

5. Just Google it!!

When we think about education we need to include new ingredients in the recipe. Information nowadays flows through the fingertips of students, much more information than what they can handle. Worse, they don't have the skills to think critically about data flowing through their devices. Getting information is no longer a challenge, knowing how to use it and the power associated to having access to all this data archives in many fields of expertise, is the new gold race. The question one can pose is: "Why do I need a teacher if I have Google?" In an excellent book, with precisely this title [4], Ian Gilbert touches critical aspects of the new role of a teacher, the role of a tutor preparing the future of mankind at the speed of light.

The European Commission is investing strongly in the pursue of information on this path. In projects like Discover the Cosmos [5], Open Discovery Space [6], Go-lab [7], European Hands-on Universe [8], etc., we can find cutting edge science education examples where real research is used as tools to teach science in schools. In many cases, where this concept is being implemented, we have real scientific discoveries flowing through the hands of little scientist's apprentice.

6. Science research in the fingertips of students. Can they really do that?

The question at hand is: Can students produce new science? Do we trust the science they produce? Well, many examples can be given at this point. The previously mentioned discovery of a supernova by high students in the US (Fig.1) is one example of an innovative discovery done by young researchers. Another example is the International Astronomical Search Collaboration, a project that have students finding new asteroids, helping scientists determine the orbit of rocky objects, tracking possible menaces to our planet. In Portugal for instance over 20 asteroids where discovered by students (Fig 3).

Figure 3. *First asteroids discoverers in Portugal from Escola Secundária de Alvide in 2011*

This project is now being integrated as a virtual lab in Go-lab [7] (Fig.4), a project aiming to open up remote science laboratories and their online models (online labs) for the large-scale use in education. Teachers from all over the world will be able to involve their students in real research, providing them with a unique opportunity to understand the scientific method while using it.

GO-LAB

Figure 4. *Global Online Science Labs (www.go-lab-project.eu)*

7. Inquired Based Science Education while discovering the cosmos

The idea of having students performing real scientific research might not be so surprising to educators, the problem is, how to get started and what to do? Discover the Cosmos [5] (Fig.5), is offering solutions to this riddle, it has nicely gathered over 500 examples of resources that can be used to inspire and engage students to follow the scientific method in classroom and in many examples obtain new results.

Figure 5. *Discover the Cosmos (www.discoverthecosmos.eu)*

Students involved in the project where able, for instance, to use robotic telescopes, like the Faulkes Telescopes [9] and explore the Universe in a total different way (Fig. 6).

Figure 6. *Image taken by a Portuguese School using the Faulkes Telescope*

All the sudden, the cornerstones of our knowledge about the Universe were flowing though their hands and amazing pictures being taken while learning curriculum content. Learning took a whole new meaning to thousands of students reached by this project.

8. Flipped Classroom in today's world

There is a silent scream coming from students from all over the world asking us to change the way we teach them. Information flows through their fingertips with the velocity of light. Science outreach shows invade their televisions and games with cutting edge design and interfaces are everywhere. How can a teacher compete with Morgan Freeman while he talks about Black Holes and other fascinating subjects? Or Whoopi Goldberg narrating a Journey to the Stars ? Well, in fact, the question is: why should they? Teacher's should embrace the possibility of using skilled science outreach promoters e assume their role as tutors. Having these nice shows without an in-depth reflection is useless. This is where the presence of a teacher/tutor is key. The flipped classroom model [10] uses precisely this philosophy of sparkling student's interest and pursuing the inquiry based methodology for learning skills.

9. Tools and Resources

Taking this important step of flipping a classroom needs to be accompanied by proper tools and resources. In the previous items some examples have been shown, like Discover the Cosmos's resources and tools such as the Faulkes Telescope. These are good examples of material that allows teachers to engage their students in meaningful learning experiences. The European Hands-on Universe Consortium for example has developed a very powerful and user-friendly tool for image processing, Salsa J (Fig.7). Students can analyse images and perform elaborate studies such as finding the black hole in the center of our galaxy, determining the existence of a planet around another star, etc.

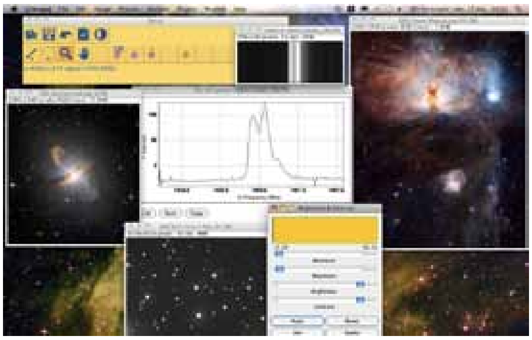

Figure 7. Salsa J, an user-friendly image processing software specially designed for astronomy research

10. But what about the teachers?

The acceptance of these fast changes is not easy for teachers that were not educated in the innovative systems we are trying to implement today, nor prepared to embrace the fast growing ICT skills needs in order to keep up to date with the novelties falling like leaves in the hands of their students. The digital divide [11] is not only affecting developing countries, it is also victimizing those whose ICT literacy or skills is not yet so developed. For this reason, and in order to prevent teachers assuming the role of a live barrier, we need to train and provide a continuous support to educators in the form of continuous professional development tools and resources. A 24/7 support network of practitioners must be in place. This is precisely what the GTTP is trying to achieve. Besides this, a smart repository of tools and resources, a one-stop-shop for teachers, where they can find all the solutions they might need to redesign their classrooms is mandatory. This is precisely the goal of Open Discovery Space [6] (Fig.8), an ambitious aggregator of smart solutions of elearning that will provide not only the material but also the connections to sustainable solutions for support and professional development.

***Figure 8** – Open Discovery Space (www.opendiscoveryspace.eu)*

11. Collaboration and joint strategies

There are many projects out there addressing different general and specific needs on the field of science education. But the community we are trying to reach is composed by millions of people. How do we effectively reach all children in the world ensuring that everyone has the same opportunities? Well, it is easy; we share the best we can. Our financial resources are finite but our will to make a difference is not. Joint efforts, common and well-structured strategies, collaboration instead of competition are the key to the achievement of success. The Galileo Teacher Training Program, using this philosophy, is reaching out children from all over the world (Fig.9)

Figure 9 *– Some countries reached by GTTP (from left to right: Tanzania, China, Portugal and Indonesia)*

12. Conclusion

Finding the correct ingredients for the construction of a literate and self-aware global civilization is a giant's task. But if we all devote our best to this mission and using the tools at hand, it is a feasible one.

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Educational Projects with the Faulkes Telescopes

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Abstract

The Faulkes Telescope Project (FTP) provides access to research class telescopes for educational use with the aim of engaging students in Inquiry-based Science Education and STEM (Science, Technology, Engineering and Maths) subjects.

School students regularly have the opportunity to collaborate on real research programmes with both amateur and professional astronomers on topics such as monitoring comets, follow-up of newly discovered asteroids, parallax observations of asteroids and exoplanet systems.

In this paper we present the results from a selected number of Inquiry Based Science Education (IBSE) projects which students have undertaken using the telescopes and telescope data.

Keywords

Astronomy, inquiry-based science education, research, robotic telescopes

1. Introduction

The potential of astronomy and space to inspire in students an appreciation of science as a whole is well known, but without a wide range of quality resources it is very difficult for any teacher to unlock that potential.

Fortunately, many such resources exist, including robotic telescopes that can be used by students to take images of objects in the cosmos and carry out their own astronomical research.

One such resource is the Faulkes Telescope Project (FTP) which offers access to 2-metre professional instruments that can be used by schools students in the classroom, enthusing them in STEM subjects though engaging them in real astronomical research.

Since September 2011, FTP has been involved in the EU-FP7 funded 'Discover the Cosmos' (DtC) project which aims to spark young people's interest in science and scientific careers through the use of innovative e-science initiatives. Robotic telescopes are one of these initiatives, and schools from the 8 European countries involved in DtC have been able to access the Faulkes Telescopes to both carry out their own research projects and to help with the work of professional and amateur astronomers. These IBSE projects are described in section 3; first we present the tools and resources that are available for DtC schools to use through FTP.

2. The Faulkes Telescope Project

The FTP [1] was established in 2004 with the aim of enthusing students in subject areas such as science, mathematics and information technology. With funding from the Dill Faulkes Educational Trust [2] and the UK Government, two 2-metre telescopes were built in Hawaii and Australia, specifically for UK students to control and use over the Internet from their classrooms. The locations of these telescopes, known as Faulkes Telescope North (Hawaii) and Faulkes Telescope South (Australia), can be seen in Fig. 1.

Figure 1. *Location of Faulkes Telescope North and South*

In 2005, the US-based Las Cumbres Observatory Global Telescope (LCOGT) network [3] took over the project and bought the two Faulkes Telescopes for the beginnings of its network of telescopes across the globe. LCOGT aims to build two networks of telescopes, one with 24 × 0.4 metre telescopes for use in education and one with 17 × 1 metre telescopes for scientific use [4]. The planned locations for the extended LCOGT network are shown in Fig. 2.

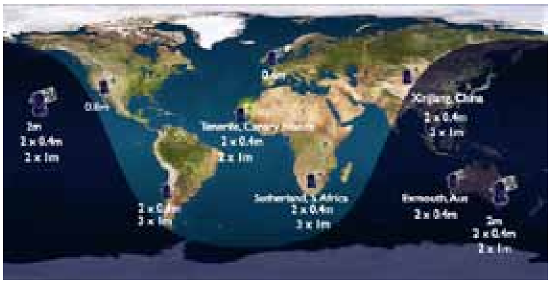

Figure 2. *Planned locations for the extended LCOGT network*

2.1 Access to the Faulkes Telescopes

Currently, the two 2-metre Faulkes Telescopes are available free for any school in the UK and Ireland, and selected schools across Europe and the US, to use, but access requires registration with the Faulkes Telescope Project. To then observe on the telescopes you must log into your account and choose a time and date that suits you before booking the corresponding session on the telescope. Each session lasts 30 minutes, and to apply for more observing time in your account you simply have to fill out an online form requesting more time.

Eventually, access to all the telescopes offered by LCOGT will be provided free of charge to schools all over the world, enabling students to carry out their own personal astronomy research from the telescope of their choice.

2.2 The Telescopes

The 2m Faulkes Telescopes are housed in a clamshell design enclosure which opens fully when the skies are clear and the conditions are good for observing (Fig. 3).

Figure 3. *The enclosure for Faulkes Telescope North*

The telescopes themselves consist of a 2m primary mirror and a smaller, secondary mirror. Light from the astronomical sources falls onto the telescope's primary mirror, is reflected back onto the secondary, and then reflected onto the detector (Fig. 4).

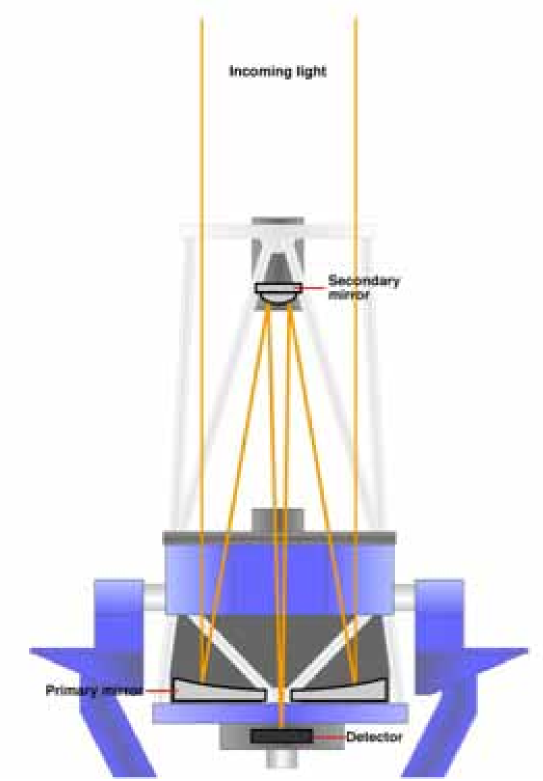

Figure 4. *The light path in the 2m Faulkes Telescope*

The detector consists of a set of filters and a CCD camera. The filters are used to allow only particular wavelengths of light through to the camera. Different filters can be used to bring out different regions in astronomical objects. The CCD camera is made up of an array of 2048 x 2048 pixels, which are sensitive to any light that falls on them. The field of view of the camera (the amount of sky that the camera can image) is fixed at 10.5 x 10.5 arcminutes – equivalent to about 1/3 the diameter of the size of the full Moon (Fig. 5).

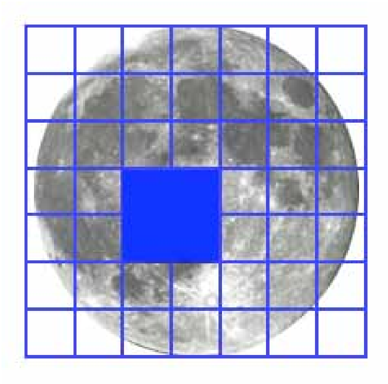

Figure 5. *The field of view of the Faulkes 2m telescopes in comparison with the full Moon.*

2.3 The Data Archive

Although there is a restriction on telescope use at present for schools across Europe, the data archive, where every image taken by the telescopes is stored, is freely accessible for anyone in the world to access. This is particularly useful for teachers and students who are just starting out on astronomy projects, as it gives them the chance to learn the processes behind analysing the data before using the telescopes and gathering their own. The archive, which can be found on the LCOGT website [5] is simple to access, and can be searched by a variety of parameters such as object name, object type, telescope used for observation, date of observations and filters to name but a few.

3. Educational Projects

FTP provides a fully supported education programme to encourage teachers and students alike to engage in research-based science education using robotic telescopes. The projects range from beginners to advanced level, and some have pre-packaged data taken from the data archive so that students and teachers can either learn the steps involved in the projects, before carrying out their own observing with the telescopes, or just complete a simple activity in a science class. All necessary project resources (worksheets, guidance notes, data etc.) can be accessed free of charge from the Faulkes resources portal [6].

The educational materials on this portal are mainly aimed at students aged 11-14 years. With input from astronomers across the world, more advanced research projects are being produced, giving older students (15-18 years) the chance to carry out real astronomical research, helping astronomers in their quest to answer some of the key questions in astronomy.

Of particular interest in the resources portal are links to projects which schools can carry out with other schools, or at the request of professional/amateur astronomers. These projects contain all the necessary background information needed to participate in the observing, along with guidance documents on what to do with the data once it has been acquired.

Below we describe some of the projects carried out by schools, both in collaboration with each other, and with astronomers.

3.1 Collaborative Projects Across the EU

After meeting for the first time at a European Hands-On Universe (EU-HOU) [7] Teacher Training Session in Poland in 2010, users of the Faulkes Telescopes from across Europe came together in a joint collaborative project to study asteroids in the Solar System. Teachers from the UK, Ireland, Poland, France and Portugal attended the training workshop and the idea to join together and begin work on a project with their students, began to form. After returning to their countries, they successfully applied for funding from the EU Comenius Programme which aims to introduce and strengthen European links to the school's curriculum [8].

The 2 year project, which began in 2011 consisted of 6 schools from the countries above working together on the "In Orbit with Europe!" project, using robotic telescopes to observe asteroids in the Solar System, sharing their results and producing short stories based on the topic of asteroids [9].

In January 2012, the schools began their project using Faulkes Telescope North to observe asteroid Kariba and produce a light curve of it as it tumbled through space. Joining up on Skype, and supported by the FTP team, each school was allocated 30 minutes on the telescope, during which time they observed the asteroid continuously. Only a couple of weeks later, they had analysed their data using the free software package SalsaJ [10] and produced the lightcurve seen in Fig. 6.

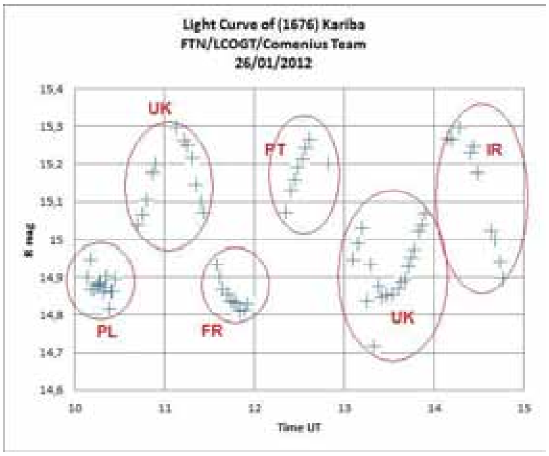

Figure 6. *Lightcurve of asteroid Kariba, as produced by the 6 member schools of the "In orbit in Europe!" project. The data points from each school (France – FR, Poland – PL, Portugal – PT, Ireland – IR, United Kingdom – UK) are highlighted on the plot.*

From this lightcurve, the rotation period of the asteroid can be obtained and from the data here, it appears that asteroid Kariba takes just under 3.5 hours to make a full rotation.

The team continued their project with observations of a smaller, fainter asteroid in October 2012, this time using Faulkes Telescope South. Their target, (11264) Claudiomaccone was known to have a moon and the students aimed to produce a lightcurve showing the moon eclipsing the asteroid, again using the free software package, SalsaJ. The lightcurve they produced is shown in Fig. 7. Although the telescope was taken over by a target of opportunity during the session, a hint of an eclipse can be seen in the curve.

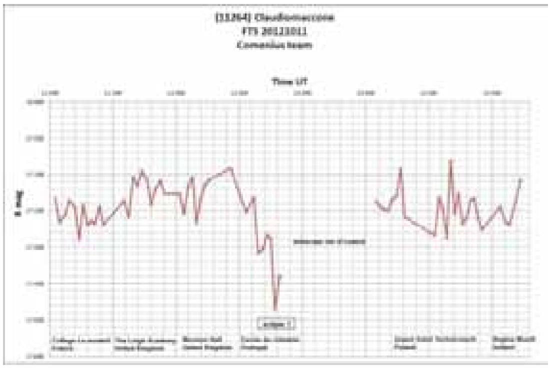

Figure 7. Lightcurve of asteroid (11264) Claudiomaccone, produced by the "In orbit with Europe" team. The position of the possible eclipse of the asteroid by its moon is highlighted.

The final observing project the team carried out, in March 2013, was perhaps the most challenging – they aimed to measure the parallax of an asteroid using both Faulkes Telescope North and South (Fig. 8). The target was asteroid (270) Anahita, and once more, SalsaJ was used to analyse the data files which the schools obtained.

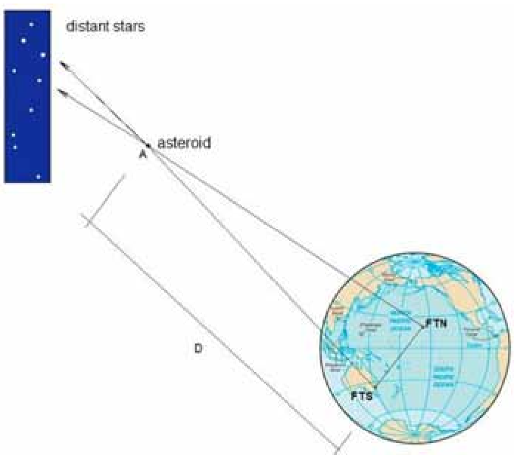

Figure 8. How asteroids can appear to be at 2 different points with respect to the background stars.

With some help from a professional astronomer in Paris-Meudon Observatory, the team managed to calculate the distance to the asteroid, and after checking the actual distance as given by the NASA Jet Propulsion Lab Horizons website [11], found their values agreed within 0.15%. This was a fantastic achievement for the schools involved, and proof that more complex work can be carried out by schools using data obtained from the Faulkes Telescopes.

3.2 Working with Professional Astronomers

Since March 2013, FTP has been working with astronomers at the University of Colorado on a project observing exoplanet systems around cool stars. After obtaining spectra from the Hubble Space Telescope, the astronomers asked FT users to observe these stars in the hope that sunspots on their surface will be distinct enough that the light output of the star can be seen varying over time. By measuring this variability, the spin period of the stars can be determined, which in turn will help the astronomers to improve their understanding of the environments in which these exoplanets are found. Once enough data has been taken for these objects, students will be able to use free software with detailed instructions to perform their own analysis to supplement that being performed by the experts. At present, the astronomers are not wholly sure that the variability will be measurable, but this highlights the work carried out by real researchers and gives students a taste of how even if a project does not give the anticipated results, scientists can still learn a lot from the processes that they conduct.

In another research project which began in September 2012, FT users have been invited to collaborate with the world-renowned Lowell Observatory to image small, icy bodies in the far reaches of our Solar System.

The Lowell Observatory in Flagstaff, Arizona is famous for the discovery of Pluto, once the ninth planet of our Solar System, now one of a handful of dwarf planets since the IAU reclassified it in 2006.

As part of a project to refine the orbits of other

Pluto-like objects, schools using the Faulkes Telescopes are collaborating and helping the astronomers gather their data.

Centaurs and Kuiper Belt Objects (KBOs) are icy bodies which orbit the Sun beyond Jupiter. With characteristics of both asteroids and comets, the Centaurs orbit between Jupiter and Neptune and usually cross the orbit of at least 1 gas giant. KBOs are found beyond Neptune, in an area known as the Kuiper Belt (or Kuiper-Edgeworth Belt, see Fig. 9).

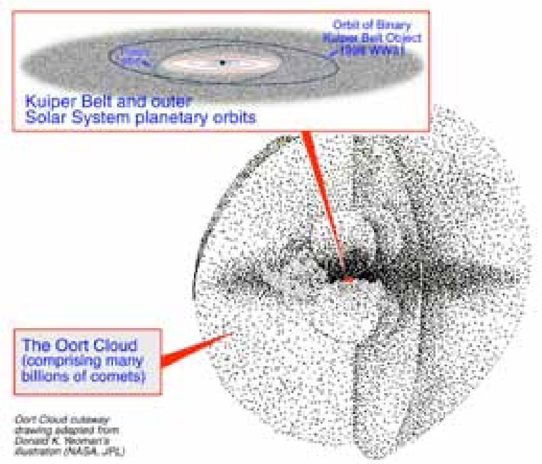

Figure 9. *The Kuiper Belt and Oort Cloud surrounding our Solar System*

It is these types of objects which Faulkes Telescope users have been asked to observe. The objects in the target lists are published on the front page of the FT website and have only been observed on relatively few occasions. This means that their exact position on the sky, and the shape of their orbit are not well known - but with the help of schools, this can be changed.

4. Future Plans

4.1 Rosetta Mission

In 2004, the European Space Agency (ESA) launched a 'comet chaser' mission to rendezvous with Comet 67P/Churyumov-Gerasimenko [12]. Due to arrive in 2014, Rosetta will consist of an orbiter and a lander, and aims to study the make-up of this dirty snowball, whilst it is far from the Sun. Comets are made up of rock, gases and ice, and orbit the Sun in highly elliptical orbits, originating either from the Kuiper Belt (short-period comets) or the Oort Cloud (long-period comets). Comet 67P/Churyumov-Gerasimenko is a short period comet, orbiting the Sun once every 6.6 years, but despite the regular trips that it makes to the inner part of our Solar System, very little is known about this object. In order to get as close as possible to the comet, accurate calculations of its orbit are essential, and this is where schools come in – the more ground-based observations of Comet 67P/Churyumov-Gerasimenko that can be obtained, the more accurate its position can be calculated. Using the 2m FTs will be invaluable for this as schools can observe the comet and measure its position using free software thus helping the mission scientists with their work.

4.2 GAIA Mission

In September 2013, the ESA will launch a mission to map the positions of a billion stars in the Milky Way galaxy, to find their precise positions and apparent motions through space [13]. A by-product of this will be the detection of hundreds of thousands of previously unknown objects, ranging from asteroids in our Solar System to planets orbiting other stars, and supernova explosions. FTP will work closely with the GAIA mission team to send out information to FT users on these previously unseen objects in the hope that schools can carry out follow-up observations with the telescopes, analyse the images and conclude what types of objects these are. With so much data coming in every day from this mission, the chances for schools to take part in real research and make real discoveries are truly, out of this world!

5. References

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[6] http://resources.faulkes-telescope.com/

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

[8] http://ec.europa.eu/education/lifelong-learning-programme/comenius_en.htm

[9] http://grudziadz.planetarium.pl/comenius/

[10] http://www.euhou.net/index.php/salsaj-software-mainmenu-9

[11] http://ssd.jpl.nasa.gov/?horizons

[12] http://sci.esa.int/rosetta/

[13] http://sci.esa.int/gaia/

EUHOU-MW "Connecting classrooms to the Milky Way"

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Abstract

A first European network of six radio-telescopes for education has been developed in the course of the EUHOUMW "Connecting classrooms to the Milky Way" project, supported by the Life Long Learning Programme (Comenius) of the European Commission and a consortium of 11 European partners. It aims at re-awakening the interest of the new generation for science. This educational project links with some frontline astronomical topics, like the development of the major research facility at Horizon 2020 SKA (Square Kilometre Array). It focuses on secondary level pupils and their teachers. A multilingual Web interface has been developed to enable learners to remotely control the EUHOU-MW instruments and to observe on-line with a browser. A pedagogical sequence has been developed in order to focus on the main concepts underlying the proposed tools and to enable the learner to follow the scientific methodology from the data observation to the physical understanding of observed velocities. This includes a kinesthetic activity to explain the modelling coupled with an activity using the simulator of observation. A 10-A0-panels exhibition has also been prepared and printed to be presented in interested classrooms as support material. All the pedagogical material including videos is freely available on the "Hands-On Universe, Europe" Web site.

Keywords

Radio-astronomy, remotely-controlled telescopes, pedagogy, kinesthesia

1. Introduction

The current lack of interest for science among the young generation [1] can be challenged by researchers who are the best promoters of the science they work on. In addition, the scientific community should explain to the general public why important public funds are used to develop major instruments (e.g. Square Kilometre Array by Horizon 2020). Proposing scientific activities with research-quality instruments to secondary school pupils enters in this outreach effort towards the society. Radioastronomy is typically a not-so-easy topic to explain, and instruments are often complicated to use. Onsala Observatory/Chalmers University in Sweden was the first to develop a "Such A Lovely

Antenna" (SALSA) for education in the course of the 2004-2006 EU-HOU project (Minerva/ICT funding), enabling European secondary school pupils to observe remotely. In Section 2, we present the instruments that have been deployed in five different European countries in the course of the 2010-2012 EUHOU-MW project. In Section 3, we describe the Web interface that has been developed to control these instruments. In Section 4, we explain how the modelling concepts necessary to understand the observed spectral lines can be introduced with kinesthesia. In Section 5, we explain the pedagogical sequence that has been tested with secondary school teachers, undergraduate and master students (initial teacher training).

Figure 1. *Small Radio Telescope (SRT) installed in Craiova. Similar instruments have been deployed in Krakow, Lisbon, Madrid and Paris.*

2. The EUHOU-MW partnership

Eleven European partners have been involved in this project aiming at introducing 21cm observations in secondary level:

(1) France, Pierre & Marie Curie University

(2) Belgium, Planetarium of Brussels, Royal Observatory of Belgium

(3) Cyprus, Saint Nikolas Lyceum

(4) Germany, Föderverein Astropeiler Stockert e.V.

(5) Greece, Institute for Space Applications and Remote Sensing, National Observatory of Athens

(6) Poland, Jagiellonian University

(7) Portugal, NUCLIO – Núcleo Interactivo de Astronomia

(8) Romania, University of Craiova

(9) Spain, Universidad Complutense de Madrid

(10) Sweden, House of Science

(11) United Kingdom, University of Glamorgan

While five countries (1,6,7,8,9) decided to host a 3m dish, six others partners are supporting the activities and the dissemination activities at national level.

Figure 2. *European EUHOU-MW partnership*

3. Radiotelescope network

Five identical 3m dishes have been acquired from the USA Cassi-Corp company. Each instrument is equipped with a spectroscope (bandwidth: 1.07MHz = 225km/s at 21.1cm) enabling observations at 21.1cm (1420.4MHz). They have been designed to observe the hyperfine transition of the hydrogen. The probability to observe this transition is very low (P~10-7), but the hydrogen in the Milky Way is very abundant (1.23 1010 Msol, [2]).

They have been deployed in major European cities: Craiova, Krakow, Lisbon, Madrid, Paris. The protection of frequency bands (like the band centred on 21.1cm) for radio astronomical signals prevent big cities from major electromagnetic pollution (while they severely suffer from light pollution).

It has required important efforts from each local team to install them and make them operational. The instruments have been provided with a Java control software enabling local observations.

Radio-astronomical instruments operate at the diffraction limit. The Full Width Half Maximum (FWHM) size of the Airy spot is: q=70 deg l/D. Hence the 3m dishes operating at 21cm have a FWHM of 5 degrees corresponding to 10 times the diameter of the Moon.

4. Multilingual Web interface

Figure 3. *Multilingual Web interface developed to monitor the EUHOU-MW radio-telescope network*

An essential and challenging aspect of the project was to develop a Web interface enabling secondary school pupils and their teachers to remotely observe with the instruments. Antoine Radiguet has undertaken this task under the supervision of Philippe Salomé in Paris. A single Web page enables to control the different instruments. A booking system has been developed enabling each user to register and to book in advance observing slots. During his observing slot, the user can take control remotely of the chosen radio-telescope. He can choose the position of observations in three ways: (1) he can click on a Galactic map (in Galactic coordinates) displaying the distribution of HI and the visibility area (at the time of observations), (2) he can point on a map giving local coordinates (azimuth, elevation) or (3) tape directly Galactic latitude and longitude in degrees. The three ways of pointing are displayed on-line (e.g. if you click on one, you will get the other two).

Once the desired position has been chosen and the observation asked for, a webcam displays the radio-telescope and shows its displacements during the pointing, calibrating and observing. Once the observation is completed, a HI spectrum is displayed. In order to ease the handling of the observation (a 21cm spectrum displayed in velocity), easy reduction and analysis procedures are proposed. The user can adjust a baseline on the continuum level (due mainly to the background outside the 21cm line), he can select the peak of maximum velocity to add a point on the rotation curve, and then click on all the peak of the spectra to reconstruct positions of the 2-dimension structure of the Milky Way (spiral structure).

Similar observations can be performed with a "simulator" of observations: the same operations are performed but instead of providing instructions to an instrument the request is sent to the professional archives. These archives consist in an all-sky survey performed at 21cm [2], with a 0.5/1degree resolution. Besides removing the on-the-spot aspect of the observations, this functionality enables to get data which are not observable at a given time, and to get data with a better resolution. It is thus a valuable tool to compare observations and understand possible effects of the resolution.

Last, all the observations acquired by the EUHOU-MW instruments are stored in an archive. They can easily be browsed with the parameters of observations. It is then possible to perform the same reduction and analysis steps described above. It is also possible to download the selected spectra in cvs or fits format, and e.g. to display them in the SalsaJ software.

The Web interface is available in 16 languages including Vietnamese, Indonesian and Russian. The booking system is ruled by several levels of administration: the radio-telescope administrator and the language/national administrator.

5. Kinesthesia

Figure 4. *Kinesthetic activity lead by Prof. Alexander Rudolph (Pomona Univ., Berkeley, USA)*

Even though the Web interface provides easy to use tools, it is not yet a self-sustained pedagogical tool to be use in classrooms. It has to be embedded in a pedagogical sequence. The modelling procedure used in the Web interface assumes circular orbits and relies on not-so easy concepts (Galactic coordinates, Galactic radius, radial velocity, line of sight, etc.). In order to overcome these difficulties, Alexander Rudolph (Pomona University, Berkeley, USA, during his sabbatical at UPMC) has developed a kinesthetic activity focusing on concepts in a ludic way.

This type of approach at the cutting edge of cognitive sciences provides an important place to the bodies' participants who act directly in the modelling.

Four circles modelling orbits are drawn on the ground with chalk before the training session. Then considering a constant rotation speed (a reasonable assumption for a galaxy, even though it can be questioned), equally spaced ticks are then drawn long every orbit (the same interval is used for each orbit.) The simulation scene is ready: each participant stays at one tick. At each clap/signal, the participants will move to the next tick, simulating the differential rotation of the Milky Way. It is also possible to simulate a rigid rotation (like a CD-rom), asking the participants to follow the orbits aligned along a cross centred on the central black hole of the Milky Way. This is a very efficient way to feel physically the different types of rotation and how it relates to velocity.

Adding bungee strings to this simple set-up enables to define a Doppler detector. Applying adapted approximations to the radial velocity formula that describes the observed velocities allows to define relative velocity patterns in each Galactic quadrants. It is possible to feel these relative velocities with the Doppler detector.

It is also possible to present the Galactic coordinate system: the Sun (itself orbiting around the Galactic centre) is the origin of a Cartesian system.

6. Pedagogical sequence

The kinesthetic activity becomes meaningful when it is included in a whole pedagogical sequence addressing several concepts in different manner. We propose to proceed as follow. (1) The researcher point of view is first presented with e.g. a diaporama presentation. He presents in a simplified manner our current knowledge of the Milky Way from a general point of view and from the radio-astronomy perspective. He thus shows the professional neutral hydrogen data cube [2], e.g. under the form of a movie displaying the different velocities planes from -300km/s to 300km/s. This observational data are stored in Galactic coordinates. This movie displaying the velocities of the hydrogen gas in our Milky Way (these are observations) exhibits complex behaviours. We know that 90% of the hydrogen gas lies in the Galactic plane (at Galactic latitude 0 degree). We thus restrict the analysis to the Galactic plane and assume circular orbits for the gas. With a little of algebra, a formula for the observed radial velocity Vr can be derived:

Vr= V Ro/R sin l – Vo sin l, where V is the circular velocity, R is the Galactocentric radius (i.e. the distance of a cloud of gas to the Galactic centre), Ro the distance of the Sun to the Galactic centre and l the Galactic longitude of the observation performed in the Galactic plane (at a Galactic latitude b=0). Galactic quadrants are usually defined by astronomers: quadrant #I: l=0-90deg; quadrant #II: l=90-180deg; quadrant #III: l=180-270deg; quadrant #IV: l=270-360deg. It is then possible to perform some approximations in order to get a simple understanding of the above formula, and to get a general behaviour of the velocity. First, for each quadrant the sign of l is know. Second, in quadrants #II and #III, the Galactocentric radius R is larger than Ro, while in quadrants #I and #IV most of the gas lie with Ro but not all. Last, we know that in most galaxies the rotation curves are flat, so we can try to approximate V with Vo.

These 3 approximations enable to get a sign of the velocity in each quadrant. This can be check with bungee cords in kinesthesia. A simple activity can be proposed to find the sign of the velocity in each quadrant with the formula. Then, a computed-based activity can be proposed e.g. on the EUHOU-MW simulator of observations, to see how this modelling is used in the Web interface.

This pedagogical sequence provides an understanding of the methods. Learners have then the basis knowledge and know-how to use the EUHOU-MW radiotelescopes and understand their manipulations.

7. Dissemination materials

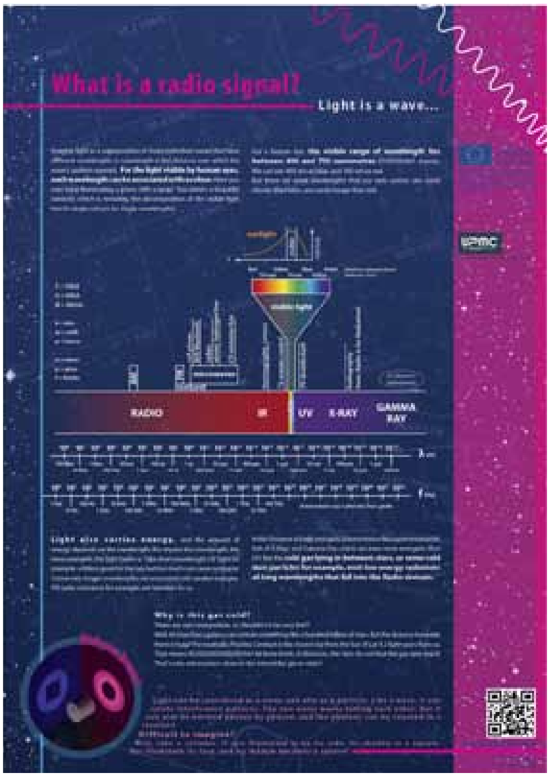

Figure 5. Example of one A0 panel (English version) prepared for the exhibition.

Ten A0 panels presenting the basics of radioastronomy have been developed as a support activity for school using of the EUHOU-MW instruments. It has been done by Yannick Libert with the support of a graphic designer (Aurore Mathon). Each panel has been translated by the partners in 10 languages. This exhibition has been printed by each partner to circulate in the interested schools.

A second exhibition (in A4 format) adapted for middle school level is currently finalised.

CD-roms gathering the pedagogical resources prepared in the course of the project are currently printed and will be distributed in each partner country. The material is also available on the Web site of the project www.euhou.net.

8. Conclusions

We have developed pedagogical tools inspired by research activities. Beside the technical tools, a whole pedagogical sequence has been implemented and tested with European teachers.

Questionnaires have been distributed during three European teacher training sessions and have shown a positive feed-back on the EUHOU-MW activities.

The EUHOU-MW radio-telescope network is available, every interested learner can register and apply for observing time. The system is operational but additional feed-back from users is most welcome as it could enable us to improve it.

Additional languages can be included if the translation work can be done in our pootle translation server.

The instruments are well-adapted to develop school projects, and possible international school collaborations. These instruments can indeed be used 24 hours a day, and can be used in day-time in Europe, but also in night-time in other parts of the world.

9. Acknowledgements

The author acknowledges the contribution of all the EUHOU-MW partners and actors to the development of this project.

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The CosmoQuest Virtual Research Facility: Motivating Everyday Scientists

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Abstract

In order to handle the onslaught of data spilling from telescopes on the Earth and on orbit, CosmoQuest has created a virtual research facility that allows the public to collaborate with science teams on projects that would otherwise lack the necessary human resources. This second-generation citizen science site goes beyond asking people to click on images to also engaging them in taking classes, attending virtual seminars, and participating in virtual star parties. These features were introduced to try and expand the diversity of motivations that bring people to the project and that keep them engaged overtime. During the 2nd quarter of 2013, users were asked to complete a survey on motivation, engagement in science, and basic demographics. In this oral presentation we overview the facility and discuss how CosmoQuest's user motivations compare to those of users of other Citizen Science websites.

Keywords

Citizen science, crowd sourcing, motivation, cyber-infrastructure

1. Introduction

In creating the CosmoQuest Virtual Research Facility, we sought to answer the question, "What would happen if we provided the public with the same kinds of facilities scientists have, and invite them to be our collaborators?" It had already been observed that the public readily attends public science lectures, open houses at science facilities, and education programs such as star parties. It was hoped that by creating a central facility, we could build a community of people learning and doing science in a productive manner. In order to be successful, we needed to first create the facility (section 2), then test if people were coming both to learn and to do science (section 3), and finally to verify that people were doing legitimate science (section 4). During the past 18 months of operations, we have continued to work through each of these stages, as discussed below. At this early date, progress is on-going, and much research remains to be done, but all indications show that we are on our way to building a community of people learning and doing science.

2. Infrastructure within CosmoQuest

In constructing CosmoQuest, we brainstormed what facilities are available at top public and private astronomy departments and centers, and then sought ways to construct virtual versions of these opportunities that are scaffolded for use by the general public. Our initial list of desired facilities, each detailed below, includes: science teams working on ambitious citizen science projects, seminars and star parties (using Google Hangouts-on-Air in place of a lecture hall), planetarium shows, social and collaboration spaces, educator training, and classes. In addition to these interactive features, CosmoQuest also has extensive static content for learning.

2.1 Research Opportunities

At the heart of CosmoQuest are a series of citizen science projects. The initial set of projects focuses on two broad sets of tasks: Mapper projects that explore the surfaces of rocky worlds, and Investigator projects that look at objects moving through our solar system.

The three Mapper projects – Moon Mapper (launched January 2012, Lunar Reconnaissance Obiter data), Asteroid Mapper: Vesta (launched September 2012, Dawn data), and Planet Mapper: Mercury (launched July 2013, MESSENGER data) – each ask community members to help team scientists map specific features, including: craters, various types of fault lines, boulders, crater chains, and albedo features. Each interface uses a parallel interface (see Figure 1), allowing community members doing mapping to easily move between projects. To help users understand what they must do, each project has written, interactive, and video tutorials.

Figure 1. A Mapper Project Interface

Investigator projects – Ice Investigator (which ran Q1 2012) and Planet Investigator (launching August 2013) – study objects moving through the sky. Ice Investigator, specifically had project participants looking for asteroids and Kuiper Belt Objects in the residuals of subtracted image pairs from a variety of ground-based telescopes. Planet Investigators will ask participants to study time series images from the Hubble Space Telescope to look for moving objects, to identify storms on outer planets and their moons, and to aid in cosmic ray rejection, fine-tuning of astrometric solutions, and determining limiting magnitudes of images. These projects have an interface very similar to a mappers project, and similar sets of tutorials.

All CosmoQuest citizen science projects have their own discussion boards on the CosmoQuest forums and are led by teams of scientists eager to publish the citizen scientists' results.

2.2 Hangouts-on-Air

In late 2011, Google launched their Hangouts software, which allowed groups of up to 10 computers to join into a videoconference for free. Shortly after, select users – including CosmoQuest – were invited to use Hangouts on Air – a version of the Hangouts software that uses YouTube Live to stream the Hangout to an unlimited audience.

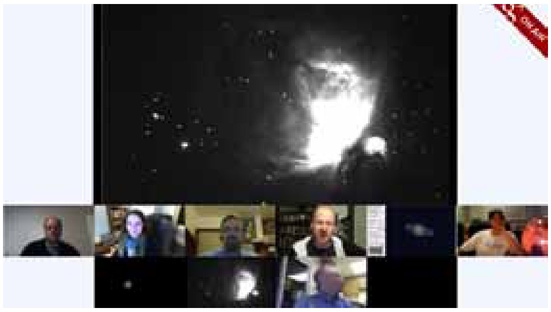

Figure 2. *A Google Hangout-on-Air facilitated Virtual Star Party*

CosmoQuest quickly adopted this software for presenting facilitated science presentations and star parties to live audiences around the globe. A science communicator hosts every Hangout, and makes sure that all guests communicate in a way that is understandable to the public. As needed, the facilitator asks clarifying questions or provides on the fly explanations for topics being discussed. Weekly, 1-hour programs include: Learning Space, a program on astronomy education research and programs; The Weekly Space Hangout, which covers the weeks best news and science articles; Astronomy Cast, which covers a single topic in-depth; and the Virtual Star Party, which invites participants to view through-the-eyepiece (with a webcam) views through telescopes. There are additional events on a less regular basis, including NASA Science Updates related to lunar science (co-produced with MyMoon and the Dawn Mission), the Astronomers Without Borders (AWB) AstroArt series (a co-production with AWB), and special event coverage (such as for the Mars Curiosity Landing).

During live Hangouts-on-Air, viewers can interact with the hosts and guests via text comments (on YouTube, G+, and Twitter via a hashtag). This allows community members to ask questions and provide input in the moment, just as can be experienced during classic, face-to-face seminars. During star parties, viewers are invited to suggest objects and ask astronomy questions to the professional astronomers.

Statistics on viewership are complicated by three factors: During a live show, you only have access to how many viewers are watching at any moment, not how many unique total viewers there are or for how long they stay. The statistics on live viewership disappear after the live show is over. Videos may (and generally do!) appear on both the CosmoQuest related YouTube channel as well as the YouTube channel of whomever hosts the Hangout on Air. The latter problem is related to Google always placing videos in the YouTube account of the Hangout Host for privacy reasons. Taking all these issues into account, we estimate more than 250,000 video views since January 2011. Top events had more than 8000 simultaneous viewers (e.g. Mars Curiosity Landing), and typical events (e.g. Learning Space) have 30-100 live viewers, depending on who the guest may be.

All Hangouts-on-Air are archived at http://youtube.com/AstrosphereVids

2.3 Communications and Collaboration

Science is not generally done in isolation. In order to assure that our community members can readily communicate and collaborate with one another and with team members (including scientists, educators, and facility programmers) we have established a forum, blogs, and social media accounts. The forum typically has 600 visitors at any time who collectively write 150 – 250 posts a day. As of 20 July 2013, CosmoQuest had the following social media followings: Twitter, 1868 (for main account); Facebook, 1546; and G+, 37935. The large bias toward G+ reflects where CosmoQuest has placed its social media effort. In addition to these forms of multi-directional interaction, CosmoQuest also uses blogs to push content, with the primary blog being read by roughly 500 people every day.

2.4 Classes

In order to facilitate systematic, topical learning, CosmoQuest also offers continuing education classes designed for adult learners. These classes are restricted to 8 students, and utilize active learning methods. Courses have a fee (used to pay the instructor and organizer), but are not for university credit (although teachers receive continuing education hours). All classes are listed at http://cosmoquest.org/Classes To date, all students have successfully passed the classes, completing homework assignments and course projects.

2.5 Planetarium Content

Working in collaboration with the Ward-Beecher Planetarium, CosmoQuest is hosting both planetarium shows and planetarium imagery that is available for use under a Creative Commons attribution, share-alike, non-commercial license. This allows planetariums to show and even remix all content for their own use. Current collections include the “Cosmic Castaways” planetarium show (also available for flat screens), and a collection of images and videos of Mauna Kea Observatory. These programs may be found online at http://cosmoquest.org/blog/scienceonthehalfsphere

3. Community Member Survey

During the spring of 2013, the CosmoQuest Citizen Science Facility asked its participants to take a voluntary survey addressing their motivations, demographics, and engagement in astronomy. This trial survey was run to determine if CosmoQuest’s novel environment attracted community members with the same or different motivations than had been seen in prior research conducted by the Zooniverse. Users were asked to participate in this survey through a newsletter, social media, and an alert window that appeared on every page of CosmoQuest. In exchange for taking this survey, users received access to a behind-the-scenes video about the CosmoQuest build team’s facility.

In total 334 people responded to this survey. In the following sections we study their demographics, site usage, engagement in astronomy, and motivations.

3.1 Demographics

A brief overview of our 334 survey participants shows a population that is predominately male, middle-aged, and college education. When compared to US Census statistics from 2010, we have 48% in the age range 45-64, whereas this group only makes up 30% of the adult population of the US. Meanwhile, 58% of our respondents have attained at least a bachelor’s degree, compared to 28% of the adult population of the US.

Almost half of the individuals in our survey population have a job in a STEM-related field, and three quarters of the population had some formal training in science beyond secondary school. This is clearly an already much more scientifically literate population than the population at.

3.2 Site Usage

We asked survey participants to report on their usage of the CosmoQuest site. A major goal of the project is to foster sustained citizen science and community activity. Although 42% of the participants responded that this was their first time on the site, the next largest group, at 22%, had been a part of CosmoQuest for over a year. CosmoQuest launched in 2012, so this indicates that there is a dedicated core of users from nearly the beginning. This self-reported data is consistent with site statistics, which show roughly 30% of those who do citizen science do so more than once.

Of those survey participants that reported trying at least one citizen science project, almost half of those tried more than one. (Options: Moon, Vesta, Mercury, and Kuiper Belt Objects. The first three of those use the same mapping tools.) The most popular parts of the site beyond the citizen science projects are the Forums and the Hangouts on Air. This is consistent with our website and social media analytics.

3.3 Motivations

At the heart of this survey is the desire to find out the motivations behind participation in citizen science. The choices given are based on interviews from [1] and [2]. The two most cited primary motivations were interest in astronomy/space science (28%), and contributing to original scientific research (29%). While these motivations were also the most listed in prior Zooniverse studies, the importance of contributing to research was much higher for that project (near 40% in the 2 studies cited), and the importance of astronomy/space science was less (between 10 and 15%). Further, learning and teaching were negligible motivations for Zooniverse users, while we found 10% of all users (5% per motivation) were motivated by these two factors. The only other motivation to receive more than 5% of the responses was the motivation to study science in general (9% of CosmoQuest responses), which is a result comparable to Zooniverse.

3.4 Engagement in Astronomy

We feel that to be successful, CosmoQuest must not only get people to click through our site, but rather we must also change how they engage in astronomy and seek astronomy content. Following on prior work by Astronomy Cast [3] we asked users to self-assess their engagement with astronomy prior to participating in CosmoQuest and after. Currently, the majority of the people coming to CosmoQuest (89%) already actively seek astronomy content or are amateur/professional astronomers. Of the 12% of people who either only passively read astronomy content, or who didn't engage in astronomy content at all prior to coming to CosmoQuest, 4% became actively engaged in astronomy. This indicates that while CosmoQuest can inspire people to actively seek astronomy content, it needs to do more to recruit people with only a passive interest in astronomy.

3.5 The Nature of Science

We also asked about people's understanding of the Nature of Science. This is a fundamental question, as we are asking citizen scientists to actually participate in the scientific process. Options for this question were taken from Aikenhead & Ryan's (1992) instrument for studying views on science, technology, and society. A third of the respondents defined science primarily as "a body of knowledge," and another third as "exploring the unknown." Although there is no one "right" answer to this question, we hope to show science as a process, one that is accessible to many people, not just those in academia. In future research, we will compare participant views on the nature of science with their level of engagement in the scientific process through citizen science.

4. Scientific Success

It is beyond the scope of this paper to provide a full overview of the statistics demonstrating the scientific success of this project, however we will provide highlights. In Ice Investigators, users recovered the same Kuiper Belt Objects discovered by professionals viewing the same images. For the Mappers projects, we refer you to Antonenko et al. [5] and Robbins et al [6], with the following summary: It was found that the aggregate results (averaged position and size of crater markings) of 15 individuals viewing an image was comparable to the aggregate results of 8 professional crater markers using the software of their choice. A comparison of this scope has not yet been completed for Asteroid Mappers: Vesta, however an initial validity check found that the CosmoQuest community members found all the same craters as a professional scientist, and the centers and sizes were all within error of the professional markings. Planet Mappers: Mercury is too new for a complete analysis, however initial data seems accurate.

5. Conclusions

CosmoQuest has successfully created a virtual research facility that engages members of the public who are motivated by both science content/research and education through teaching and learning. These individuals are capable of accurately contributing to research. We find from this survey of 334 CosmoQuest users that we are engaging a population with a largely pre-existing interest in science and astronomy. We also find that users are exploring multiple projects and multiple parts of the site.

There is more work to be done with this dataset in correlating motivations with educational factors and site behaviors. We also need to do more work to study how much learning is taking place beyond the limited number of classes that are taking place. This abstract represents a successful beginning to a long-term experiment in engaging the public in science.

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HY.P.A.T.I.A. – An Online Tool for ATLAS Event Visualization

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1. Introduction

Since 2008 the LHC[1], the world's largest and most powerful particle accelerator ever built has been searching for answers to fundamental questions of physics. It was built at CERN[2] over the course of ten years by a collaboration consisting of more than 10.000 scientists and engineers from more than 100 countries. It has been called "The experiment of the century" but several large experiments take place in its underground tunnel. The larger one is the huge ATLAS[3] experiment/detector, taking data from hadron-hadron collisions since the end of 2009.

ATLAS is a precision instrument the size of a seven storey building and perhaps the largest collaborative effort ever attempted in the physical sciences. Its members are 3,000 physicists from 176 institutes all over the world. ATLAS detects billions of collisions every day and a small fraction of those is recorded for later study. The registered products of the collisions are called "events" and are the data used by HYPATIA[4] (HYbrid Pupil's Analysis Tool for Interactions in ATLAS) in various scientific and educational scenarios.

It is widely known that high school students have very little knowledge about particle physics and modern physics in general. Most of the school curriculum is focused on basic physics concepts which have been known for centuries. There is very little information about the current state and direction of physics and state-of-the-art research. Nuclear and particle physics is very rarely mentioned in class. This leaves students with a very stale and antiquated perception of physics and fails to ignite their interest in the subject. HYPATIA is a tool that can be used to bridge this gap by involving the students in something which is happening right now: the analysis of the ATLAS data. In addition, HYPATIA should be considered to be a tool for the various inquiry based science teaching models.

2. The HYPATIA/applet

HYPATIA offers a graphical representation of ATLAS event data. The students can play with the events and in this way study the fundamental building blocks of nature and their interactions and at the same time learn how the gigantic state-of-the-art detectors work. This gives students a realistic and exciting look at the research being done at CERN and stimulates an enthusiastic interest in it and at possible scientific careers. The applet version of HYPATIA[5] is also very flexible in the sense that the educators can choose the level of difficulty they want to attain and at the same time adopt it for their own application according to the students' background. It has been tested through the "Discover the COSMOS"[6] EU-funded educational/coordination project in several schools and by teachers from different countries. An advanced version of it is used at the University level and more specifically for the fourth year undergraduate laboratories by students of the University of Athens and also at the International Physics Masterclasses[7].

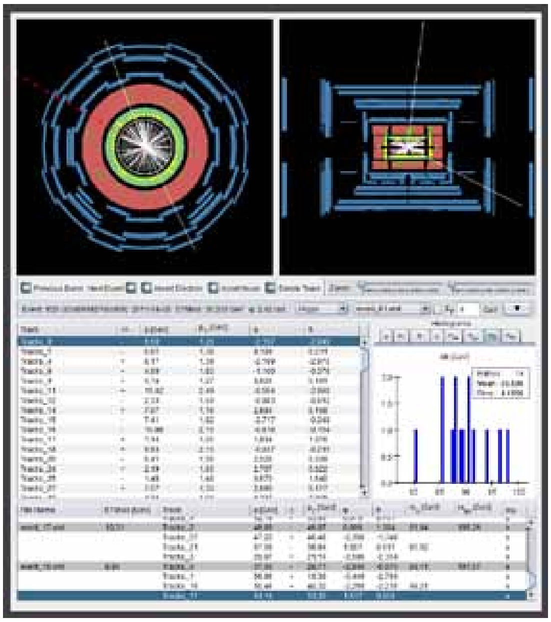

Figure 1. *HYPATIA applet – full version*

HYPATIA runs on almost any operating system and web browser as long as it supports java[8]. It requires very few resources and can be used freely from the University of Athens (UoA) website.

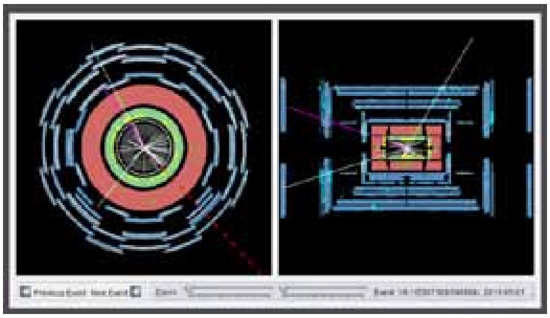

Figure 2. *HYPATIA applet – first level*

The applet is quite simple and intuitive to use for the purpose of this exercise, but still basic computer skills are required. Fig. 1 shows the overall view of the full version of the HYPATIA/applet.

The HYPATIA/applet supports four different versions aimed at various levels of users. The first level (Fig. 2) consists mainly of the two canvas views which display cross sections of the ATLAS detector (one transverse to the LHC beams and one along the beams). The user can browse through different events and observe the number of tracks per event and their distribution in each view. This is a good starting point for entry level users who only want to get an idea of what the ATLAS detector looks like, what do collisions of particles at the unprecedented energies produce and how their products ("tracks") are detected.

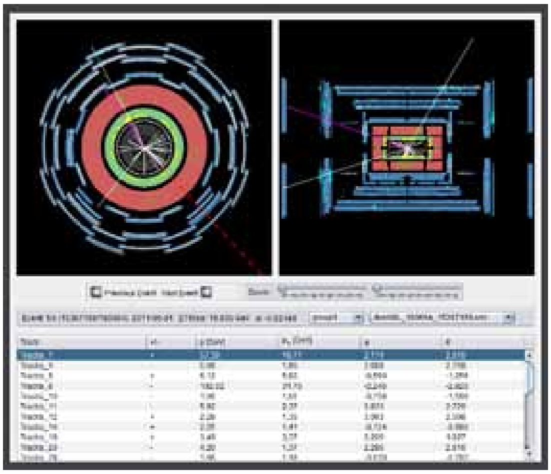

Figure 3. *HYPATIA applet – second level*

The second level of the applet (Fig. 3) adds the information about the track momenta and their directions in a tabular way. Here, the user is challenged to identify the different kinds of lepton tracks. The muons should reach the outer detectors, the muon chambers (the blue chambers) in at least one of the views and the electrons should stop in the electromagnetic calorimeters (green ring) depositing considerable energy there (yellow marks) in at least one of the views. The user can study the properties (energy/momentum, direction and charge) of each track and see how the different kinds of particles behave in each layer of the detector.

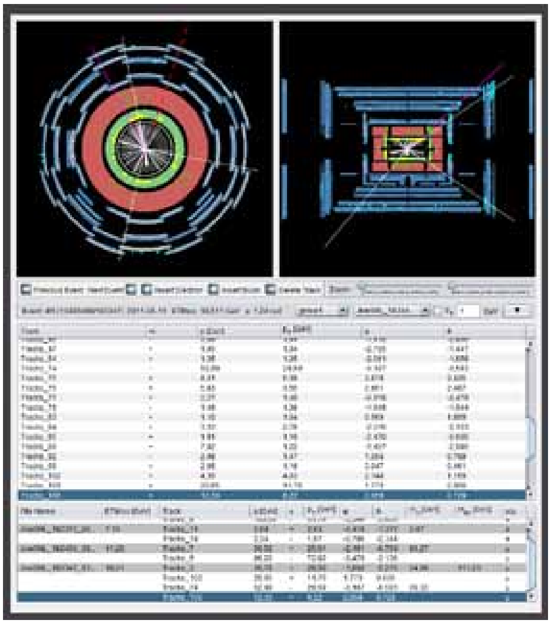

***Figure 4**. HYPATIA applet – third level*

The third level of the HYPATIA/applet (Fig. 4) gives the user the possibility to combine tracks in order to search for invisible short-lived particles which decay into several tracks. In order to do that, the program calculates the invariant mass of the tracks chosen by the user and inserts its value in a table. When two or more particle tracks-traces in one "event", originate from the same point, which we call "vertex", they may belong to one original particle which decayed into these tracks. In order to check this hypothesis the user has to calculate the "invariant mass" of the original particle and investigate if these decay products came from the same particle Examples of short lived particles are the carriers of the weak force the Z0 and W bosons as well as the Higgs bosons. As an example, the Z0 bosons can decay to two muons or two electrons, and the calculated invariant of the combination should be approximately 91.2 GeV, in order to be considered a Z0 boson decay. This can be checked by plotting the relevant histogram of the invariant masses which is available in the full version of HYPATIA/applet.

For that purpose, the user has to find two muons or two electrons and use the "Insert electron" or "Insert muon" button twice to insert them into the invariant mass table. The resulting invariant mass value appears under column mll. If the invariant mass is made from a two-electron combination, an "e" is marked in the last column, otherwise if it is made from a two-muon combination, a "μ" is marked in the last column. Note that the decay to one muon and one electron combinations are not permitted because they violate lepton number conservation. One can also delete tracks with the "Delete track" button and replace them with others.

The full version of the applet (Fig. 1) gives access to the plotting of various histograms which are generated automatically from the tracks that the user adds to the invariant mass table. This is the version which is used in the mini masterclasses.

The mini masterclasses are events held at various schools and other institutes by the University of Athens/IASA and Ellinogermaniki Agogi. Their goal is to show the students how a real researcher works and help them understand the goals and challenges of modern particle physics. The format of the mini masterclasses is similar to that of the International Physics Masterclasses. First the students learn the basics about particle physics, the standard model and the work being done at CERN and ATLAS, by attending one or two lectures given by the experts. Most of the times the students attend a "virtual visit" to the ATLAS experiment where the scientists at the counting room of the experiment give the students a tour and answer questions posed by the students via videoconference. Following the virtual visit, the students (or a selected smaller group) are given instructions on how to analyze event data to look for Z and Higgs bosons using HYPATIA.

The events that the students use in their analysis are real data from the ATLAS experiment. In the end, the students present their findings and compare them to those of their classmates and the expected results from the literature.

3. Activities

HYPATIA has been part of the International Physics Masterclasses since 2008. In 2013 alone 58 institutes from 37 countries chose the Z-path and used HYPATIA in their activities with visiting school students. In addition, IASA in cooperation with the Ellinogermaniki Agogi School organized 23 events (mini masterclasses) during 2012 and 2013 in cities all over Greece, but also in other European countries. Through those events more than 230 teachers and 600 students used HYPATIA and learned about particle physics and the fundamental building blocks of nature. They also learned about the fundamentals of particle detector operation and studied the way particles interact with them and leave a characteristic signature according to their different types.

The students were shown what a real researcher does, and how new particles are discovered. This gave them a realistic and exciting look at the research being done at CERN and stimulated an enthusiastic interest in it. It also inspired teachers to talk to their students about particle physics and showed them a way to integrate it into their class at a level that is suitable to their students.

They also saw how scientific inquiry works in real life. This has the objective of igniting the student's interest in particle physics, and physics in general. Our aim is to drive the students to learn more on their own and investigate further and even pursue a career in physics.

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EU-HOU Internet Educational Solar Radio Telescope

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Abstract

The Internet Educational Solar Radio Telescope, developed within the Hands on Universe Europe project, was designed to be used for interactive radio astronomy lessons via internet. The system receives the radio waves that come from the Sun's chromosphere, of around 3 cm wavelength, and has been conceived to use mainly off the shelf components, thus being easily reproducible. The use of an embedded microcontroller based server installed close to the rotator and antenna avoids the need for a control room, a PC server and long cable runs, and thus enables easy setup at the hosting institutions.

Keywords

Solar radio telescope, remote experiment, embedded server, antenna rotator.

1. Introduction

The idea of using regular satellite television components for educational radio astronomy experiments has been exploited by many dedicated teachers and amateur radio astronomers around the world for many years now. Very simple systems that can offer a rough estimate of the temperature of the Sun can be cheaply and easily assembled, building instructions being available from many online sources [1, 2]. With a little more effort, by adding a data acquisition system and supplementary shielding, the precision can be significantly improved [3]. These simple systems are very well suited for portable outdoor sessions, provided that the weather conditions are good. There are several initiatives that have gone further by adding an antenna rotator, which provides remote control of the system, allowing use regardless of weather conditions. The ESA-Dresden [1,4] and RAMEAU [5] use amateur radio azimuth-elevation rotators of the Yaesu G-5500 type, but this is poor in positioning precision and is rather slack, and thus is not very well suited for the purpose. A cheaper and more precise rotator using off the shelf satellite television DiSEqC (Digital Satellite Equipment Control) motors has been proposed in [6] for the MIT Haystack VSRT (Very Small Radio Telescope). Furthermore, in 2007 Imai Laboratory of Kochi National College of Technology in Japan announced the internet Solar Radio Observatory (ISRO, http://sun.kochi-ct.jp/), which is a system that can be controlled in real time over the internet [7]. For position control of the antenna, this system also makes use of the Yaesu G-5500 amateur radio antenna rotator. Due to the time zone difference, the ISRO in Japan is only of limited use for schools in other parts of the Earth at reasonable times for classes.

The idea of an affordable distributed network of internet controlled solar radio telescopes has been proposed with the goal of providing full time access for schools regardless of their geographic region. The prototype Internet Educational Solar Radio Telescope (IESRT) presented here incorporates several ideas which are intended to allow for easy reproduction and installation.

2. System description

The system receives the radio waves (~ 3 cm wavelength) that come from the bottom of the Transition Layer (just above the Sun's chromosphere, which is located between the photosphere and coronal halo). At this wavelength, the Sun temperature is around 7-10.000K.

IESRT has been designed to use mainly off-the-shelf hardware (available on the market today and modified accordingly), in order to ensure lower cost, and to ensure easy setup at the hosting institutions.

The main functional blocks of the system are the embedded control server, the azimuth-elevation antenna rotator, the radio receiver, and the power supply.

For visual feedback of the antenna motion, internet video streaming is required. In order to keep the flexibility of the system and maintain compatibility with most internet browsers, the choice of the model and type of the video camera is left to the host institution.

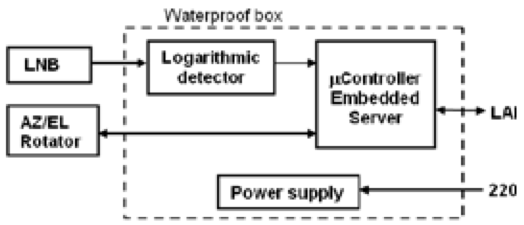

Figure 1. *Block diagram*

2.1 The embedded control server

Usually remote internet experiments today make use of regular desktop or laptop computers that are readily available, in which case an indoor space (a classroom or laboratory) is needed for the setup. This is a natural choice in a case in which the experiment is located close to an indoors area. But if the experiment is located outdoors in a specific position demanded by the experiment itself, as is the case for the IESRT, then the routing of multiple signal cables can be difficult or even impossible. For these reasons the use of an embedded server installed close to the rotator and antenna was chosen, so that only mains power and an internet connection (which can be via wireless) are required. This avoids the requirement for a control room, a PC server, and long cable runs, and makes the installation much less frightening.

The embedded server has been built around the Microchip PIC18F67 microcontroller. It provides rotator control and position reading, analog to digital conversion of the incoming signal from the radio receiver, internet communications and hosting of the control webpage.

The server receives position commands from the user (azimuth and elevation in degrees) and returns voltage values in the embedded webpage. The design of the webpage has been kept as simple as possible, showing the actual position of the antenna (degrees) and the returned voltage.

Figure 2. *Graphical user interface*

The user can orient the antenna manually using left/right and up/down arrows, or can input directly the required AZ-EL position in decimal minutes.

2.2 The antenna rotator

The azimuth-elevation antenna rotator has been developed within the project, and comprises two modified DiSEqC motors, of the AMIKO DM-3800 type. This type of motor has metallic gears and zero-backlash design, and an angular range of ±80°. Two such motors were assembled together with the shafts orthogonal, in order to provide both azimuth and elevation movement.

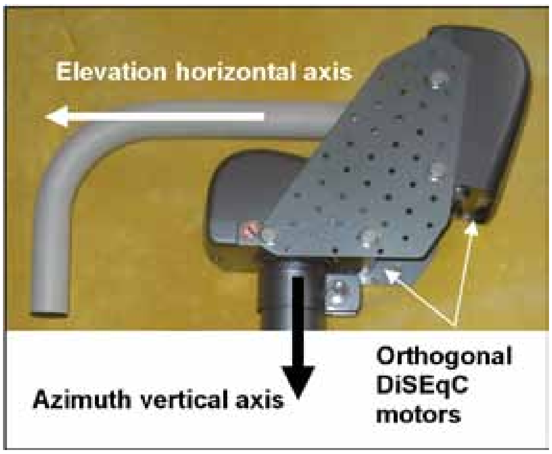

Figure 3. *Antenna rotator*

Only the mechanical assembly and the motor/position transducer assembly were kept, the control electronics being replaced by a one wire serial controller built around the Microchip PIC18F1230 microcontroller. This modification ensures good positioning speed at lower supply voltages and has been made in consideration of the option of supplying the IESRT independently at 12V from solar panels and a sealed lead-acid buffer battery.

2.3 The radio receiver

The radio receiver consists of an ARCON Sweety Cassegrain dish (43cm diameter) fitted with a universal LNB (Low Noise Block) for the Ku band, and this is a component that is currently used for geostationary TV satellite reception. When supplied at 12 V, the frequency band covered is 10.7-11.7 GHz.

The microwave signal (950 - 1950 MHz) from the LNB is carried to the logarithmic detector by a coaxial cable which also provides the DC power supply for the LNB. The detector returns a DC voltage proportional to the signal strength of the source (i.e., here, the Sun).

Figure 4. *The IESRT prototype*

The most common type of small satellite antenna dish found on the market today is the offset (off-axis feed) type. In order to minimize the thermal effect of solar reflection upon the focal point over the LNB (increased noise level, damage to the components) a Cassegrain type antenna was chosen (the same antenna type used for ALMA).

In a Cassegrain antenna design, a secondary convex reflector is placed at the focal point of the paraboloid reflector, and this focuses the incoming radio waves onto the LNB, which is placed behind the main dish and is thus protected from direct sunlight. For the same reason the color of the reflector was chosen as anthracite black in order to minimize reflection of visible and infrared light to the focal point.

The ARCON Sweety model chosen has 33dB

gain and 2.5° HPBW (Half Power Beam Width).

3. Exercise

The lessons associated with this online experiment may cover introductory radio astronomy notions such as electromagnetic spectrum, solar radio emissions, astronomical coordinate systems, radio telescopes, antenna types and radiation patterns.

During the online exercise, the students must answer several questions in order to arrive at the result.

3.1 Where is the IESRT located?

The geographical position of the IESRT must be obtained from a map posted in Google Maps by the host institution. This is a good opportunity to introduce and discuss geographic coordinates and conversions between them.

A coordinate can have one of three basic forms: Sexagesimal - consisting of degrees (an integer), minutes (an integer), and seconds (an integer or decimal number); Decimal Minutes and Seconds (DMS) - consisting of degrees (an integer) and minutes (a decimal number) (MinDec); or Decimal Degrees - consisting only of degrees (a decimal number) (DegDec).

3.2 Where is the Sun?

Using an online Sun position calculator (e.g. JavaScript Sun Calculator [8]), the azimuth and elevation of the Sun is obtained, for the IESRT geographical position found at the previous step. The JavaScript calculator returns the position of the Sun in decimal degrees.

The IESRT is set to zero toward South, accordingly the IESRT azimuth = Sun azimuth - 180°. The result must be converted from decimal degrees (D.ddd) to degrees and decimal minutes (D.MMmm). Negative/positive values for elevation correspond to orientations of the IESRT respectively below and above the horizon.

These values for azimuth and elevation are used for pointing the IESRT to the Sun. The returned voltage is recorded. Similarly, the corresponding power values for the ground and sky are obtained by pointing the dish to the surroundings and to the clear sky.

3.3 What is the Half Power Beam Width?

Dish antennas have high gain compared with an isotropic radiator (dBi) or with a dipole (dBd), i.e. the energy reception is concentrated in a particular direction.

One parameter which describes the directivity of an antenna is the half power beam width HPBW, which is defined as the solid angle in which half of the received power is concentrated. This corresponds to 3dB decrease (0.5 in power or 0.707 in voltage).

When pointed to the ground the entire antenna HPBW is “filled” with radiation.

Since the Sun has a smaller angular diameter (0.5°) only a small area of the antenna HPBW will be illuminated by the Sun, the returned voltage corresponding to one point of the Sun’s temperature. In order to obtain the real value of the Sun’s temperature, the area ratio of illumination must be taken into account.

We know the angular diameter of the Sun and the antenna HPBW (given in the technical specifications).

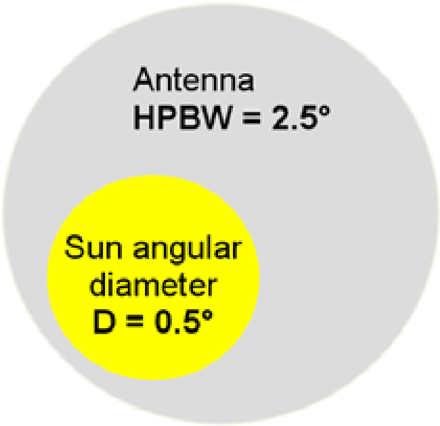

Figure 5. *Antenna Half Power Beamwidth*

3.4 What is the one point of the Sun's temperature?

Between the one point of the Sun's temperature, ground temperature and the corresponding returned voltage for the Sun, ground and sky, the following relation applies:

$$\frac{T_{\bullet SUN}}{T_{GND}} = \frac{V_{\bullet SUN} - V_{SKY}}{V_{GND} - V_{SKY}} \quad (1)$$

In the equation (1): $T_{\bullet SUN}$ is one point of the Sun's temperature, T_{GND} is the temperature of the ground (can be estimated at $\cong 300K$), $V_{\bullet SUN}$ is the returned voltage corresponding to one point of the Sun's temperature, V_{GND} is the returned voltage corresponding to the ground temperature, and V_{SKY} is the returned voltage corresponding to the sky temperature (received from all directions).

The one point of the Sun's temperature will be:

$$T_{\bullet SUN} = \frac{V_{\bullet SUN} - V_{SKY}}{V_{GND} - V_{SKY}} \cdot T_{GND} \quad [K].(2)$$

3.5 What is the temperature of the entire Sun?

The temperature of the entire Sun is related to the area ratio (between the antenna HPBW area and area of the Sun), as following:

$$T_{SUN} = T_{\bullet SUN} \cdot A_r \quad [K]\ (3)$$

where:

$$A_r = area\_ratio = \frac{A_{HPBW}}{A_{SUN}} \quad (4)$$

$$A_{HPBW} = \frac{\pi \cdot HPBW^2}{4} \quad (5)$$

$$A_{SUN} = \frac{\pi \cdot D^2}{4} \quad (6)$$

The area ratio will be:

$$A_r = \left(\frac{HPBW}{D}\right)^2 \quad (7)$$

For the ARCON Sweety Cassegrain antenna the area ratio is:

$$A_r = \left(\frac{2.5}{0.5}\right)^2 = 25 \quad (8)$$

The temperature of the entire Sun:

$$T_{SUN} = T_{\bullet SUN} \cdot 25 \quad (9)$$

The calculated (estimated) temperature of the Sun at 3 cm wavelength should be between 7000 – 10000 K.

4. Conclusions

This online solar radio telescope provides an easy way for teachers to approach the field of radio astronomy in their classes by doing hand-on experiments, and this is a time at which the basic notions can be introduced to the students, thus allowing them further to perform more complex tasks in this field. In order that such an approach can be really effective by providing full time access during class hours all around the world, a distributed network of such internet controlled solar radio telescopes is needed. Further improvements of the system are considered for better sky coverage, more flexibility by adding wireless connection to the internet, and solar energy power supply.

5. Acknowledgements

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Science in the Schools: The Extreme Energy Events project

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Abstract

The Extreme Energy Events (EEE) project, a cosmic ray physics experiment, is at the same time an excellent outreach project. Its scientific goal is the study of extended air showers from high energy cosmic rays and extreme energy events by detecting the muon component of the shower. To this aim, a network of muon telescopes has been installed in high schools distributed all over Italy; each telescope consists of three planes of Multigap Resistive Plate Chambers which allow the reconstruction of the muon direction. The search for extended air showers is based on the search for coincidences between telescopes. The project was conceived by Prof. A. Zichichi in order to interest high school students in science and give them a hands-on experience of scientific research.

Keywords

cosmic rays, extreme energy events, extended air showers, multigap resistive plate chambers, muon telescope.

1. Introduction

The Extreme Energy Events (EEE) project, a cosmic ray physics experiment, is at the same time an excellent outreach project. Its scientific goal is the study of extended air showers from high energy cosmic rays and extreme energy events by detecting the muon component of the shower. To this aim, a network of muon telescopes has been installed in high schools distributed all over Italy. The search for extended air showers is based on the search for coincidences between telescopes.

The project was conceived by Prof. A. Zichichi in order to interest high school students in science and give them a hands-on experience of scientific research. The students construct the muon chambers themselves; they are then involved in all stages of the project: installation and commissioning of the telescopes, data-taking and analysis.

The EEE project is financed by the Italian Ministry for Education, Universities and Research (MUIR), the National Institute for Nuclear Physics (INFN) and the “Centro Studi e Ricerche e Museo Storico della Fisica Enrico Fermi”; CERN is also a partner in the project.

2. The detector

The design of the muon telescopes and the choice of the detector were based on a number of requirements: large area coverage, to increase the probability of detecting some of the many thousands of particles produced by cosmic rays with energies > 1018 eV and extending over some km2; pointing capability, to reconstruct the direction of incoming muons; ease of construction; robustness and reliability.

Each telescope consists of three planes of detectors; these are large area (80x160 cm2) Multigap Resistive Plate Chambers (MRPCs): gaseous detectors of the parallel plate type, each consisting of a stack of glass plates enclosing a total of 6 300-micron gas gaps. The distance between the glass plates is kept fixed be means of nylon fishing line spacers in a zigzag layout. The outer surfaces of the external plates are painted with a conductive paint, which allows to apply the high voltage needed for the chamber operation; the internal plates are electrically floating. A cross section of the EEE MRPC is shown in Fig.1. These chambers are similar to the MRPCs of the Time Of Flight (TOF) detector of the ALICE heavy-ion experiment at LHC, used for particle identification [1].

Charged particles going through the MRPCs ionise the gas; the electrons are multiplied due to the high electric field and the subsequent avalanches created inside the gas volume induce electric signals on pickup strips. The glass plates separating the gas volumes stop the avalanche development; however, as they are transparent to the induced signal, the total signal is the sum of signals due to all avalanches in all gas gaps. This ensures high efficiency combined with excellent time resolution.

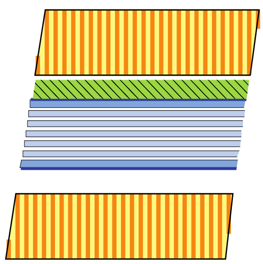

Figure 1. *Cross section of the EEE MRPC.*

24 pickup strips are used for the signal readout; they are made of 2.5 cm wide adhesive copper tape glued on a vetronite sheet; the dis-

tance between strips is 7 mm. Two planes of readout strips are used (anode and cathode); thus a differential signal is sent to the readout electronics.

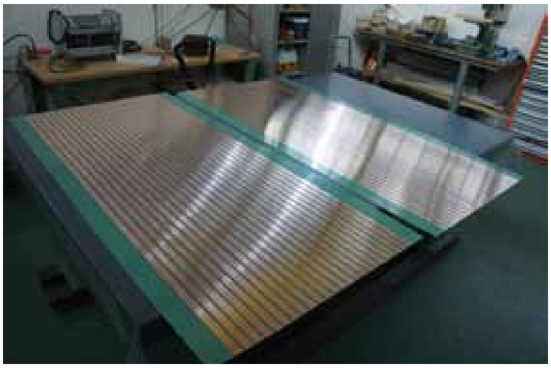

Figure 2. *The two readout planes made of copper strips glued on vetronite.*

Each MRPC is placed in a gas-tight box with dimensions 200x100x5 cm3.

3. Electronics, readout, data acquisition

The NINO chip, a low-power, 8-channel ultrafast amplifier and discriminator, developed for the ALICE TOF, is used for the front-end electronics [2,3]. The input is a differential signal and the output is an LVDS signal. The leading edge of the signal gives the time measurement whereas the trailing edge is used to calculate the time width, proportional to the input charge and used for slewing corrections. The front-end cards, each containing 3 NINO chips, match the 24 readout strips of the readout planes.

For each MRPC two such cards read out the signals at the two ends of the strips. From the time difference measured, the hit position along the strip can be calculated. Each card also privides the OR of the 24 inputs.

The trigger is a six-fold coincidence of the OR signals from the two sides of the 3 chambers of each muon telescope.

The readout of the LVDS signals is done by Time to Digital Converters (TDCs), giving the time of the hits on the MRPC strips. Each EEE station is equipped with a VME crate containing two CAEN TDCs: V1190A (128 channels) and V1190B (64 channels). These are based on the High Performance TDC (HPTDC) developed by the CERN microelectronics group [4]. The trigger card, either a home-made card (developed by CERN and Catania) or a variant of the ALICE LTU, also sits in the VME crate; a Global Positioning System (GPS) card is also part of the readout system; this provides the absolute time stamp needed to look for coincidences between muon telescopes in different locations. The communication between the VME crate and the PC used for data acquisition is ensured by a CAEN V1718 USB bridge.

A LabView programme is used for the data acquisition running on a Windows PC. This programme also provides monitoring of the data and online histograms.

4. The construction of the MRPCs

The MRPCs for the muon telescopes are constructed at CERN by students of the high schools participating in the project. Groups of 5-10 persons, consisting of pupils and teachers and accompanied by INFN or University researchers, from the same town or a neighbouring one, typically spend a week at CERN. There, under the guidance of CERN and INFN physicists, they assemble the chambers and do preliminary tests.

Figure 3. Stretching the fishing-line spacer in a zig-zag pattern.

Details of the chamber construction procedure are given in ref. [5]. Fig. 3 and 4 show some of the steps (stretching the fishing-line spacers and lifting a glass plate).

Figure 4. Using a vacuum system, a glass plate is lifted in order to be placed on top of the previous one.

For the students taking part in the chamber construction at CERN this has been a valuable experience from all points of view. They construct a detector from scratch, with their own hands, and they see it working. Often, it is the first time that they use a drilling machine or a soldering iron. They learn how to work in a team; they get hands-on experience of how research is done; profiting from their stay at CERN they visit some experimental installations. At the end of the chamber construction they do the first tests of the chambers: by flowing gas through the chambers they check the gas tightness and repair leaks; they then apply slowly high voltage, monitoring the dark current, and measure the efficiency plateau.

5. Chamber performance

The MRPCs are operated in avalanche mode with a gas mixture consisting of 98% Freon C2F4H2 and 2% SF6. For a voltage difference between anode and cathode in the 18 kV range, efficiency better than 95% and time resolution of the order of 100 ps have been measured. The result is position resolution of ~ 1 cm along the pickup strip; thus the muon direction is reconstructed with an angular resolution of 0.3o(rms). Details of the chamber performance, studied with cosmic rays and with a test beam at the CERN East Hall, are given in ref. [6] and [7].

6. Installation and operation of the muon telescopes

After their construction and first tests at CERN, the MRPCs are transported to Italy and distributed to the corresponding schools. Each school is equipped with a mechanical support structure, which allows the distance between the planes of the muon telescope to be varied between 50 cm and 100 cm. An EEE telescope is shown in Fig. 5.

Figure 5. A muon telescope on its support frame.

The schools are equipped with a gas mixing system (Bronkhorst) and a special cabinet to contain the Freon and SF6 bottles; also with the front end, readout and trigger electronics described in section 3. For the high voltage needed for the operation of the MRPCs, DC-DC converters are used, since for security reasons the use of high voltage cables in the schools is not allowed.

The installation and commissioning of the telescopes is done by the INFN or University researchers responsible for each school, in collaboration with the pupils and teachers involved in the project. In this way the pupils are exposed to all aspects of a physics experiment. During the commissioning phase the performance of the chambers is thoroughly studied. Then, during routine data-taking with cosmics, which happens on a 24-hour basis, the students have the responsibility of doing daily checks, monitoring the data quality and keeping the system running smoothly. Often they are also involved in the data analysis, running the reconstruction software provided by the EEE collaboration.

An event display has also been developed based on java. Fig. 6 shows the first event recorded by the Liceo "A. Scacchi" in Bari.

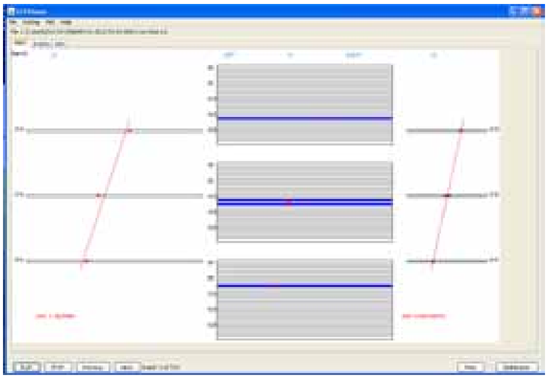

Figure 6. *Display of the first event recorded by the telescope of Liceo "A.Scacchi" in Bari.*

7. Status of the project

More than 120 MRPCs have been constructed up to now. There are 40 telescopes, most of them distributed in high schools all over Italy, plus two at CERN and two in INFN sections. Their geographical distribution is shown in Fig.7.

Figure 7. *Map of Italy showing the location of the EEE telescopes; the numbers inside the stars correspond to the number of telescopes.*

Many more schools are interested in joining the project; during the second half of 2013 another five schools will be sending groups to CERN to construct chambers.

In addition to analysing the data locally, each EEE station regularly transfers the recorded data for storage to the Ettore Majorana Foundation and Centre for Scientific Culture (EMFCSC).

The educational potential of the project is being exploited in many ways. In the early stages of their involvement with the project, the students follow introductory lectures on cosmic rays and detectors. On some occasions they visit INFN or University laboratories. Some of them participate in Conferences of Centro Fermi or National Symposia of the EEE project, where the status of each EEE station is presented.

A number of University students, from the groups collaborating with the high schools involved in the project, have done their diploma work, master's or PhD thesis on various aspects of the EEE project: development of electronics or software for remote control of the experiment, simulation and data analysis. For example, the Lecce group has developed a device to supply the high voltage for the MRPCs and the low voltage for the front end electronics; this is interfaced with the DAQ PC and controlled by means of dedicated software, so that the HV/LV system can be monitored remotely [8].

Up to now more than 20 presentations have been given in conferences on instrumentation and detectors, cosmic ray physics and physics education and outreach; in addition to these contributions to conference proceedings, a number of papers has been published in scientific journals.

8. Coincidence results

The capability of detecting extensive air showers with the EEE stations was proven when the first coincidences were observed. Results from such coincidences between two telescopes in two high schools in L'Aquila, less than 200 m apart, have already been published [7]. Later on, coincidences were observed between two telescopes in Cagliari, located 520 m apart [8].

Monte Carlo simulations are also on the way, using sophisticated programmes (CORSIKA and COSMOS) to compute the expected number of coincidences as a function of the distance between stations, their altitude and so on [9]. It is obvious that the coincidence rate decreases as the distance between telescopes increases, thus, from a certain distance on, special techniques for effective rejection of the background due to accidentals must be put in place.

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Netzwerk Teilchenwelt – Hands On Particle Physics Masterclasses in Germany Best Practice in Sharing Authentic Science with the Public

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Abstract

The Big Bang, antimatter and cosmic particles - being active in Netzwerk Teilchenwelt means being up to date with modern research in physics. Netzwerk Teilchenwelt (Network Particle World) is a collaboration of 24 German research institutes and CERN in Geneva. Since 2010, each year 4000 students and 500 teachers all over Germany have entered an optional multi-step program. They start out as particle physicists for one day in mobile Masterclasses, facilitated by young scientists in schools and other educational institutions. If analyzing real CERN data or doing their own measurements with cosmic particles sparks their interest in basic research, they can qualify for more and more intense research experiences in their region and on site at CERN. In the past 3 years, an active network of students and teachers, together with more than 100 young scientific facilitators has emerged from this program, creating sustainable structures for reaching out to each village throughout the country.

The unique approach of Netzwerk Teilchenwelt - STEM (Science, Technology, Engineering and Mathematics) promotion under a special brand - is presented with its particle physics projects. Potentials and challenges of the network are described. First results of an evaluation on network activities are included as well as insights into the organization and cooperation with other physics partners.

Keywords

Hands on Particle Physics, Masterclass, Netzwerk Teilchenwelt.

1. Introduction

How did the universe evolve? What are the building blocks of matter? How do they interact? What happened after the Big Bang? Thousands of scientists follow these questions and try to "understand whatever binds the world's innermost core together" [1], at the largest experiment in the world - the Large Hadron Collider (LHC) at CERN in Geneva.

Details of this fascinating research, e.g. the recently discovered Higgs particle, are spread through the media, and are thus in the public eye. Teachers are faced with questions by their students, such as, for example, whether black holes are really dangerous. However, they find little support in physics textbooks to this kind of query, since the textbooks' state of scientific knowledge mainly ends 100 years ago.

Alarming results on the quality of science education in recent years [2] have triggered a number of initiatives, thanks to which a positive trend for instance in the number of students studying science at German universities can be presently noted [3].

Nevertheless, great efforts are still needed to

- communicate ideas and findings of current basic research as general cultural assets,

- encourage the ability to classify and evaluate this research and the resources used for it, and, ultimately its acceptance,

- advance the quality and actuality of physics education in schools,

- ensure the next generation of STEM specialists,

- convey ways of thinking and skills that are generally used in modern science and engineering, and

- let it become a matter of course for all scientists to explain and communicate their scientific work to society.

2. Structure and goals of the network

2.1 Construction of the network

Since 2006 TU Dresden has been coordinating the program International Masterclasses, which gives secondary school students all around the world the chance to work collaboratively and analyse real data from particle physics experiments with physicists as their mentors. Using the experience in coordination of the International Masterclasses with excellent results [4], a national network was developed to make this approach accessible to a wider circle of students and teachers. In addition to the Particle Physics Masterclasses, an astroparticle branch of activities with cosmic ray detectors (Kamiokannen, [5]) and CosMO experiment [6] has been developed since 2011.

Sixteen research institutions in Germany were already participating in International Masterclasses and thus included in the Netzwerk Teilchenwelt. In addition, further institutions joined, so that 24 research institutions in particle and astroparticle physics from all over Germany merged into the foundation of Netzwerk Teilchenwelt in 2010 [7].

The project is funded by the German Federal Ministry of Education and Research (BMBF). After the successful completion of the first funding period from 2010 to 2013, the project was recently approved for follow-up support of another three years.

The initiator and leader of the project is Michael Kobel from Technical University Dresden. Under his guidance and under patronage of the German Physical Society (DPG), all locations offer the multi-level program described in sec. 4.

Figure 1. *24 Particle Physics Institutes at 22 locations all over Germany are building the network, in cooperation with CERN*

The staff consists of 5 persons, one full-time and four half-time positions. Besides that there are about 140 young scientists involved in the network´s activities (about 40 local organizers and about 100 scientist, typically PhD or experienced master students, conducting Masterclasses – see 3.2). Special tasks are carried out at the University of Würzburg (development of teaching materials, s. 5), DESY in Zeuthen (development of astroparticle physics activities, s. 3.3), CERN (student and teacher workshops, s. 4.3), as well as at TU Dresden (coordination, evaluation – s. 7).

With its unique concept Netzwerk Teilchenwelt covers various aims:

a) convey the fascination of modern research in particle and astroparticle physics to students and teachers,

b) train teachers and project leaders in modern physics,

c) offer measurements with original data from CERN, including current research results (e.g. discovery of a Higgs boson), and from experiments with cosmic particles

d) provide sustainable, motivating and authentic teaching, learning and research experiences, and

e) facilitate direct contact between scientists, young people and teachers.

Furthermore, Netzwerk Teilchenwelt allows:

f) high school students to gain insight into the topics and methods of research in particle physics,

g) young scientists to gain experience in science communication and to improve this skill, and

h) teachers to get in close contact with science.

3. Particle Physics Masterclasses

Particle Physics Masterclasses are the core activity of Netzwerk Teilchenwelt. In addition, an Astroparticle Physics Masterclass is in development.

3.1 The Masterclass concept

While a Masterclass is a familiar part of education in the arts, UK physicists have transferred the idea to particle physics beginning arround 1997 (R. Barlow et al.) [4].The first Particle Physics Masterclasses invited high school students (15-19 years old) for one day to a nearby research institute or university. Students learned the basics of particle physics and analyzed data under the mentorship of particle physicists.

In 2005, this concept was adopted by IPPOG and extended to the International Masterclasses [8], providing high school students around

Europe the opportunity to become "physicist for a day". The students have lectures in the morning, followed in the afternoon by a measurement with real data from the Large Electron Positron Collider (LEP) collider at CERN, which was still active at the time. At the end of the day, students participate in an international video conference - together with up to four other student groups, and young moderators from CERN or Fermilab, to combine and discuss their results.

International Masterclasses are organized by TU Dresden and QuarkNet [9] every year in spring over the course of four weeks. In 2013, 160 institutes from 37 countries attracted about 10,000 participating high school students to these Masterclasses.

3.2 Teilchenphysik-Masterclasses

The Particle Physics Masterclasses organized by Netzwerk Teilchenwelt – called „Teilchenphysik"-Masterclasses – are normally held in schools, sometimes also in school labs, at fairs or exhibitions. Young scientists, most of them PhD or master students, visit classes and enable high school students to work with real data from CERN experiments and analysis tools (Minerva, Hypatia). Each workshop lasts 4-6 hours and covers an introduction to particle physics and a hands-on activity. The measurement provides a basic experience of research (problem definition, sampling, statistical evaluation, analysis); previous knowledge is not necessary.

In contrast to International Masterclasses, there are no video conferences, but a „Teilchenphysik"-Masterclass includes a quiz and a question-and-answer session. With this concept, Particle Physics Masterclasses are now available at any date, at any place and for a much larger group of young people than ever before in Germany.

Figure 2. *High school students analyzing a collision event, measured at the LHC*

3.3 Outlook: Astroparticle-Masterclasses

Since 2011, Netzwerk Teilchenwelt offers hands on workshops with cosmic particles of several days duration. For a one-day program an Astroparticle Physics Masterclass is currently being prepared.

Here, students and teachers should be given the opportunity to work with data of the Auger experiment. These new Masterclasses will also be integrated into the International Cosmic Day, which is an activity of many astroparticle outreach projects worldwide [10].

4. The network's multilevel approach

The activities of Netzwerk Teilchenwelt are aimed at young people aged 15 to 19 years and at teachers in schools, project leaders in school labs or other educational institutions. They build the user community – each year more than 700 teachers and 4200 high school students participate in the network´s activities (Fig. 3).

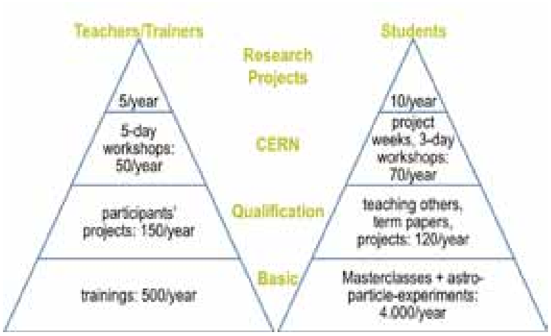

Figure 3. *Network activities, building on each other*

The activities build on each other, with increasing amount of involvement and decreasing number of participants.

4.1 Level 1: The basic program

The main idea of the basic program is to attract many students and teachers to expose them to particle physics research. For high school students participating in the basic particle physics program means participating in an International or „Teilchenphysik"-Masterclass. In the future it will be also possible to participate in Masterclasses in astroparticle physics. We meet about 4000 students this way every year – so the „Teilchenphysik"-Masterclasses are really the heart of our networks activities.

The basic program for teachers also includes participation in an introductory event, which is in this case usually training in particle physics. A few locations offer teachers' days in the context of the International Masterclasses. Others run year-round trainings at their institutions or in cooperation with the educational institutions of their federal state.

4.2 Level 2: Qualification

At the end of each basic workshop the attendees are informed about further possible activities in the network.

Students wanting to become a member of the network are asked to pass on their knowledge to others in many different ways. For example, the ambassadors can help as tutors in other Masterclasses, give a talk in their school or elsewhere, or promote at local events of institutions (e.g. "Long Night of Sciences"), etc. Thus, there are no boundaries in the intensity and creativity of the qualification. The commitment is defined by the participants themselves; the locations of the network only support them.

The second level for teachers means becoming a multiplier and disseminator. They qualify for the next level by organizing Masterclasses and workshops in consultation with their local organizer of the network.

4.3 Level 3: Consolidation

Twice a year 30 of the most committed young people are invited to a three-day workshop at CERN in recognition of their commitment.

For teachers Netzwerk Teilchenwelt runs five-day workshops at CERN twice a year. They are organized in cooperation with CERN within the framework of the German Teachers' Program and offer a varied schedule, including on-site visits, lectures about particle physics, seminars and of course the face-to-face contact with scientists [11]. Each year about fifty teachers are able to participate in these workshops, funded by Netzwerk Teilchenwelt

Uta Balko, a teacher from Berlin, took part in the first workshop for teachers in October 2010 and says: "To have really been at CERN is the greatest thing for every physicist - so also for every physics teacher." For her, the most important experience was to witness highly modern research first hand, because "the students are very interested in this current research, thus I want to be able to comment on this issue." She also hopes "that (she) can fascinate (her) students more for physics and science and spread (her) enthusiasm." [12]

4.4 Level 4: Research projects

As the icing on the cake of the multistage program of Netzwerk Teilchenwelt, ten students and a few teachers can be active in the program level "research projects", where students finally realize extensive research works, supervised by their local institution. Participation in research weeks at CERN is a special option for the ten most active students. Depending on the federal state, students can contribute this work as a particular achievement ("BeLL") or so-called fifth test component in the grade of their high school diploma. Moreover, many of these student works have been rewarded with prizes in various awards.

Teachers can collaborate as research delegation in institutes; however, this depends on the regulations of the federal states. Scope, content and organizational form can be arranged individually and vary from region to region.

5. Teaching material

To provide the learning institutions with materials on particle physics not only for preparation and post processing of Masterclasses, but also for project days and school lessons, Netzwerk Teilchenwelt has created educational material covering the following topics:

1. Portraits of the elementary particles (Fig. 4)

2. Instruction for building a cloud chamber

3. The ATLAS experiment

4. Research in and applications of particle physics

5. Handouts for participants in a Particle Physics Masterclass

6. Material for Masterclass facilitator

All educational material was created by a team of researchers, didactic experts and science-communicators in order to reach a high level of clarity, professional correctness and an appropriate choice of terminology. The teaching material is used in Masterclasses, the CERN-workshops and everyday school life. Moreover, the online forum of Netzwerk Teilchenwelt [13] collects feedback to improve the material steadily.

In collaboration with the project "Discover the Cosmos", scenarios have been developed combining the typical applications of the network with IBSE (Inquiry Based Science Education)-methodology [14]. The scenarios are available for download in numerous translations at the Discover the COSMOS-portal [15].

Figure 4. *Using particle portraits to introduce the Standard Model of particle physics*

6. Special activities

A number of further activities have been developed supplementary to the multi-step program. This development confirms the image of a strongly creative and self-dynamic network. The vision of the initiators has become reality.

Figure 5. *Netzwerk Teilchenwelt bags, Atlas Lego model, participation at science fairs, 358 likes on facebook, hand-made Higgs-earrings, particle-zoo-buttons*

6.1 It's cool to be involved

So far, the network has presented itself at congresses, science fairs and conferences. Furthermore, the network will be represented with exhibits and information at Deutsches Museum Bonn soon.

Not only these events but also creative demonstration materials as well as social media activities have made sure that more and more people get in touch with the network (Fig. 5). A sense of cohesion has grown and all the people involved feel: It's cool to be a member of the Netzwerk Teilchenwelt! It's up-to-date to learn more about the world of particle physics!

6.2 Video-Competition (IN)VISIBLE?!

How can you make tiny particles visible? How can science be explained in a short movie? In 2011 and 2012 the Netzwerk Teilchenwelt has arranged a particle physics video contest called "(IN)VISIBLE?!". Teenagers from all over Germany were invited to participate in the video competition by providing a creative movie which answers a question related to particle physics. Prize winners were awarded a visit to CERN.

6.3 Educational Scenario Contest

In 2012, an "Educational Scenario Contest" was arranged. Teachers from all over Germany were invited to develop either a scenario on the basis of the IBSE educational scenario template which was proposed by the Discover the Cosmos project or to create supporting materials with the target to reinforce the student's activities. Prize winners created a game, wrote a textbook with exercises on particle physics, and developed a modular presentation on cosmic rays. These contributions are published and available for download at the Discover the Cosmos portal [14].

6.4 Working groups of active teachers and students

Especially after participation in CERN workshops most of the teachers and students are highly motivated and wish to continue their work in the network. Following on this, last year we started to organize a teacher round-table in Dresden, meeting every 3 months. About 5 to 10 teachers participate in lab tours, lectures, and a general exchange of information.

Teachers enjoy this opportunity for many reasons, among them the chance to meet like-minded colleagues. However, due to their everyday workload plus their voluntary engagement in introducing modern physical research into school permanent organizational input is needed to keep this round table running.

On the initiative of a group of very active high school students we invited this year in May 120 of our student-alumni of Netzwerk Teilchenwelt who have participated in three or all stages of the network. Some of them are still at school, some of them already at university, studying physics - but there were also other subjects. 35 of them accepted the invitation. The 2-day meeting was very intensive and resulted in starting several working groups, e.g.

- international exchange program for alumni,
- particle physics study groups in schools,
- particle physics taster course in schools,
- particle physics for primary-school pupils,
- particle theatre …

All these are ideas for future activities, which shall be organized by this very active group of Teilchenwelt alumni themselves.

6.5 Training of young scientists

As noted in 3.2, most „Teilchenphysik"-Masterclasses are facilitated by young PhD students. This opens a win-win situation for both scientists and high school students: Normally, the PhD students quickly establish a good relationship with the high school students, who consider them "closer" to themselves than a normal teacher. Our PhD students gain experience in important soft skills like communication, presentation and organization.

To provide them with some basic communication tools and pedagogical knowledge Netzwerk Teilchenwelt organizes a workshop once a year. This is also a great opportunity to discuss experiences or new materials developed.

7. First results of the network's evaluation

An essential part of the first project period was an evaluation of the "Teilchenphysik"-Masterclass by using a pre, post and follow-up questionnaire. The results of the evaluation will be presented comprehensively in [16]; here two results of the study are noted in advance, showing that the „Teilchenphysik"-Masterclasses are positively assessed by the students in general (Fig. 6) and in more detail (Fig. 7).

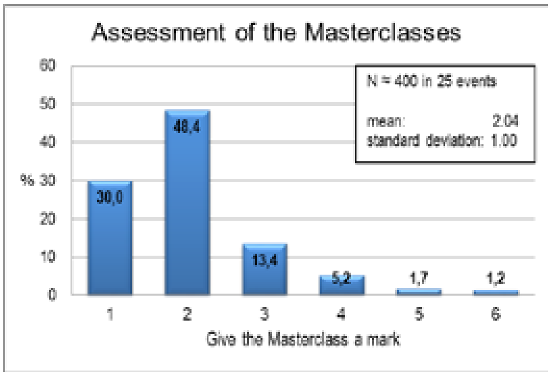

Figure 6. *Students rating of „Teilchenphysik"-Masterclasses (1 = highest, 6 = lowest)*

In Fig. 6 participating students were asked to mark the „Teilchenphysik"-Masterclass. The mean value of their answers is 2,04 . Each result plotted in Fig. 7 is combined from several questions, e.g. 7 questions such as: "the introduction was understandable to me" or "the task of the measurement was clear to me" were asked in the category "challenge and recognition".

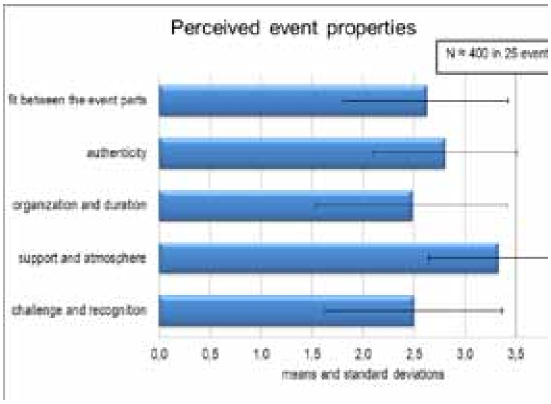

Figure 7. *Rating of special properties combined from several questions (0 = disagree, 4 = totally agree)*

The best rated feature is support and atmosphere. This effect is certainly related to the situation that PhD students hold the Masterclasses. Also authenticity is rated very high, which is again due to the fact that the facilitator is a real scientist and that the students have the possibility to do measurements with real data.

8. Conclusion

Netzwerk Teilchenwelt gives high school students the chance to get in touch with modern particle physics research and real data of the LHC experiments. Students learn about the fundamental building blocks and forces and gain insight into the scientific research process. Especially the hands-on part of the Masterclasses, which gives students the opportunity to conduct their own measurements and to get in touch with young scientists, is a unique experience which teenagers classify as outstanding.

As an out-of-school place of learning Netzwerk Teilchenwelt offers education closely related to science, subject-specific and complementary to the school teaching. Furthermore, the project is operated nationwide and distinguished by its mobility. These characteristics make it possible to also reach young people in the countryside, where there are usually fewer offers of informal science education.

The system consists of 4 levels in which the teenagers advance depending on their engagement in the network. Categorizing teenagers in levels allows for providing everyone a tailored advancement particular for the needs of the teenagers.

The main features of this network approach ensuring its success are:

1. the multilevel and pyramid-like structure of activities

2. the concept of “mobile scientists”

3. win-win situation for the participating institutes as well as for teachers and scientists

4. synergies with corresponding projects

9. Acknowledgements

Netzwerk Teilchenwelt is run by the Institute of Nuclear and Particle Physics at the Technische Universitaet Dresden. It is funded by the federal ministry of education and research (BMBF) and it is under the patronage of the German Physical Society (DPG). Netzwerk Teilchenwelt is partner of the international networks IPPOG, Discover the Cosmos and QuarkNet.

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Bringing Astronomy Research into the Schools

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Abstract.

To awake children´s interest in scientific topics, it's necessary to keep also the young ones in touch with modern science and preferably, with the researches themselves. The Haus der Astronomie (HdA) in Heidelberg acts as a main junction to connect researchers with teachers in order to transfer modern science from the very frontline of research into the classroom. As an example, the functioning principles of a complex infrared detector were broken down to fit into an environment that young students are very familiar with. Together with the Deutsches SOFIA Institut as research facility and the HdA as coordinator, a DIY-heterodyne-simulator was designed for classroom use. The device was successfully tested by a partner school network of the HdA. This gadget can be accomplished by an Infrared Kit showing how infrared astronomy works in unrevealing the invisible universe.

Keywords

Hands-on activities, infrared astronomy, inter-institutional collaboration, web-based learning.

1. Introduction

Would the second law of Keplers laws of planetary motion be more understandable to the pupils if Johannes Kepler himself would stand in front of the pupils explaining his theories? What about Erwin Schroedinger himself talking about his cat in order to boost quantum mechanics popularity in schools? No one knows the answer of these hypothetical questions, but one thing is clear: After the appearance of Stephen Hawking in TV series like Star Trek or The Big Bang Theory the attraction of science on the learners rises what becomes noticeable by the numbers of questions about Stephen Hawking a teacher gets confronted with. Also the transmission of experiments run on the ISS by Chris Hadfield and others into the classroom changes the attitude of former non-physicists into physics-enthusiasts [1]. At least one result can be extracted from this kind of broadcasted science: The interest in science could be enhanced by bringing celebrated men or frontend science and its researches themselves in touch with the young ones.

In this paper we describe how the HdA manages to bring researchers, teachers and pupils together in order to transport astronomy research into schools. In Sec. 2 we describe the role of the HdA in the interplay of Universities, Institutes and the partner school network to achieve the desired aim. As an example of the fruitful collaboration between scientists and teachers the wide ranging education and public outreach project SOFIA is presented in Sec. 3. Herein we demonstrate how educators can interact with researchers in order to make frontline astronomy, in the form of an infrared detector, suitable for classrooms. Further on the role of pupils in this process is discussed as well as the role of the internet. Additional material in form of a collection of hands-on experiments for pupils concerning infrared astronomy provided by the HdA is introduced at the end of this section. Conclusions are drawn in Sec. 4.

2. The HdA and its connections

The Christoph-Probst-Gymnasium, the workplace of one of the authors, benefits from the proximity to Munich and the two excellent universities there, the ESO headquarter in Garching, lots of museums etc. For a teacher of natural sciences this exhibits an almost non-finite source of inspiration, keeps the knowledge on the pulse of scientific breakthroughs and offers the opportunity to bring pupils and researchers together without circumstances. It's therefore an easy thing to motivate pupils for science or to bring them to extracurricular places of learning.

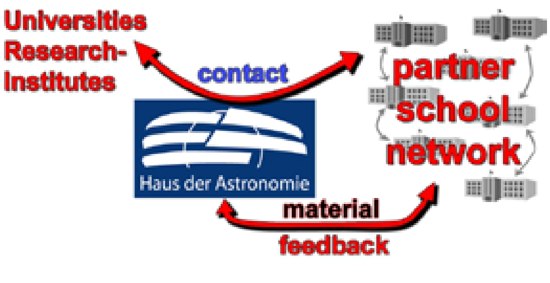

Figure 1. *Interplay between the HdA, partner school network and universities*

The challenge for teachers without such kind of privileged location is to organize this kind of get-together or to get into contact with frontend research. At this point the HdA comes into play (see Fig. 1). The HdA is a unique center for astronomy education and outreach in Germany. One mission is to foster the exchange of knowledge between scientists and to communicate the results of astronomical research in the media and to the public, especially to teachers of different kind of schools. The HdA benefits from the proximity to the Max-Planck Institute for Astronomy as neighbor and the Center for Astronomy of the Heidelberg University, the largest university astronomy group within Germany. But also regular contacts with researchers and educators of universities all over Europe, USA, Chile and South-Africa are established. With this background teaching materials dealing with different subjects of frontend science were created and provided for the usage in schools. These materials cover the exploration of Mars, latest results concerning the origin and evolution of the Milky Way in collaboration with a Special Research Program at Heidelberg University, or Infrared Astronomy with the airborne observatory SOFIA in consultation with the Deutsches SOFIA Institut (DSI) at Stuttgart University which is a main aspect later on.

The education material is tested and evaluated in workshops with pupils of different ages at the HdA and distributed to members of the network of partner schools of the HdA. The network is a collaboration of 36 schools distributed all over Germany that are interested in natural sciences especially astronomy. Besides field testing of HdA material, the schools themselves develop teaching units for different astronomical research areas and distribute them on the network. One of their most important tasks is to make the material fit into the curriculum of the different school types and to serve all ages. Therefore the network acts as an optimizer for the distributed teaching material.

Some of the partner schools are clustered in subunits because of their interests in the same topic. More than ten members for example took part in the Pan-STARRS Asteroid Search Campaign in spring 2013 coached by Carolin Liefke of the HdA. Four partner schools concentrate on spectroscopy in theory and practice with auspicious preliminary results in analyzing scientific data obtained by one of the most sophisticated far infrared detector to date that will be described in more detail later on. Even the fledgling discipline Astrobiology is covered by some colleagues performing and recording experiments with water bears and distribute the movies to the network. Some groups join in a special webpage for their subject but all members of the network are in close contact via email and meet at least once a year at the HdA for a teacher training, workshop and an exchange of experience.

3. The flying education platform SOFIA

A very intense and long-standing collaboration between the partner schools and the DSI was established by Cecilia Scorza. The project SOFIA (Stratospheric Observatory for Infrared Astronomy) is a predestinated one for bringing astronomy research into the schools. The airborne observatory SOFIA (see Fig. 2) is a German-American joint project run by the German Aerospace Center (DLR) and NASA.

Figure 2. *The airborne observatory SOFIA on a test flight ©DSI*

It's a Boeing 747 SP airplane with a 2.5 m telescope on board that observes the universe in infrared light through a hole in the fuselage as big as a barn door [2]. The cruising altitude with more than 13 km is higher than that of normal airplanes in order to escape the terrestrial water vapor that absorbs nearly all light in the mid- and far-infrared. Airborne infrared astronomy has a long tradition at NASA. The predecessor of SOFIA the Kuiper Airborne Observatory (KAO) was in service from 1974 until 1995 and helped discovering for example the rings of Uranus in 1977 [3] using an 91 cm telescope. Besides research at the edge of the stratosphere KAO was intensively used for astronomy education and public outreach [4]. Not only because there was enough space on board of the airplane to take teacher or journalists up in the air, but for giving the educators the unique possibility to be literally at the frontline of modern astronomy. The success of this FOSTER (Flight Opportunities for Science Teacher EnRichment) teacher project was enormous and had a deep long-lasting impact not only on the teachers that carry their insights and experiences into the classrooms but also on the pupils that got first-hand information and motivation from their teacher back from the stratosphere. The idea to utilize educators as disseminators to bring modern astronomy into schools continues in the AAA (Airborne Astronomy Ambassadors) program where American and German teachers get the chance for a ride at the edge of the stratosphere.

3.1 From the stratosphere into the classroom

3.1.1 Frontline research at its best…

In order to profit from this flight as much as possible it's necessary to understand at least the basics of the research objectives as well as the instruments and detectors on board. Here again the HdA acts as a helping hand for the German AAA-Teachers by providing astronomical background knowledge and by establishing contact with scientists that are responsible for the instrumentation on SO-

FIA and with observers using SOFIA. Two of the authors had the chance to fly on board of SOFIA in July 2011. The preparation for this flight leads to the construction of a small circuit board for classroom usage that simulates on of the infrared detectors flying on SOFIA. This would have been impossible without the assistance of the HdA and the fruitful collaboration between scientists and educators. This project is described in the following.

The simulated device is the German Receiver for Astronomy at Terahertz Frequencies (GREAT, see Fig. 3) which was developed by a collaboration of various research institutes in Germany under the principal investigator Rolf Güsten at the Max-Planck Institute for Radioastronomy in Bonn [5].

***Figure 3**. The detector GREAT and the telescope counterweight at the aft of the telescope while filling up with liquid nitrogen.*

It's a high resolution spectrometer working in the frequency range between one to five Terahertz and is designed for studies of interstellar gas and the stellar life cycle, from a protostar's early embryonic phase when still embedded in its parental cloud, to an evolved star's death when the stellar envelope is ejected back into space. The high frequency and extremely detailed spectral resolution of l/Dl=106-107 in order to have a high resolution in velocity regarding to the Doppler-effect requires enormous technical effort. The transport of the THz-signal coming from the telescope is extremely inefficient when using coax cable or waveguides. Additionally the size of the spectrometer would have to be huge in order to provide the required resolution. The solution of both challenges is the transformation of the THz-signal to lower frequencies i.e. into the GHz-band by using the heterodyne principle. In this process the THz-signal coming from the telescope (RF) is mixed with an artificially created signal (LO) of constant frequency produced by a local oscillator. Due to the mixing process mediated by an electronic component the resulting signal (IF) consists not only of the harmonics of the original RF- and LO-signal but also of the sum (RF+LO) and difference (RF-LO) of both. Using special filters the difference-signal is extracted and can be analyzed with familiar methods of GHz-technology.

3.1.2 …transformed for pupils intellect

The educator is used to break down complicated correlations in science to a level to where pupils can follow. One way of doing this is to transform the invisible and unfamiliar phenomenon analyzed by GREAT into the well-known world of the pupils. This means using audible high frequency sound of some ten KHz instead of light of some THz. Additionally we used gadgets children are familiar with like MP3-Players as generators for RF- and LO-frequencies instead of equipment found only in high-tech laboratories.

3.1.3 The signals

Instead of real astronomical signals high frequency sound is used that is modeled by the free software "audacity" and stored as WAV-files to the memory of the MP3-players. The LO-signal generator plays a single sinus-wave with a definite frequency whereas the signal of RF can be whatever wanted: a single sinus-wave or a triad or even a melody is possible. Besides creating audio-files audacity can also analyze audio signals. If the IF-signal is brought to the computer by the earphone jack the waveform of the signal can me made visible. Also a frequency analysis due to a fast Fourier transformation can be done.

3.1.4 The mixer

The easiest way of bringing RF and LO together is by soldering the wires of both signal-generators together or using an ohmic resistor as mixer. As a result the electronic circuit looks very trivial. The only difficulty is not to feed the LO-MP3-player with the RF-signal and vice versa. This challenge is solved by using resistors at the input of the MP3-players. This kind of mixer is called linear mixer because the applied voltage of both signal generators is linearly transformed into electric current because the characteristic of the ohmic resistor is a linear one.

The more sophisticated mixer is one that uses a diode as mixer (see Fig. 4). This so called nonlinear mixer transforms the applied voltage from the signal generators in a more complex way, depending on the characteristic of the diode. In the case described in the following a Shottky-diode was used.

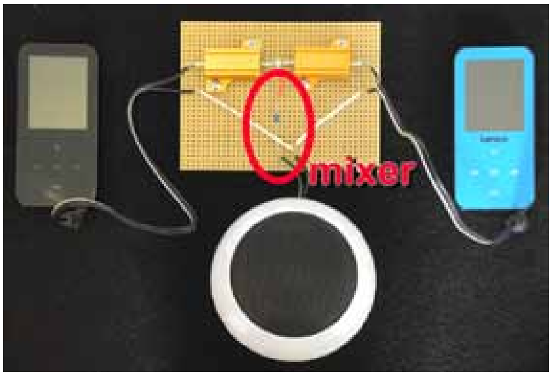

Figure 4. *The circuit board with the mixer-diode, two resistors to protect the MP3-players that act as signal generators and the active speaker for making the mixed signal audibile.*

3.1.5 Experiments

The first experiments were done using the linear mixer in order to create a beat. Although it sounds like the creation of an additional frequency, the beat consists only of the two original frequencies. This can be revealed by using two nearby frequencies for RF and LO like RF = 500 Hz and LO = 440 Hz. The mixed signal can be made audible by a simple active loudspeaker or be analyzed by the audacity software (see Fig. 5). The frequency analysis clearly depicts the existence of only two frequencies. Mathematically spoken the argument of the RF sinus-function doesn't interact with the LO sinus-function. It is therefore not possible to create new frequencies using the linear mixer what means that it is not recommended for the use in GREAT.

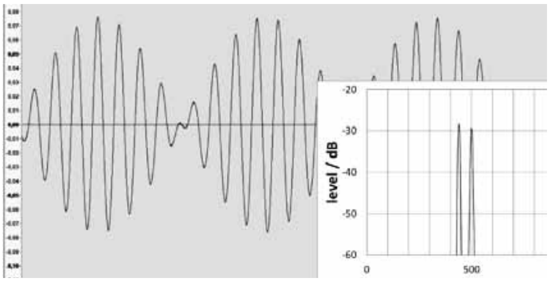

Figure 5. *The waveform of the beat and the corresponding frequency analysis.*

Interdependencies between the arguments of both sinus-signals are expected when using a nonlinear mixer. Assuming that the characteristic of the diode-mixer can be roughly approximated as a quadratic function nearly flat near the apex and steeply rising beyond a certain voltage the resulting electric current is the square of the sum of both signals. Using trigonometric identities it can be shown that this yields to the creation of harmonics of the original signals and to tones with the sum and difference of the RF- and LO-frequency. In order to examine the real behavior of a Shottky-diode-mixer the two MP3-Players were fed with frequencies that differ only by some hundred Hertz. In the test case RF = 3800 Hz and LO = 3300 Hz. It's then easy to hear the difference signal as a deep humming noise of one of the IF-signals at 500 Hz. This fact can be proven by looking at the waveform of the IF-signal that clearly doesn't show the slope of a beat as well as a look at the frequency analysis (see Fig. 6). Besides the original signals also its harmonics as well as the sum at 7100 Hz and the difference frequency at 500 Hz can be revealed. Using a low-pass filter to cut off the high frequencies the remaining low frequency signal can be processed further on.

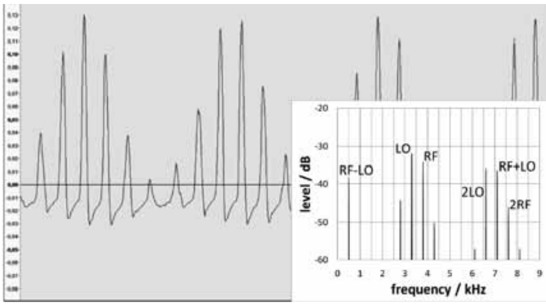

Figure 6. *The waveform of the diode-mixed signal and the corresponding frequency analysis.*

It has been shown that this small cheap clearly arranged and easy understandable circuit board is able to simulate the operating mode namely the heterodyne principle of one of the most sophisticated infrared detectors used in astronomy research. It's now up to the pupils' creativity to generate signals for the MP3-Players.

3.1.6 Signal pool

It's necessary for the pupils to train and to repeat the experiments to consolidate their newly acquired knowledge. It would be most suitable if the learners themselves create new variations of signals they can alter with the heterodyne simulator. The more examples they produce the better. Therefore the idea behind this tool as well as the construction guidance has to be published on the internet in order to distribute it as widely as possible [6]. To do so we used a special website called Wissenschaft in die Schulen (WIS) that is specialized in publishing educational material for teachers as well as for learners concerning natural sciences (see Fig. 7). WIS is an offshoot of the German astronomical magazine "Sterne und Weltraum" published by the editors of the German edition of Scientific American and intends to deconstruct the science objectives in the issued magazine for the usage in the classroom. Another possibility for the distribution as well as for the testing of the gadget is the network of partner schools that gives feedback in the shortest possible time. So the launch of this heterodyne simulator already begins with a sample of rudimentary signals generated for the first experiments also published in WIS. It is planned to build up a signal-library on the internet in which the pupils themselves distribute their created signals and get into contact with each other.

Figure 7. *The WIS-website: www.wissenschaft-schulen.de*

3.1.7 Collection of infrared experiments

Besides this very special tool described above a couple of hands-on experiments covering the whole range of infrared astronomy that activate all human senses is arranged by the HdA namely C. Scorza and O. Fischer [7]. Beginning with experiments with ordinary webcams as sensors for near infrared light, continuing with simulating the working principles of an astronomical infrared imager by observing a model of the bok globule B67 up to experiments with advanced thermal imagine cameras in order to investigate the physics in the mid infrared. This Infrared Kit (see Fig. 8) is particularly developed for the usage in schools and includes extensive educational material. This Kit was intensively tested and is intensively used by the network of partner schools.

Figure 8. *The Infrared Kit with Hands-on experiments dealing with infrared astronomy.*

4. Conclusion and Outlook

In this paper we describe how to bring astronomy frontline research into schools and what roles different institutions and individuals have to take over in order to get the desired results. It's an absolutely pro to have an institution like the HdA as an organizer or agent sitting in between the universities or research institutes and the schools or teachers. It's easier for the educators because they don't have to spend one of their most limited resources namely time in looking for the right partner for their interest. For the institutions to raise the interest of pupils for their kind of research objectives it's ideal to have an information source to ascertain which school shares the same interests and has already done similar things before. If the schools are organized in a network with intense contact and feedback channels in between the outcome of the collaboration between researchers and teachers could be optimized. Arising problems could be solved easier because of the broad experience of the network and quicker because the burden could be shared across several partners. Generalizing the outcome for pupils of different ages or of different school types is simplified because the network consists of educators teaching pupils of different ages in schools of different types. With this support it is possible to make frontline research like the heterodyne spectrometer GREAT described above comprehensible. It has been shown that this device could be decomposed into a DIY-instrument that fits in your pocket and helps understanding one of the most sophisticated infrared detectors to date. Another example mentioned is the collection of hands-on infrared experiments put together in the Infrared Kit.

The internet is the main distribution medium to make the developed education material accessible to every teacher and pupil who is interested. It is the only way to publish interactive material that improves and accumulates examples with time. It should therefore be used as a forum to exchange contributions, ideas and experience more than as a simple download area.

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Utilising the Bulgarian National Observatory Spectral Repository in Astronomy Education for Schools and Amateur Clubs

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Abstract

This paper reports on the creation of a unique online astronomical resource called 'SpecRec'©. The Rozhen repository in the Bulgarian National Observatory currently holds more than a thousand spectral plates both physically and as digital previews. Additionally there are more than seven thousand recorded spectral observations. SpecRec, designed to be free to browse and download, so it can be used educationally for several purposes. It offers opportunities for students and amateur astronomers to study real observational data and practices as a model for their own emerging practice. Those who wish to work at a more advanced level will also be able to acquire and process the samples of raw observational data themselves. Furthermore, the online resource will hold a selection of existing professional astronomical analyses, primarily in the form of a collection of articles published in international journals, predominantly in English. This offers the astronomy student the opportunity to compare their own findings, and learn by example how to publish their own observational results. The importance of open access astronomical educational resources is discussed.

Keywords

Education, Spectral Repository, Astronomy, Open Access, Internet

1. Introduction

Forty years ago, the Bulgarian Academy of Sciences (BAS) took the initiative to build a National Astronomical Observatory (NAO) for Bulgaria [1]. One of the main priorities driving this decision next to increasing knowledge about the universe has been to provide better education concerning astronomy. This has been the most expensive investment for Bulgarian Academy of Sciences and the National Observatory still houses the most expensive equipment that the BAS possesses. Given the price of utilizing the equipment, to date, only professional astronomers have been allowed to use it. Globally, there is a movement towards increasing access to observation facilities and equipment for broader audiences. A key problem is that newcomers to astronomy do not necessarily have experience in processing the results they are gathering during their spectral observations. In this paper, we describe the opportunities now evolving for these wider groups to study real observational practices by following the example of professionals so they can learn how to process their own observational results. The tools for processing the results are already publically available from the major European observatories for free, such as the European Southern Observatory (ESO), which offers a comprehensive software package. For example, Scisoft is a collection of publically available astronomical software utilities which includes spectral processing [2]. By introducing 'SpecRec'©, we aim to provide observational results and raw observational data from the spectral repository of the Bulgarian National Observatory. The objective is to allow students and amateurs to have the opportunity to analyse the results themselves, making comparisons between theirs and existing published professional analyses.

2. Background

When the National Astronomical Observatory was designed, the way in which astronomical observations were to be collated in archives was planned from the outset. Spectral observations metadata were originally recorded manually, in the format shown in Figure 1. On the top, the spectral plate itself is shown. It is stored in an envelope, shown below. On the envelope, details are provided of the camera which was used to take the observation and the object observed. More detailed information fields was written using a manual typewriter alongside handwritten notes; these are folded and stored in the envelope with the plate. All this data are sufficient for the observation to be processed.

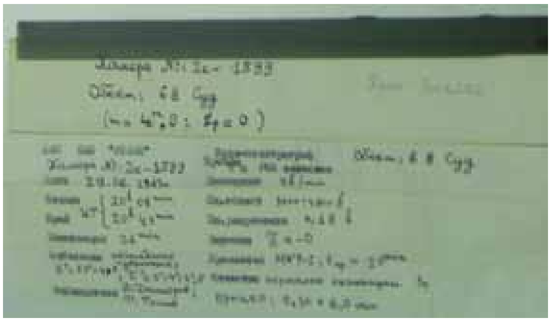

Figure 1. *Envelope with spectral plate*

This was common tradition at all European observatories storing spectral archives at this time, for example, the German observatory Leibniz Institute for Astrophysics, Potsdam and the French observatory of Bordeaux. In Bulgaria, in the beginning of the '90's, a plain text file was created by Ina Barsova in which every row contains the number of the plate, object observed and when it was observed and by whom (Figure 2). Further atmospheric conditions (seeing), camera setup and emulation type are presented. This represented one of the first attempts to computerise the archive and store the estimate of the quality of the spectra obtained. After the introduction of the CCD (charge-couple device), all data has been stored electronically on CDs. However, largely, this digital data has remained inaccessible to the public and has only been available to professional astronomers.

1493	58050	HR2017	IIaO	60	08/09041983	2	1	
1502	58050	HR2017	IIaO	60	09/10041983	2	1	
1507	109387	KAPPA Dra	IIaO	8	10/11041983	2	8	
1508	87901	ALPHA Leo	103aF	5	10/11041983	2	-	unusable
1509	164284	66 Oph	IIaO	15	25/26041983	2	28	

Figure 2: *A simple coding of observational history*

A selection of repositories of scanned plates already exists in Strasbourg library. For the last decade, one of the largest astronomical archives in the world is also being digitized (Vatican Observatory) [3]. Furthermore, there has been considerable interest in placing digitized spectral data online in Virtual Observatories [4]. To a large extent, this is driven by the perceived need for a standardized public access repository or spectral archives rather than the current situation in which groups of astronomers work independently on different datasets [5]. Although to date public access (where available) has tended to focus to deliver benefits for the academic sphere. This possibility of standardisation is increased by the creation of an open format suitable for metadata for all kinds of library archives, such as Dublin Core [6]. This already has been implemented, for example, by the National Academic Library and Information System, Bulgaria. The main idea is to utilize the existing software which supports the Library of the Institute of Astronomy and add the plates and all other observations as items.

Currently, in Bulgaria, all of the spectral data CDs and glass plates are organized and well preserved within the Library of the NAO. However, they are remotely located in the mountains, where there is no high speed internet connection, practically placing restrictions on their use. Furthermore, photographic spectral plates are not digitalized. For this reason, a digital repository of spectral observations is required for Bulgaria, drawing on the expertise developed in Europe in existing repository and archive design.

3. SpecRec

SpecRec is a continuation of a project begun by one of the paper's authors (PG) in 1993 called 'Educational programmes for the IBM PC'. This programme was able to evaluate the knowledge of students. When the Astronomical Association of Sofia was created in 1994, one of the main goals of its creation was to boost the education in astronomy across all age groups by providing access to informational resources. This prompted the creation of the SpecRec on the grounds of not only providing information, but assurance of the quality and value of this knowledge in the astronomical sphere. The Astronomical Association, Sofia, publishes a weekly newspaper 'Telescope' targeted at amateur and student astronomers who have their own equipment. It is only recently, due to cost reasons, that an acceptable quality spectroscope is likely to be within the reach of this community; hence the need for an open access spectral repository resource for this community.

The novel idea in SpecRec is that both the raw data and the scientific publications analysed by professionals are to be provided together in a linked format. The benefit of this is for astronomers (students, amateurs or professionals) who wish to choose and process data, or to observe the objects themselves, and build further on existing research. Additionally, selected educational resources are linked with all raw data. This could be used to teach the laws of physics underlying what we observe through a spectroscope. The comprehensive nature makes SpecRec a highly effective tool which allows both teachers and students to find with ease educational material together with the raw original data for them to analyse themselves. The presence of existing research also allows educators and students to see what has been of interest within the academic and professional world to date in relation to that particular data.

As such, SpecRec is envisioned as a powerful collection of resources within an open access approach to astronomical education. In the open internet environment, we observe an abundance of datasets observed by professional and amateur astronomers. One problem with this is assessing the quality of the data; it is important that students and amateurs have access to the higher quality data-sets for ease of analysis. There is an abundance of data but there is no guarantee of producing a high quality analysis by picking a data-set at random. SpecRec addresses this issue by preselecting a set of spectral observations which have already been used to create academic publications, using peer review publication as a quality control measure. Furthermore, it also demonstrates the entire process of observation and analysis, by providing raw data linked with the resulting publications.

4. Current State

The total photographic spectral archive consists of about 7000 observations; however, a selection has been made of about 1000 which is sufficient for educational purposes. Currently, the photo data available is in a preview format. This means that if anyone wants to obtain and analyse the data, they have to request it through e-mail or the website to receive a scan of original plate.

It is particularly important to note that the format chosen has been based on the Dublin Core Metadata Initiative which seeks to standardize metadata formats and descriptive vocabularies for the purpose of long-term maintenance and management across different spheres [6]. This will ensure that SpecRec can be accessed by existing information systems and made compatible with other repositories.

Another feature of SpecRec is the possibility for users (if they consent) to mark which spectral archives are of interest to them; thus opening up the possibility of sub-groups and communities all working on one particular data-set.

5. Future Work

One key part of the overall project is to scan the preselected photographic plates and produce data-sets. For this purpose, a new device is being built which will automate the process. This will increase the speed of processing through automation. It is hoped this tool will be used more extensively by other repositories for the same purpose. When it is ready we would like to gain valuable feedback from teachers/educators and amateur clubs.

Another feature could be an internet forum in which professional astronomers give advice to students and amateurs on how to analyse their data and overcome problems when doing so. The hope is that by providing an internet meeting-place, greater facilitation between educators, students, amateurs and professionals can occur.

6. Acknowledgements

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Using Geogebra to teach analemma

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Abstract

Solar analemma is one of the most elegant celestial observations for a primitive observer. However, the shape and size of the analemma also teaches us a lot about parameters of the Earth's motion around the Sun. I present a small "Geogebra" applet which is used to teach analemma to Astronomy Olympiad participants.

This applet assumes that equation of time (EoT) is just sum of two sine functions. The applet allows users to vary various input parameters and see their effect on the shape of the analemma or on the EoT curve. More such applets can be built using intrinsic capabilities of Geogebra and can be used to teach difficult concepts in Astronomy.

Keywords

Analemma, Geogebra, Use of ICT.

1. Introduction

Since the birth of human civilisation, people have looked at the sky and wondered about motion of celestial bodies. First we probably noticed passage of all the bodies from east to west then we noticed exact paths of the Sun and the Moon. Neolithic groups started aligning mammoth rocks to track motion of the Sun and then they started noticing more subtle effects like north-south movement of the sunrise / sunset point and different lengths of the day during summer and winter.

Celestial coordinate systems developed in ancient Greece account for all these motions. However, there are other smaller effects, which probably were noticed only after independent timekeeping devices such as sand-glasses. Analemma is one such curious effect.

Even in modern context, analemma is a phenomenon, which is simple to describe but difficult to explain. Simply put, if an Observer sets his / her wide angle camera at a fixed spot for an entire year and keep clicking image of the Sun at exactly same civil time with a gap of fixed number of days, he/she will notice the positions of the Sun trace a shape resembling Roman numeral '8'. This shape is famously known as Analemma of the Sun. Alternatively, Analemma can also be obtained by tracing tip of the shadow of a gnomon round the year at a fixed civil time every day.

Figure 1. *Analemma captured by astro-photographer Anthony Ayiomamtis from Athens, Greece [1]*

2. Understanding Analemma

Analemma of the Sun is caused by two peculiarities of the Earth’s motion. Firstly, as the Earth’s axis is tilted with respect to the normal to it’s orbital plane by about 23.5 degrees (e), the declination of the Sun keeps changing over the year. This primarily results in vertical displacement of the Sun in the analemma. The elliptic orbit of the Earth means that the Earth's orbital speed keeps changing at every point with it being fastest at the perihelion and slowest at the aphelion. This primarily accounts for width of the analemma.

Exact shape size and inclination of the analemma will thus depend on a number of parameters involved directly or indirectly in individual phenomena above and the way they get coupled to produce final “Equation of Time” (EoT). To get correct shape of analemma, one needs to specify inclination of the Earth's axis (e), eccentricity of the Earth's orbit (e), ecliptic longitude of the perihelion (lp) and day number of the vernal equinox (Ng) as the global parameters and latitude of the observer and hour angle of the Sun as the observer specific parameters. For example, in Fig. 1, the left analemma is captured at local noon and the right one is captured for the same location at early evening.

The EoT as shown in Fig. 2 (black line) tells us how much earlier or later as compared to the “expected time of local noon” (i.e. culmination of the mean Sun) the Sun would culminate on any given day. It is an asymmetric curve and it is responsible for width of the analemma.

It is not possible to analytically obtain exact EoT curve. Usually values for EoT are computed numerically for each day and the curve is plotted using these values. Alternatively, approximate analytical solutions can be obtained for very small eccentricities and EoT is plotted using this approximate solution.

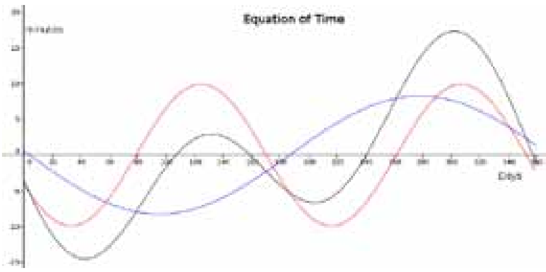

Figure 2. *Equation of time (black line) and individual contributions by ellipticity (blue line) and inclination (red line)*

One of the possible ways of approximating the EoT is to view EoT as summation of two independent sine curves. Fig. 2 shows these two sine curves. The red line is resulting from inclination of the earth’s axis and the blue line is resulting from elliptic orbit of the earth.

3. Analemma using Geogebra

3.1 Geogebra

Geogebra [2] is an open-source software developed by M. Hohenwarter from J. Kepler University, Linz, Austria and his team. It is available for different OS platforms including Linux, Mac and Windows. In very few years, it has become preferred tool of educators worldwide. In the Wikipedia [3] pages, Geogebra is the primary tool for drawing mathematical figures and graphs. It is available in more than 50 languages worldwide and there active online community of users who provide support for new members.

3.2 Two sine curve approximation

One can derive expressions for both the sine curves by mere examination of their shapes as seen in Fig. 2. For example, if one takes red curve, it is evident that it has a period of exactly half a year, it’s zero phase point coincides with the equinox dates and its amplitude is about 10 minutes. For the blue curve, the period is one year, phase zero corresponds to aphelion point (July 2) and its amplitude is about 8.25 minutes. Using this information, we construct the two curves as follows:

$$E_1=\left(\frac{\omega\left(\tan^{-1}(\cos(\epsilon))-\pi/4\right)}{2\pi}\right)\sin\left(\frac{4\pi(N_\gamma-N)}{P}\right)...(1)$$

$$E_2=\left(\frac{\omega\left(\pi/2-e-\cos^{-1}(-e)\right)}{2\pi}\right)\sin\left(\frac{2\pi(N-N_{\lambda_\gamma})}{P}\right)...(2)$$

Here P is number of days in a year, w is number of minutes in a day, N is number of days since start of the year, Nlp is day number of perihelion point and Ng is the day number of the Vernal Equinox point. The EoT is then obtained simply by adding E1 and E2.

3.3 Insertion into Geogebra

These equations can directly go as input functions in Geogebra. It can then show final EoT graph. One can change value of these parameters by hand and see how shape of EoT curve varies.

One can also convert the information about declination and EoT to angular coordinates on the surface of sphere to plot position of the sun in the sky. One can obtain declination by

$$\delta(N)=\sin^{-1}\left(\sin\epsilon\sin\left(\frac{2\pi(N-N_\gamma)}{P}\right)\right)...(3)$$

Using this, we can define coordinates of the Sun as

$$\left(\frac{(H+E)}{15}\cos(\delta(N)-\phi),(\delta(N)-\phi)\right)...(4)$$

Here f is latitude, E is EoT in hours and H is hour angle. One can then vary N and get position of the Sun on different days.

All this mathematics can also be done using a calculator or a spreadsheet. However, the applet designed tries to take a generalised approach. This is the true strength of Geogebra. Instead of fixing some value for each of the input parameters, all parameters (P, w, N, Nlp, Ng, f and H) are introduced as sliders on top right of the panel. This helps user to change any one parameter or a combination of these interactively and see its effect on EoT in an animated manner. Similarly, Geogebra has an inbuilt feature to let any parameter on slider span its entire domain as an animation and show output. Thus, if we fix other parameters and set animation of N, we can see the point (Sun) tracing the shape of analemma directly.

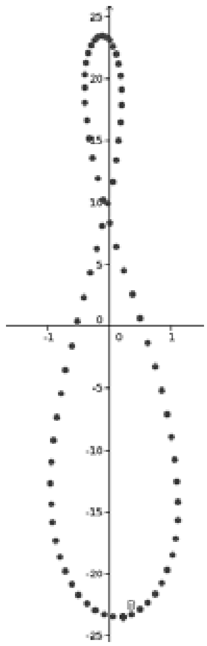

***Figure 3**. Analemma generated by the Geogebra applet, with H=0, f =0 and other parameters similar to the Earth.*

3.4 Validity of the approximation

The approximation used is valid for sufficiently wide range of input parameters. Obviously, it will break down for very high eccentricities. Also crude conversion of EoT to plane of the sky starts distorting the shape at sufficiently high hour angle.

For an Earth like scenario, error in EoT as compared to the accurate numerical solutions is less than 15 seconds on all days. In percentage terms, it amounts to less than 4% on all days except when EoT values are close to zero (i.e. the mean Sun nearly matches with the true Sun)

4. Introducing the applet to the students

The topic of Analemma has covered regularly in the training programme of Indian National Astronomy Olympiad. It was typically introduced through equations and explanations. Most common feedback received from the students in all these years was that this particular topic was difficult to visualise and many were not able to grasp the concept clearly. The Geogebra applet was first created in 2012 and has been used in last 2 training camps. This applet was demonstrated after initial introduction of the concept of analemma. We found that student interest in understanding the principle behind analemma increased drastically once they were able to visualise the EoT and analemma through this applet. They were able to answer questions about analemma with different parameters with more ease.

The domain of parameters included in this applet allows us to tweak them to get different shapes of analemma like “teardrop analemma” (as would be the case on the Mars). Going back and forth between analemma locus and EoT curve allows students to see for themselves exactly which changes in the shape of EoT curve would result in fundamental change in the shape of analemma. After some trial and error, students start predicting the shape of analemma for a given set of parameters and they feel immensely happy when their predictions are correctly fulfilled.

After the experience of these two camps, author has uploaded this applet [4] on the internet and hopes that more students will benefit from using the applet.

5. Outlook

Author hopes to create more such applets for astronomy specific situations like orbital motion, precession of stars, Ptolemic model of the Universe etc.

6. Acknowledgements

Author acknowledges HBCSE’s Olympiad-NIUS programme, which helped to carry out this work.

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"Sun4all" – Scientific tool for classroom to help to discover the cosmos

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Abstract

The project "Sun for All" originally funded by "Ciência Viva" in 2005, has as its main objective the promotion of Astronomy in different levels of education. It focuses on the exploration of the properties of the Sun using the spoils of spectroheliograms of the Astronomical Observatory of the University of Coimbra (which includes more than 30000 observations collected sine 1926) and the electronic infrastructures – as Salsa J. The project "Sun for All" allows students from all over the world to work with real solar images and accomplish scientific results. Teachers and students are asked to apply activities in the classroom or make their own and share on "Discover The Cosmos" webpage. These activities require the interaction of students with the solar database, available at the Observatory of Coimbra's website. In this paper we present the project and describe its recent developments.

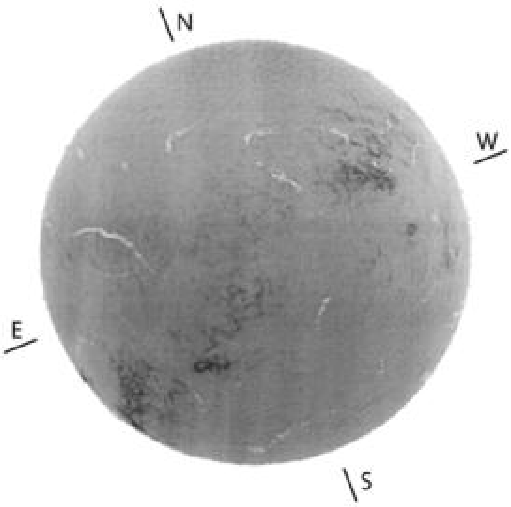
Keywords

Astronomy , Sun, spectroheliograms, Observatory, University of Coimbra, electronic infrastructures.

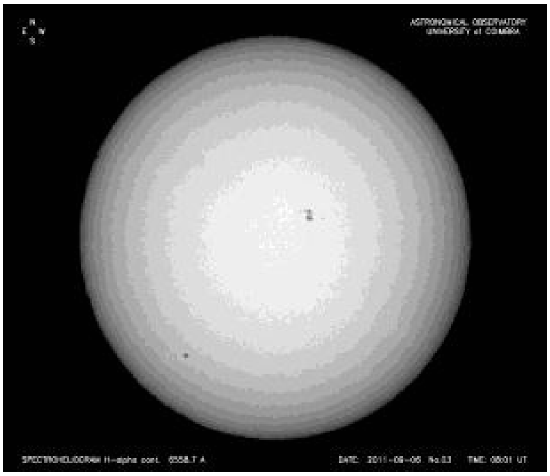
1. Introduction

The project "Sun for All" (hereafter Sun4all - www.mat.uc.pt/sun4all) was started in 2005 at the Astronomical Observatory of the University of Coimbra, hereafter Observatory, funded by the "Agência Nacional Ciência Viva" (ref. 2005 117/18). The aim is to promote Science in general and Astronomy in particular, in schools. The collaborative work between the scientific community, teachers and students allows exploring the different scientific resources in the classroom: research tools, scientific software, simulations, visualization and databases. The educational activities, enriched using these tools, may promote the scientific method in school, motivating students for a career in science.

The basis of this project is the collection of over 30000 images of the Sun (spectroheliograms) existing at the Observatory as a result of work of astronomers during more than 80 years. The daily solar observations began in 1926 [1], figure 1.



a)



b)

Figure 1: *Spectroheliograms from the Astronomical Observatory of the University of Coimbra, a) photographic (06/09/2001; b) CCD camera (06/09/2011).*

The images between 1926 and 2007 (acquired using the traditional photographic methodology) were digitized and they will be soon at the new website from the Astronomical Observatory of the University of Coimbra. Images since 2008 (acquired using a CCD camera [2]) are daily uploaded in a web database under a collaboration between the Observatory and the Observatory of Meudon - Paris: http://bass2000.obspm.fr/home.php .

As said above Sun4all was born in Portugal and had his first phase of dissemination and implementation during the period 2005 - 2011, mostly in primary and secondary schools in Portugal.

Since 2007/2008 Sun4all is included in the EU-Hands on Universe (http://www.euhou.net/). On the other hand Sun4all appear on the report "Europlanet Best Practice Guide. Outreach Activities Aimed at Schools and Teachers" [3].

In 2012 Sun4all start a second phase of development. Firtly Sun4all joined the FP7 project "Discover The Cosmos" (http://www.discoverthecosmos.eu/), which has as its main objective the promotion of Astronomy in different levels of education and achievement and sharing lesson plans from teachers. Also during 2012 Sun4all received again financial support from "Ciência Viva" by means of the initiative "Escolher Ciência" (Choose Science - (http://www.cienciaviva.pt/escolherciencia/), devoted no national high schools. We, so, create the "Sun is really for all". Very recently Sun4all was contacted in order to collaborate with the FP7 project "Socientize" (http://www.socientize.eu/), devoted to the citizen science.

2. "Sun for all" – The beginning

In the beginning of this project the idea was to get available the scientific data in digital format via web and to propose a set of activities that enable the use of the solar images in order to introduce to the scientific method and research, having the Sun as a motivation. The particularly goals were:

• The promotion of Astronomy in different stages of education;

• Exploring the properties of the Sun using the spectroheliograms;

• Promoting (in schools) a set of activities, that can be used by different areas such as Mathematics, Physics, Biology and Informatics;

• Participation in a global effort to count the sunspots in all set of images.

This project is divided here in nine activities and it´s organized and adapted to different disciplines and academic levels:

• Counting sunspots in all spectroheliograms;

• Determination of the radius of the earth, by the observation of the Sun;

• Counting sunspots in different days in order to check the variation;

• Cycle of 11 years (in sunspots and in other solar activity features: plages, filaments, etc.);

• Movie of solar rotation;

• Solar activity features versus climatic indices;

• Determination of the dimensions of a prominence;

• Determination of the period of solar rotation.

The activity of the sunspot count assumes a main role in this project as it has not been possible (until now) to count the sunspots for all spectroheliograms. We are convinced that the collaboration of students, teachers and the general public will be able to count sunspots ans, so, to contribute to the analysis of the entire collection (in a few years). The counting method is simple, explained in the Sun4all site, and each image (and counting) is "validated", only after being treated by different people. This count can be made "by-hand" or using the software open source Salsa J (http://www.euhou.net/index.php/salsaj-software-mainmenu-9), figure 2.

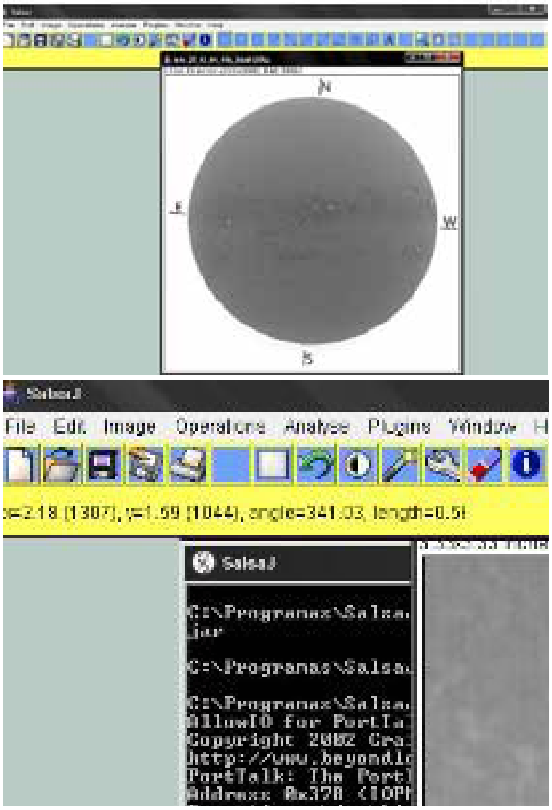


Figure 2: *Example of the sunspot counting activity using the software Salsa J.*

All the information about the activities (guidelines of the activities, documents to support its implementation, a forum for sharing ideas and the publication of results) can be found at the Sun4all webpage. On the other hand the project offers the possibility to help (in person or by video-conference) the activities implementation. In collaboration with the Mathematics Department of the University of Coimbra it also possible to share with schools the exhibition "The observation of the Sun", figure 3.

There is also a facebook that provides a possibility of immediate contact with those teachers and students that want to share ideas or obtain information: https://www.facebook.com/sol.paratodos.OAUC .

Figure 3: *Exibition "The observation of the Sun"*

Figura 4: *"Sun for all" on the portal Discover The Cosmos.*

During the first phase of the project reaches more than 500 students and 25 schools in Portugal (including Madeira e Azores islands) – see the webpage of the project and [4,5,6].

3. Discover The Cosmos – European Project

With the aim to reach more students and teachers (in particularly outside Portugal), the project Sun4all had the opportunity to be part of the european project "Discover The Cosmos", which has as main objective the promotion of Astronomy in different levels of education . This project aims to help teachers to create lesson plans on Astronomy, with the use of virtual tools that enables the research and the scientific method, according to the methodology of Inquiry Based Science Education (IBSE). Project "Discover The Cosmos" include 15 partners (of 8 European countries + USA) and aims the creation of a roadmap of educational activities (lesson plans) which contain all the necessary information (in different languages) to be able to be reproduced by teachers. This documentation will be a reference for stakeholders - educational research, teachers, students, educational decision makers, etc. The participation in this European project was an opportunity of Sun4all at the international level: http://portal.discoverthecosmos.eu/en/node/192573, figure 4.

On the other hand this association also contributed to greater dissemination and implementation of the project at national level, by the interaction with different schools. In this context we would like to point out a national competition involving students and teachers: "Mini Congresso Solar". This contest, organized in collaboration with NUCLIO (http://nuclio.org/), was based on the application, manipulation or reproduction of spectroheliograms obtained during April 2013, with goal to build an activity achievable in the classroom and presented in the form of lesson plan. Three applications were presented (the photos corresponds to the presentation made by the students in the Observatory, 9th June 2013):

- "Determinação do Período de Rotação Solar por análise digital de vídeo" (Solar period determination using a digital video) - Escola Secundária Adolfo Portela, Águeda, figure 5;
- "Animação de uma mancha solar" (Animation of sunspot) - Escola Secundária de Loulé, figure 6;
- "Pequenos/grandes divulgadores de Ciência" (Young science communicators) Escola Básica Infante D. Henrique – Repeses, Viseu, figure 7.

Figure 5: *Students from the Escola Secundária Adolfo Portela, Águeda, during the presentation of their work.*

Figure 6: *Students from the Escola Secundária de Loulé, during the presentation of their work.*

Figure 7: *Students from the Escola Básica Infante D. Henrique – Repeses, Viseu, during the presentation of their work.*

The involvement of teachers, students and families in this contest revealed the importance of these kinds of activities in order to put in contact schools scientific, community and the general public. The students were very enthusiastic and the presented works revealed a structure IBSE.

4. "O Sol é mesmo para todos" (The Sun is really for all) – the suite of Sun4all at national level

Motivated by these results, we create a new project "The Sun is really for all" that aims to continue the objective of Sun4all during the academic years 2012/2013 and 2013/2014, for high school students. This project is funded by "Ciência Viva" in framework of the national project "Choose Science". It is proposed to develop activities in Astronomy with focus directly on a group of teachers in order to increase the number of activities involved.

Moreover, this is a project that will allow a closer contact between Astronomy and teachers. We point out that, traditionally, teachers reveals difficulties in this area due to lack of scientific training. For this reason teachers are involved in the project's team. Consequently, schools are also involved. These teachers and their classes will receive in their schools a member of the research team of the Observatory. They also can bring the students to a visit to the Observatory. The visit includes the museology collection, the spectroheliograph, the Schmidt–Cassegrain telescope observations and the planetarium session (telescope and planetarium will be available at the end of 2013). The costs are undertaken by the project. On the other hand the teacher's members of the project team will promote the project to other colleagues in neighborhood schools, performing at least one of the proposed activities on the Sun4all website. The activities will be documented in small reports delivered by teachers. This project includes 14 high schools all over the country (figure 8) and 29 teachers. So we intend to work directly with about 700 students. Indirectly the project can reach over a thousand students.

The project has been in place since six months and has already been implemented in two schools. They received already the visit from the research team for a lectures (Figure 9 and 10) and an activity in the classroom with the Salsa J software (Figure11).

Overall, three schools have already visited the Observatory. The remaining schools have scheduled the visit for the first period of the school year 2013/2014 (September-December), figures 12-14.

Figure 8: *Location of the schools, partenrs of the project "O Sol é mesmo para Todos".*

Figure 9: *Lecture at the Escola Secundária de Olhão.*

Figura 10: Lecture at the Escola Secundária de Loulé

Figure 11: Activity with the software Salsa J at Escola Secundária de Olhão

Figure 12: Students of Colégio da Imaculada Conceição (Cernache – Coimbra) visiting the Observatory

Figure 13: Students of Escola Secundária da Gafanha da Nazaré visiting the Observatory

Figure 14: Students of Externato da Benedita (Caldas da Rainha) visiting the Observatory

5. Final words

In this paper we describe an on-going project named "Sun for all" that, since 2005, with different approches and methodologies (eg. partnership with projects and institutions) aims to promote science in general and Astronomy in particular, among students and schools. Since then the project has been implemeted in several national and international schools reaching more than 1000 students. This project (and its results) has been frequently present in national and international confereences. The monitorization of the project and its dissemination is constantly updated on the site Sun4all (www.mat.uc.pt/sun4all). All the information are also available on facebook Astronomical Observatory of the University of Coimbra (www.facebook.com/ObservatorioAstronomicoDaUniversidadeDeCoimbra).

6. Acknowledgements

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NASA Kepler Activities and Remote Astronomy Meeting Techniques

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Abstract

The Education and Public Outreach (EPO) team for the NASA Kepler Mission have developed several astronomy teaching resources that are available for free through the Kepler website (kepler.nasa.gov). We introduce an interactive (Kepler Transit Hunt), a demonstration (Orrery Model for the Transit Method of Planet Discovery), software for making a webcam or computer camera into a simple light sensor, galleries of graphics and movies, and classroom activities including "Transit Tracks" and "Human Orrery." In the extended mission for Kepler, funding permitting, we plan to create an online teacher workshop that would be useful for teachers interested in becoming familiar with and using Kepler EPO educational materials. In addition, we examine various options for remote professional learning communities (PLCs) of teachers and results from another NASA project: Lifelines for High School Climate Change Education. That project aimed at establishing PLCs of teachers and best methods of conducting meetings remotely and communicating with Internet-based tools.

Keywords

exoplanet, orrery, transit.

1. Introduction

The Kepler Mission is a NASA Discovery Program for detecting potentially life-supporting planets around other stars. Kepler uses the transit method of planet finding: detecting the minuscule drop in brightness of a star when a planet passes in front of it. To detect an Earth-size planet, the Kepler photometer must be able to sense a drop in brightness of only 1/100 of a percent. This is akin to sensing the drop in brightness of a car's headlight when a fruitfly moves in front of it! It employs a 0.95-meter diameter telescope with a field of view a bit over 10 degrees square (and area of sky the size of about two open hands). It continuously and simultaneously monitors brightnesses of over 100,000 stars brighter than 14th magnitude in the constellations Cygnus & Lyrae. Kepler was launched in March 2009 and has collected data through March of 2013.

The Education and Public Outreach (EPO) team for the NASA Kepler Mission have developed several astronomy teaching resources that are available for free through the Kepler website (kepler.nasa.gov).

2. Kepler Exoplanet Transit Hunt

In this web-based interactive exercise, the user picks stars from a simulated star field, records brightness data, makes measurements of planet orbital period (the horizontal spacing of drops in brightness) and do calculations to determine planet characteristics including size, distance from star (using Kepler's Third Law), and estimated temperature of the planet. [1] Visit kepler.nasa.gov/multimedia/Interactives/keplerFlashAdvDiscovery/

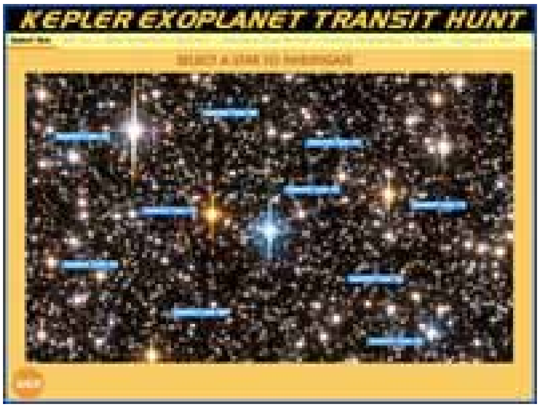

Figure 1. *Opening screen of the Kepler Exoplanet Transit Hunt shows a star field and invites the user to select a star to investigate.*

3. An Orrery Model for the Transit Method of Exoplanet Discovery

The Kepler Mission Education team has produced table top models demonstrating the principle of how Kepler finds extrasolar planets by the transit method. In general, such a demonstration model includes:

i. An orrery (model star-planet system with a light or white ball as a model star and one or more planets orbiting). The 1st orrery we created was one made of LEGO parts. Later, an orrery was created for one of the investigations in the middle school Planetary Science course from the Full Option Science System (FOSS). [2] That one is commercially available (Fig. 2).

ii. Light sensor (model Kepler photometer which can be a commercial light sensor such as those purchasable from companies such as Vernier and Pasco). We have also created free software to turn a webcam or your laptop camera into a "light sensor" as described in the next section.

iii. Computer interface (model Deep Space Network, connecting the light sensor with the computer)

iv. Computer graphic software (model Kepler Science Office, used to display data graphically for analysis)

This demonstration is especially effective for students not very experienced with graphs, since a real-time graph is generated before their eyes, directly connected with a real-time phenomenon (model planet transits) happening at the same time before their eyes.

Full description and instructions can be found at kepler.nasa.gov/education/ModelsandSimulations/LegoOrrery/.[3]

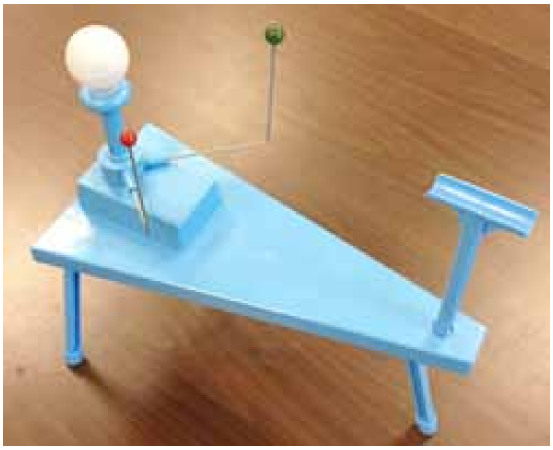

Figure 2. *Commercially available FOSS orrery.*

4. Light Grapher Software

LightGrapher is a Flash applet that turns your webcam or built-in computer camera into a makeshift light sensor to display graphically the brightness of a model star (a lightbulb or even light-colored ball). When a [darker-colored] planet passes in front of the star, the brightness drops and a dip in the graph occurs. The software receives real-time data from the external webcam or internal computer camera. It may be run either directly from this page or downloaded and run locally in your browser. LightGrapher is available free from the Kepler website:

kepler.nasa.gov/education/ModelsandSimulations/lightgrapher/ [4]

5. Classroom Activity: Transit Tracks

The Transit Tracks classroom activity has students

• understanding what a transit is and the conditions when a transit may be seen

• describing how a planet's size and distance from its star affects the behavior of transits

• interpreting graphs of brightness vs time to deduce information about planet-star systems.

On the Kepler website [5]

(http://kepler.nasa.gov/education/activities/transitTracks/) there are teacher instructions, photocopy masters for Transit Light Curves, Option Math for Transit Tracks, Kepler's 3rd Law graphs, cube root tables, an account of Jeremiah Horrocks' 1639 observation of the transit of Venus, and an answer key for the Transit Tracks Light Curves.

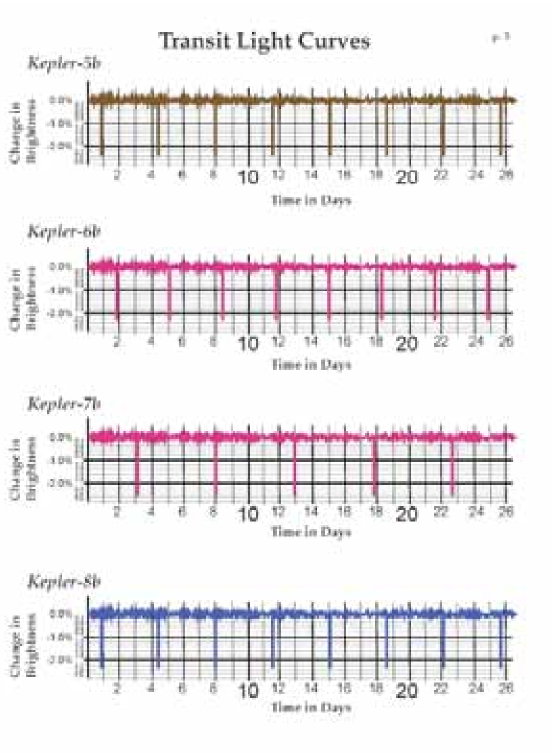

Figure 3*. Light curves from Kepler data. Students measure orbital period, distance from the star, and size (from depth of transit).*

6. Classroom Activity: Human Orrery

Human Orrery is part of the GEMS Space Science Sequence (Session 3.10) published in 2008 [6]. Students lay out and act out a kinesthetic model of the solar system in 3 dimensions: 2 of space and one of time. Each piece of tape shown in Fig. 4 is a "step" in the orbit of a planet representing a 2 week movement along the orbit line. Student volunteers act as the Sun and the inner planets, with the rest of the class timing the steps by some simple organized group clapping and/or chanting "2 weeks, 2 weeks, 2 weeks ...." The relative speeds of the planets quickly becomes apparent. Teacher instructions (PDF) are at http://kepler.nasa.gov/education/activities/gr68/

If rope circles are used, the circumferences needed are

3.64 m for Mercury (tape pieces 61 cm apart),

6.78 m for Venus (tape pieces 42 cm apart),

9.42 m for Earth (tape pieces 36 cm apart),

14.3 m for Mars (tape pieces 29 cm apart)

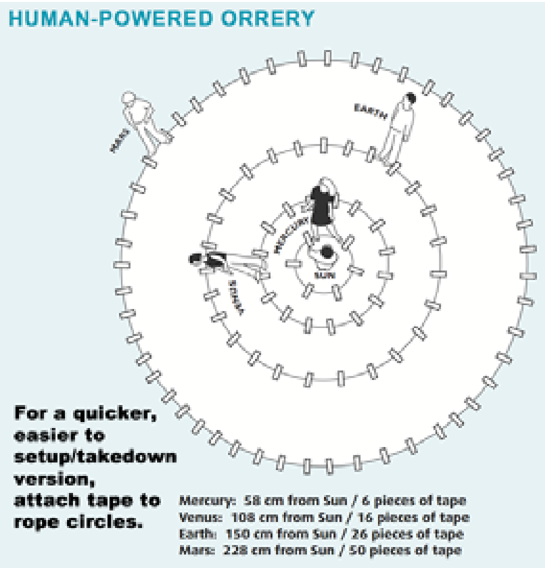

Figure 4. Layout diagram of the Human Orrery.

7. Kepler Star Wheels

The 2013 edition of the Kepler Star Wheels shows where in the sky Kepler is pointing. It also has sky positions of 17 naked-eye stars (brighter than magnitude 5) known to have exoplanets. It may be considered part of a set with Uncle Al's Hands-On Universe Star Wheels.

At http://kepler.nasa.gov/education/starwheel/, there is master for photocopy and assembly instructions. Two wheels are included: one with coordinate grid for plotting additional exoplanet stars and one without grid for cleaner simpler look - easier to read. There are two holders: one for latitudes 30°-50° and one for latitudes 50°-70°.

A set of questions to ask students when using starwheels is in the investigation Using Starmaps from the Hands-On Universe book A Changing Cosmos. [7] The 2011 version Kepler Star Wheel has over 60 stars with exoplanets marked (down to magnitude 6).

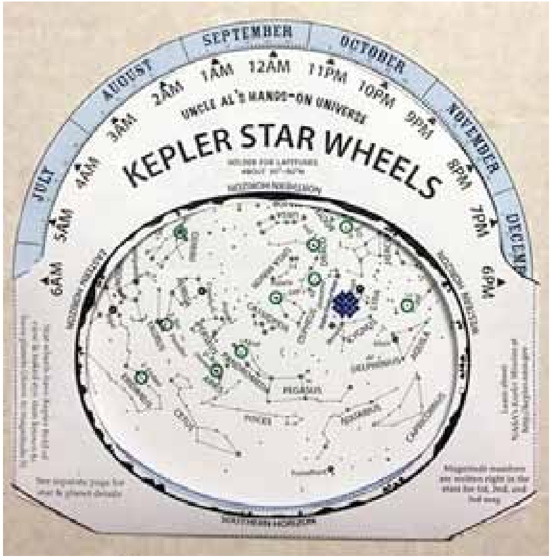

Figure 5. *The green circles on the Kepler Star Wheels are stars brighter than magnitude 5 known to have exoplanets. The small grid pattern in the Cygnus-Lyra area is the Kepler target region.*

8. Media Resources

At http://kepler.nasa.gov/multimedia/, there are galleries of graphics and movies, including Kepler discoveries, animations of the Kepler launch, artists' conceptions of planets, etc.

9. Professional Learning Communities Through Remote Communication

In the EPO plan for the Kepler extended mission is an element to create an online teacher workshop on Kepler EPO educational materials. We are using lessons learned in NASA project that was focussed on setting up remote professional learning communities (PLCs) of teachers and results from another: Lifelines for High School Climate Change Education. Two goals of that project were:

• Establish high school teacher professional learning communities (PLCs) to share ideas & identify best ways to include climate change education in their courses.

• Identify best strategies for distance-meetings.

In summer of 2010 we created a project staff Google Site Work Area that first became an experiment in group website work during the US-Hands-On Universe 2010 Conference. Participants created their own pages with items of interest to the group, including presentations. Things could go up on the site practically in real time. The experiment was successful and constitutes proceedings of most of the HOU 2010 conference.

By Sep 2010, we had recruited 20 teacher leaders for the Lifelines project though an online Google Docs Spreadsheet application. We created a Leaders website in Google Sites in Sep 2010 (https://sites.google.com/a/berkeley.edu/lifelines/) with:

• Photo Name Tags—participant photos for reference during meetings.
• Meeting notes taken live during the meetings.
• Web pages for each Leader.
• "How To" area with tips on "How to make an online application form in Google Docs," "How to make a Google Site for a PLC," "Guidelines for successful Skype sessions."

One lesson all the leaders quickly learned: teachers have very little free time, so getting participation in a PLC on a volunteer basis or even for a modest stipend is difficult. Teaching schedules do not accommodate time for teachers to communicate and share with one another.

9.1 Communication Tools

Live Remote Meeting
Platforms (synchronous)

• Adobe Connect (commercial)
• Bluejean (free videoconference system allowing various inputs)
• Elluminate (commercial)
• Google Hangout (free)
• JoinMe (free service for desktop/screen sharing via Internet)
• ReadyTalk (commercial)
• Skype (free)
• Webex (commercial)
• Wiggio (free)

Late in the project Google Hangout became available and it seems to be quite promising as a platform for live remote PLC meetings. Audio and video quality is generally good. Getting participants organized for a Google Hangout start up is not trivial, but once everyone becomes familiar, it may be viable.

Asynchronous Communication Tools:

• Google Docs (text docs & spreadsheets)
• Google Sites (free websites)
• E-mail lists
• University/district e-mail/listservs
• Google Groups
• Yahoo! Groups

We found that Google Docs and Google Sites are very simple and easy to use. Since they are free they are great tools for cash-strapped schools. In this project we created quick tips for PLC leaders on using the Google tools to serve the PLCs. Those tips are on the Leaders' site (https://sites.google.com/a/berkeley.edu/lifelines/communication-tools/google-site-tips). The Google Sites are great collaborative workspaces for Leaders and for their PLCs. Meeting notes can be taken live during meetings.

9.2 Sharing Ideas and Resources

A Course outlines website was established (https://sites.google.com/a/berkeley.edu/lifelinescourses/) for teachers to share course ideas. By Dec 2011, 22 teachers posted their course outlines there.

An excellent series of speakers were lined up throughout this project and recordings of their presentations are on this web page: https://sites.google.com/a/globalsystemsscience.org/courses-lifelines/presentations-mtgs.

Resources for climate change education were gathered throughout the project and are compiled on these web pages:

• Activities

https://sites.google.com/a/globalsystemsscience.org/courses-lifelines/teaching-resources/activities

•Information

https://sites.google.com/a/globalsystemsscience.org/courses-lifelines/teaching-resources/information

•Multimedia –

https://sites.google.com/a/globalsystemsscience.org/courses-lifelines/teaching-resources/multimedia

9.3 Good Practices for Remote Meetings

Set goals—it's helpful to have some kind of clearly defined goal(s).

9.3.1 Leaders

A leader/facilitator is essential. Teachers, swamped with teaching duties, cannot often devote adequate time for this. Our most successful PLCs were not led by active teachers:

• a retired teacher who had time and interest in this effort ended up leading a few of our PLCs, not just one.

• a district coordinator was one of our most successful Leaders and organized 3 PLCs.

The Leaders of the Detroit MI PLC, summarized some tips for success of a PLC:

• Have regular meeting times

• Have assignments/projects for participants

• Have round robins; each person say things

• Have partner to help lead

For some PLC members, especially just starting up in a PLC, their technology savvy is not up to speed. The Leader needs technological expertise and willingness to do some "hand-holding" for getting tech-newbies going with whatever platform and programs are being used.

9.3.2 Asynchronous Participation

Here are ideas for asynchronous participation generated at one of our Leaders meetings:

• brief report on a climate activity they tried out in their classroom

• analysis of a climate activity, even if they have not tried it out.

• posting a syllabus of their course, indicating precisely where climate activities or climate resources are used

• book review on a climate-related book they read

• posting link to an interesting article on climate-related subject

• e-mail discussion/thread on particular subjects

For a PLC not focussed on climate change, substitute the actual PLC subject for "climate" in the above points.

9.3.3 Live Remote Meetings

E-mail communication is vital, but voice has distinct communication advantages and voice plus visual information (via desktop sharing) is even better, as evidenced by an especially successful meeting we held in September 2012 in which every participant was made a "presenter" able to share their desktops.

About meeting times, having up front a really clear date and time to meet makes a big difference. Have a regular meeting time, so that members can plan their time. It's especially difficult to find a time for everyone to meet when participants are in 4 different timezones. Multiple meetings may be needed for that. This is not so much a problem for local or regional PLCs.

In preparation for a live remote meeting, have at least two announcements: one week(s) in advance and another a day before. Maybe even one an hour before the meeting.

Audio Etiquette is important. A really basic rule for all remote meetings: participants should mute their microphones unless they intend to speak. However, this also means they must remember to unmute when they want to say something.

Sometimes it's hard to "get a word in edgewise" because no one can see visual cues about intending or wanting to speak. So it's best to be especially on guard for avoiding cutting someone off or jumping in talking before someone has finished what they want to say. This is tricky because some people just speak faster than others and will dive right into a very short pause in a slower person's speech.

Share the microphone. Several Leaders noticed that their best responses came when everyone was given a turn to speak during the PLC. This meant having one or two times in a meeting for a set of "round robin" responses. A round-robin early in the meeting sets the tone for everyone to realize that they can contribute to the conversation.

Consider making recordings. In recording meetings and presentations, at least with the ReadyTalk system, if there is a lot of action going on in the screen (other than just changing of slides), and/or if the presenter is using a large monitor, the recording can generate a very large file very fast. This can be a problem in terms of posting in an archive. Fast on-screen action should be minimized. Show only short movies if any.

For the sake of archiving, it can be advantageous to break recordings into time segments of 10-20 minutes or less, 30 minutes max. Of course it's easiest just to let the recorder run throughout the whole meeting. If the Leader or a participant has time, they can snip the recording up before posting. The advantage is that PLC members who did not make the meeting can listen to part or all of the meeting in bite-size portions, or only to parts that interest them, if the clips are labelled by subject.

Use Desktop Sharing wisely. Often a presenter or participant will want to point something using a cursor. It's important to remember that in remote systems there is a delay, so do not move the mouse to fast. Clicking around and jumping from page to page quickly may get lost in the Internet delays.

9.4 Challenges

Two key challenges of the project were:

• Recruiting participants who would actually participate and "show up" for meetings. Even knowing their stipends could increase based on participation, some teachers, with real interest, simply did not have time to make in their busy schedules.

• Sustaining the PLCs after grant funding ends. This is actually the subject of one of the questions in our final survey for participants.

Here is a summary of challenges identified from our in-person Leaders meeting at NSTA 2011 in San Francisco:

• Getting busy people to do "one more thing."

• Recruitment

• Retention

• Participation

• Sustainability

• Getting the "right" people---those who will participate and contribute.

• Getting more than just the PD enthusiasts who are very active in PD efforts.

• Determining reasonable, doable requirements

• Setting reasonable expectations.

• Members can't always make it to live (real time) meetings.

• Getting teachers to put up their "stuff" (lesson plans, techniques…)

Ideal PLC size may fall in the range of 3 to 15. Skype may serve adequately up to 10 or so, but audio quality could be iffy. Google Hangout handles up to 10, with video, fairly good quality usually. Commercial platforms generally handle more participants with higher quality audio.

Meet in-person if possible and then meeting online goes better. In-person not always possible, depending on geographical separations.

Having a host institution can be an important factor. A PLC that has set structure sanctioned by the school district and requiring participation has a better chance of participation and success. Even then, participation will likely be less than 100%.

Complete report on the Lifelines project is posted at http://www.globalsystemsscience.org/lifelines [8]

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Across Space and Time: Creating a Community of Practice for Teachers Using Virtual Tools

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Abstract

Twelve middle and high school teachers from eleven different states plus Puerto Rico in the USA are creating a Heliophysics Community of Practice for formal educators. The objective of this Community of Practice (CoP) is to engage middle and high school teachers, their students, and the public in the science of Heliophysics.

The CoP is currently coordinated by the NASA THEMIS mission Education/Public Outreach (E/PO) in collaboration with the NASA Science Mission Directorate Heliophysics E/PO Forum and the NASA Van Allen Probes E/PO.

This paper describes the development of the CoP including the use of virtual tools used to overcome the challenges of bringing teachers together across distances and time zones.

Keywords

Community of practice, online education, teacher professional development

1. Introduction

Heliophysics is the study of the Sun and its interactions with and effects on the Solar System. NASA's Heliophysics Science Mission Directorate funds research that seeks to answer three big questions: What causes the Sun to vary? How do the Earth and the Heliosphere respond? What are the impacts on humanity?

Formal education teachers in the United States who wish to incorporate Heliophysics content into their curriculum have had opportunities to participate in NASA-funded professional development experiences that allow them to interact with NASA Heliophysics researchers and mission scientists as well as Education/

Public Outreach specialists.

The Heliophysics Community of Practice initiative grows out of previous NASA-funded teacher professional development initiatives, including the Geomagnetic Event Observation Network by Students (GEONS) project, the Heliophysics Educator Ambassador (HEA) project and the Van Allen Probes teacher professional development workshops.

In evaluations and focus groups, teachers involved in these programs had expressed a desire for sustained contact with other teachers, scientists and education specialists to support their ongoing professional development and implementation of Heliophysics education in their classrooms (Cornerstone Evaluation, 2009).

Based on this expressed need, in December 2012 and January 2013, twelve teachers who had previously participated in NASA Heliophysics E/PO professional development experiences were invited to become Lead Teachers of the newly created Heliophysics Community of Practice.

Our vision is to develop an active, collaborative, community of practice that provides formal educators with support and resources for teaching Heliophysics. Our goal is to keep NASA Science Mission Directorate middle and high school educators engaged in teaching Heliophysics in meaningful and effective ways.

2. Community of Practice Design

A community of practice is a group of people informally bound together by shared expertise and passion for a joint enterprise (Wenger and Snyder, 2000). Hallmarks of a community of practice include:

Members self-select to be a part of the community of practice;

Members share their experiences and knowledge in an informal, free-flowing way;

Communities of practice typically have core participants whose passion for the topic energizes the community and who provide leadership;

A large community of practice is often subdivided by geographic region and/or subject matter to encourage people to actively take part;

Communities of practice are self-perpetuating: as they generate knowledge, they reinforce and renew themselves.

The design of the Heliophysics Community of Practice is based on best practices research (Wenger, McDermott & Snyder, 2002; Sherer, Shea & Kristensen, 2003; Kirschner & Lai, 2007), as well as feedback from the Lead Teachers themselves.

These teachers were asked to act as Lead Teachers for nine months (January – September 2013) by participating in monthly group meetings and online interactions to shape the development of the Community of Practice. Teachers receive a small quarterly honorarium for their time and effort in acting as Lead Teachers.

3. Virtual Tools

The original plan was to have a series of monthly teleconferences, supplemented by online interactions such as discussion boards, as well as a two-day in-person retreat to be held in Berkeley, California in June 2013.

The first few Lead Teacher monthly teleconferences were conducted using the pay-per-minute ReadyTalk (www.readytalk.com) audio and web conferencing system. The audio quality, chat window and online screen sharing features of ReadyTalk were sufficient, but at the time the platform did not allow for videoconferencing. (Since then, ReadyTalk has added a limited videoconferencing feature.)

The monthly meetings were supplemented by Wiggio (www.wiggio.com), which is a free, online platform that includes features such as discussion boards, shared calendars and file sharing.

Figure 1 *Wiggio Screenshot*

Due to unexpected changes in NASA funding regulations related to E/PO travel, it became necessary to change the planned in-person meeting to an online, virtual retreat. Recognizing the need for teachers to see each other during this retreat, we began using Zoom (www.zoom.us) videoconferencing in Spring 2013. Zoom offers limited free access which we initially used to test the system, after which we signed up for a plan with a small monthly fee that allows for unlimited minutes.

4. Virtual Retreat

The two-day virtual retreat was held from June 18-19, 2013. The objectives for the virtual retreat were that the Lead Teachers would have deepened their experience of the community of practice by:

Strengthening connection between community members,

sharing resources and supporting each other in teaching Heliophysics,

expanding their knowledge of current NASA Heliophysics research,

and beginning to reflect on what community of practice means to them and ideas for future expansion.

The retreat was conducted using a combination of small and large group Zoom videoconferencing sessions and offline individual reflections and response sessions supported by Wiggio discussion boards.

The whole group Zoom sessions included facilitated discussions about the development of the community of practice, presentations by scientists and NASA E/PO specialists to provide updates on the SDO and IRIS missions, highlight Heliophysics resources and provide content background.

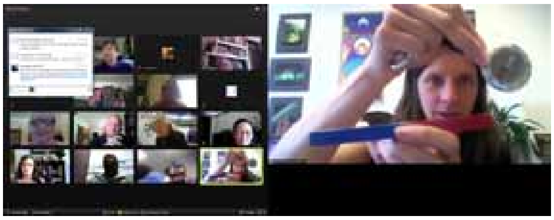

Figure 2 *Zoom Screenshot*

Similar to an in-person conference, two sessions included small group breakout meetings that ran concurrently. On the first day, teachers were assigned to a group and given an assignment to discuss. On the second day, teachers were given three choices of breakout sessions and were free to chose which they wanted to attend. All the small group breakout sessions were conducted using Zoom.

Throughout the virtual retreat, notes were taken using Wiggio document-sharing feature so that the notes were immediately available to all participants.

At the end of the two-days, the Lead Teachers were asked to complete an online evaluation survey to give their feedback on the virtual retreat.

5. Challenges and Successes

Before the virtual retreat, the NASA coordinators set up a series of informal, drop-in Zoom meetings so that participants could test out how Zoom worked for them and trouble-shoot any issues. This proved to be invaluable not only for addressing the relatively-few technical issues that arose, but also for providing the teachers and coordinators a low-key way to "meet" face-to-face, in many cases for the first time.

Scheduling the virtual retreat whole-group and small-group Zoom sessions was challenging because the teachers spanned six different time zones (from Hawaii Standard Time to Atlantic Standard Time). The willingness of teachers in the earliest and latest time zones to start the virtual retreat early in the morning or finish the retreat in the evening was critical to finding common times to meet.

Several participants expressed some concern about possible fatigue from being in front on their computer all day. To address this concern, we incorporated plenty of breaks and individual time into the agenda, as well as explicitly giving participants "permission" to take breaks, turn off their webcam and eat as needed during the Zoom sessions.

The online evaluations completed by the Lead Teachers indicated that the virtual retreat experience was a success. Comments about the virtual retreat included:

It wasn't so much what I expected, but rather I kept thinking when can we do this again. This was absolutely amazing!

This was so successful that it went way beyond my expectations.

[What I found most valuable was] the fellowship of community members sharing their knowledge of what and how they teach heliophysics concepts as well as the presenters who taught us about the missions and science they are working with.

6. Future Plans

As of writing this paper in early July 2013, there are plans for the Lead Teachers to resume their monthly meetings using Zoom, supplemented by Wiggio online discussions and file sharing.

Cornerstone Evaluation, an independent evaluation company, plans to survey the Lead Teachers at the end of their tenure in Fall 2013 to assess their perceptions of the development of the community of practice and preparedness to move forward.

Several Lead Teachers have already expressed an interest in continuing to be involved in the ongoing coordination of the Community of Practice. It is our hope that the Heliophysics Community of Practice will continue to grow.

7. Acknowledgements

Funding for the Heliophysics Community of Practice comes from the NASA THEMIS mission E/PO, the NASA SMD E/PO Heliophysics Forum and the Van Allen Probes mission E/PO.

We would also like to acknowledge the participation of the NASA Solar Dynamics Observatory mission E/PO and IRIS mission E/PO to the virtual retreat.

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Earth and Sky Images for Astronomy Communication

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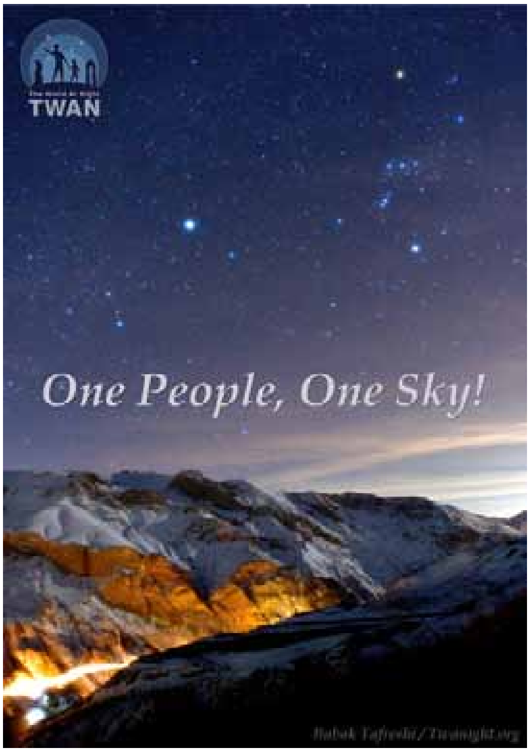
Abstract

Nightscape photos and time-lapse videos, where the Earth and sky are framed together with an astronomical purpose, is a growing support to astronomy journalists and educators worldwide. The imagery connects people with astronomy using artistic and real scenery of familiar landmarks at night. They resonate with viewers on an instinctive level and they spark the imagination. Familiar landmarks provide a context viewers relate to, even among city dwellers who have never gazed in wonder at the natural starry sky. The World at Night (TWAN) program produces and presents the world's most diverse collection of such landscape astrophotos.

Keywords

Astrophotography, Earth & Sky Photography, Astronomy Communication, Science Journalism, Science and Art, World Heritages, International Year of Astronomy 2009

1. Introduction



Hovering in the Texas twilight, Venus dazzles viewers just hours after it's seen by skygazers in Iran. Above the Vatican's domes, the familiar stars of Ursa Major circle the north pole just as they do above the spires of a Buddhist temple in China. Above Arizona's Grand Canyon, the magnificent arch of the Milky Way is seen on the same night it graces the sky above the Himalaya in Nepal. We all live under the same peaceful sky, and the familiar views they provide create a bond between us.

Initiated in 2007, and presented by UNESCO and IAU at the first Special project of the International Year of Astronomy 2009, The World at Night (TWAN) is a global program creating a collection of nighttime images and timelapse videos of the world's landmarks against the night sky. There is more than beauty captured in these images – each image also reveals a story. The similarity of the night sky above diverse cultural and historic landmarks demonstrates that humanity is one family living on a small planet amidst the vast ocean of the Universe. The author had entertained the idea of creating TWAN for years but finally accepted the challenge with TWAN as a project in partnership with Astronomers Without Borders (AWB); a US-based non-profit organization that promotes peaceful relations and understanding worldwide through a common interest in astronomy.

2. Bridging to Public

The familiar context of TWAN images, which represent mostly naked eye views, add a new tool to efforts to popularize astronomy alongside images and science results from large telescopes. Wide-angle TWAN photos have been used by media and astronomy educators worldwide as they educate viewers on many fundamental aspects of practical astronomy such as the natural look of sky, constellations, celestial motions, and sky events. These images present the night sky from various perspectives besides astronomy. The night sky appears in the images as a heritage for life on this planet, as an essential part of our nature and not only an astronomer's laboratory. The images try to reclaim the natural beauty of night sky and brings back this forgotten element of our nature to modern life where 2/3 of human population live under light polluted skies where the Milky Way is no longer visible.

In this way these landscape astrophotos also play a role in increasing awareness of the value of dark skies and the growing problem of light pollution.

With TWAN images taken at important cultural sites around the world, the connection between our many cultures and the night sky through history is emphasized, particularly in images that include ancient sites of astronomical importance. TWAN is also a bridge between art, humanity, and science, with a unique message. The eternally peaceful sky looks the same above symbols of all nations and regions, attesting to the unified nature of Earth and mankind. We are all one family under one sky.

3. TWAN Team

TWAN worldwide team includes 40 photographers, coordinators, and consultants in about 30 countries. The invited photographers are the world's best in creating landscape astrophotographs that combine the sky with important natural, cultural or historic landmarks in well-planned, real, artistic, and educational image.

Many of TWAN team members are professional photographers who are living from their image contribution to media and publishers but they have been connected to astronomy most of their life as an amateur astronomer. Some TWAN members are professional astronomers and astronomy communicators who are also involved and dedicated to night sky photography.

In the past years TWAN imagery and the program's wide range of events and workshops has dramatically promoted both the hobby and profession of night sky photography. Since 2009 one of the major programs in promoting night sky photography has been TWAN International Earth & Sky Photo Contest (twanight.org/contest). The annual contest is open to everyone world-wide with free of cost submission and valuable photography or astronomical prizes. The outstanding winner images receive remarkable recognition through media coverage of the contest. The Earth & Sky Photo Contest is a part of the outreach programs during the Astronomers Without Borders' Global Astronomy Month in April. The National Optical Astronomy Observatory at Kitt Peak is another partner of the photo contest.

4. How we Reach People

TWAN exhibitions, presentations and educational workshops have traveled to about 100 locations in over 30 countries since the project started in 2007. But larger number of people have visited TWAN website www.twanight.org where thousands of the finely selected world nightscape images and time lapse videos are displayed. The website updates weekly with new imagery and also showcases images by hundreds of guest photographers from around the world (twanight.org/guest). The website has received about 15 million visits from about 200 countries and territories since its launch on 25 December 2007 and has became the main online source for wide-field night sky photos, as well the world's most diverse collection of nightscape imagery in general. These capabilities made TWAN website one of the most popular online astronomy destinations.

TWAN also collaborates with media including National Geographic News, various TV stations and News sources, and popular science magazines such as Sky &Telescope to reach more people. In the framework of astronomy

communication using Earth and Sky photos we are also collaborating with various organizations and individual astronomers and science journalists. That includes the International Astronomical Union, International Dark Sky Association, the European Southern Observatory (ESO), UNESCO's Astronomy and World Heritage Initiative, Dark Sky Awareness Program, Galileo Teachers Training Program, and Global Hands on Universe.

5. Challenges

Careful planning and a keen eye honed by years of experience go into each unique image. Eclipses, conjunctions and celestial surprises like bright comets each bring new opportunities for unique scenes at TWAN locations. Geographic location, altitude, local topography, light pollution and many more factors must be considered in preparing for a photo session.

Selection and priority listing of potential sites is a challenge itself. UNESCO World Heritage Sites are given priority but thousands more regional and local landmarks world must be considered.

Because photographers must travel to remote sites they can still be thwarted by unpredictable problems with accessibility, government restrictions, political conditions and more. And there's always the weather ready to ruin an otherwise perfect session. There are no rules for capturing these scenes; each is unique and only a practiced eye can find the best balance of starlight and foreground illumination. Light may come from twilight, moonlight (which varies with the Moon's phase and altitude in the sky) or artificial lighting. With too little light on foreground objects, stars float unanchored above a featureless silhouette. Too much light might cause an ancient structure's reflected glare to wash out the faint glimmer of the stars above it. No two situations are alike, and even careful planning must be augmented by trial and error. All the while, the sky's motion and changes in lighting transform the scene.

The apparent motions of the sky are often captured in TWAN images as well. A single night's work reveals streaks left by stars as the Earth's rotation spins the sky above us. The motion of planets is captured with exposures on different nights, revealing their dance through the sky as they orbit the Sun. Time-lapse photography – multiple images recorded throughout the night and strung together – creates mesmerizing videos of cosmic motion.

The greatest challenge for TWAN in coordinating image creation in bizarre locations and exhibitions world-wide is financial sources. National, regional and local tourism organizations associated with designated TWAN sites will be approached for travel support for photographer visits to those sites. Major corporate sponsorship is also being sought including airlines and manufacturers of professional digital photographic equipment.

6. The Main Goals Overview

1- Creating better understanding of cultures and civilizations under the universal roof of night sky, by connecting art, science, and culture through the gateway of night sky. This also aims to show the truly unified nature of Earth as a planet rather than an amalgam of human-designated territories.

2- Introducing night sky as a heritage for life on this planet, as an essential part of our nature and not only an astronomer's laboratory, an effort to reclaim the natural beauty of night sky, and bring back this forgotten element of our nature to modern life. This also increases public awareness of dark skies importance and increasing problem of light pollution.

3- Promoting knowledge and interest to astronomy by displaying many of the celestial wonders and principles of stargazing in the images.

4- To display the universality of astronomy. In the borderless sky political and cultural separations fades away between nations: One People, One Sky.

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Introduction to Astronomical Education on National Astronomical Observatory of Japan (NAOJ)

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Abstract

This is a report on the current situation and problems of astronomical education in Japan. And this report show the strategy of education and outreach of National Astronomical Observatory of Japan (NAOJ), specially, distribution of "Diagram of Our Universe" poster, educational use of 4D2U content “Mitaka”, introduction of Makali’i, and report of “You are Galileo!” project.

We discuss the science curriculum that has the primary purpose of the formation of scientific culture all over the world.

Keywords

science curriculum, outreach program

1. The Current Situation in Japan

1.1 IYA2009 and beyond IYA activity

Through the International Year of Astronomy 2009, The IYA 2009 Japan Committee had been holding its own international projects supported by IAU, such as ‘You are Galileo! ’project, ‘Stars of Asia’ project, etc. And the IYA 2009 Japan Committee also did a lot of domestic projects. Beyond IYA, Astronomical Council of Japan was established on September 9, 2010. Members of this council are the Astronomical Society of Japan, NAOJ, JAXA, the Japanese Society for Education and Popularization of Astronomy, the Japan Planetarium Association (JPA), the Japan Public Astronomical Observatory Society (JAPOS), the Coordinating Committee for Amateur astronomers, and the Association of starry sky in Japan.

1.2 School Education

The new National Curriculum Guideline in Japan will start in 2012 school season. Between

2009-2011 school seasons, Japanese school curriculum was in force during a transition period. Under the new national curriculum, the study about Astronomy will be a little increasing. For example, the waxing and waning of the Moon has come back in elementary school (in 6th grade).

1.3 Planetarium

The Nagoya City Science Museum has established the world's biggest planetarium with a diameter of 35 meters dome screen in March 2011. Planetarium industry in Japan is being revitalized. Tokyo Sky Tree which is a new Landmark Tower in Tokyo also have a big planetarium theater. n the other hand, the International Festival of Scientific Visualization has started from 2010.

1.4 Science Communication

Ministry of Education, Culture, Sports, Science and Technology Japan have edited every year the White Paper on Science and Technology. You can read the white Paper 2009 and 2010 on the MEXT web site, http://www.mext.go.jp/english/whitepaper/index.htm .

Now preparing the White Paper on Science and Technology 2011, in this paper, you can know the policy of Japanese Science and Technology after 3.11 2011.

In order to overcome the earthquake East Japan, the Japanese government promote to Science Communication with public. Japanese astronomical community must lead the Science Communication in domestic and international with IAU 'Astronomy for the Developing World Strategic Plan 2010-2020'.

2. NAOJ education and outreach activities

2.1 History and strategy

Astronomy is one of the oldest and yet most active sciences. This means that human beings possess the fundamental desire to seek our origin and the reason for our existence through understanding of the universe.

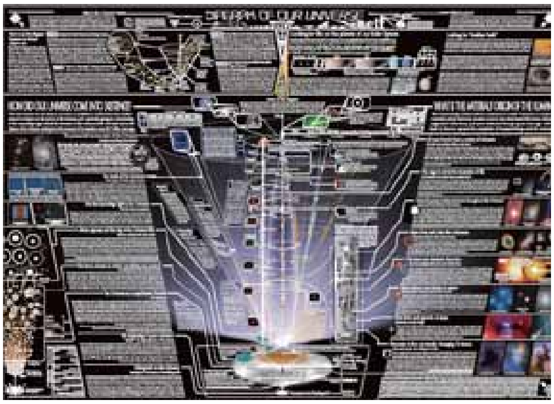
About 350 years ago, it came to be in full-fledged astronomical observations in Japan, was from Asakusa Observatory of the Edo shogunate astronomical way. Through the Tokyo Astronomical Observatory era, their jobs being passed on to the National Astronomical Observatory of Japan.

NAOJ is the National Center of astronomy research in Japan. NAOJ established astronomical information center 16 years ago, we began the dissemination of science to children and citizens further. Astronomy is so "science of all humanity".

2.2 International educational & outreach activities international

I will introduce some of the educational activities which NAOJ has been working internationally.

"*Diagram of Our Universe*" poster :

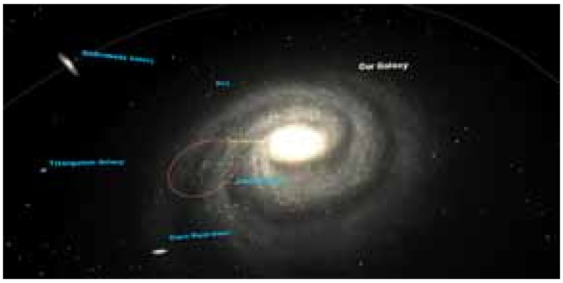


http://www.nao.ac.jp/study/uchuzu2013/

4D2U project:

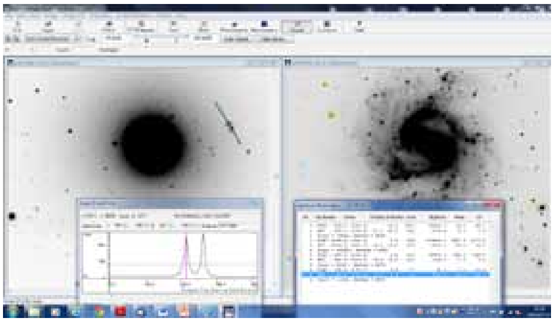
http://4d2u.nao.ac.jp/english/index.html

Mitaka
(A Four-Dimensional Universe Viewer):



http://4d2u.nao.ac.jp/html/program/mitaka/index_E.html

SUBARU Image Processor Makali`i:



http://makalii.mtk.nao.ac.jp/index.html.en

"*You are Galileo!*" project

http://kimigali.jp/index-e.html

Helping US Students of Age 12 to 14 Love Algebra* Through Astronomy – ASAMI[1]

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Abstract

ASAMI – Afterschool Science and Math Integration. merges core algebra concepts, skills and reasoning methods with Hands-On Universe curricula to engage 12 – 14 year-old students in meaningful, inquiry-based science investigations. In our 2012 pilot of ASAMI, 14 students met for 2 hours. twice a week over a period of 3 months, at Portola Middle School in El Cerrito, California, USA. Although our sample was small, the valuation using content assessments, interviews, surveys, observations and conversations revealed students' greater interest in mathematics and understanding of proportions. Furthermore, their proportional reasoning skills improved. Future work will aim to disseminate and evaluate ASAMI materials with larger and varying audiences.

Keywords

Astronomy education, science education, mathematics education, hands-on learning

1. Introduction

While the U.S.'s ability to compete in the global economy is decreasing and the need for more experts in STEM fields is increasing dramatically, the number of students pursuing and completing STEM degrees is declining[1]. One key factor contributing to this decline may be students' poor preparation for, lack of success with, and waning interest in mathematics and science in middle school (ages 12 – 14) [2] [3] [4].

Integrated/interdisciplinary approaches to teaching mathematics and science may be able to reverse negative trends in students' STEM interest and achievement. Research has shown that an interdisciplinary or integrated curriculum provides opportunities for more relevant, less fragmented, and more stimulating experiences for learners [2] [5] [6]. This paper describes the authors' efforts to bring the principles and promise of project-driven STEM inquiry to an afterschool environment with fewer restrictions on time and competing school activities.

2. ASAMI philosophy and activities

The ASAMI pilot program integrated modern astrophysics concepts core mathematics content in an informal learning environment. At the start of ASAMI, we suspected and largely confirmed through conversations with students, that many them did not like math, had difficulty understanding and applying ratios, proportion, and linear equations to solve problems. From decades of study of Hands-On Universe, we knew that students love doing astrophysics, measuring images on the computer, engaging in hands-on activities, and making their own models of mathematical and physical situations.

ASAMI was designed to see if middle-school students could learn fundmamental mathematics concepts within the context of real-world astronomy and other activities. Given the duration of the project (about three months) and the short time (four hours each week), three concepts were selected for targeting: proportionality, ratios and rates, and linear equations.. Students spent two to six hours, depending on progress, on each activity. Typically, they collaborated in groups of two or three, which is in concert with Modeling Instruction guidelines [8]. Computers with internet access were supplied by the school. Other technologies were gathered at point of need. Student explorations were led by a skilled middle school teacher/ Hands-On Universe/Modeling Instruction-trained expert teacher (Ms. Perazzo) and a UC Berkeley undergraduate (Matthew Kay), who served as a teaching assistant and mentor.

Because of the short time to prepare, we chose topics from field-tested Hands-On Universe materials, and employed HOU software . Unlike what was done in the HOU project, ASAMI leaders devoted special attention to the underlying mathematics concepts and skills and how those could be used to model scientific phenomena.

The final products of ASAMI include a syllabus, classroom guides and lesson plans (in process),. assessment instruments, and, results of the evaluation.

3. ASAMI pedagogy – inspired by Arizona State University's Modelling Instruction

Modeling Instruction has proven to be one of the most reliable pedagogies to improve student learning (see, e.g., http://modelinginstruction.org/). In the Modeling Instruction pedagogical approach, students work in groups of three, they voice their preconceptions, collect experimental data, build a model in their small groups and document their ideas on white-boards, and then assemble with their classmates (a board meeting) to present their work and a classs consensus model.

An example of how we implemented the model in ASAMI is shown in the diagram below.

Students are presented with beautiful and engaging images and learn Salsa J. Students break into groups of 3.

Students get excited about images and image processing. The classroom buzzes!

Students are challenged, to "make a scale model of the solar system (with playdoh)" – There is no use of real data at this point. Students use their existing knowledge to make a best-estimate scale model of our solar system,

Students measure real sizes of solar system objects using Salsa J on their computers, and then make new models.

All groups meet, share their results, and make a "classroom size model."

Figure 1: *Modeling Instruction Pedagogy in Action (2-hour session)*

4. ASAMI syllabus and challenge questions

The following is a list of the ASAMI Investigations/Activities.

4.1. Walk the school campus in steps, and scale in Google Maps: The challenge was to make a scale map of the campus, based on their measurements, both by pacing off distances and by using Google maps.

4.2. Google maps into Salsa J: Earth/Jupiter relationship. The challenge was to start to understand the scale of the solar system, and use the same tools that are within Google Maps on solar system objects.

4.3. Playdoh: Modifying recipes: The challenge was to make a small batch of Playdoh, based on a recipe for a much larger batch. This involved scaling between measurement systems, and using ratios and proportion correctly.

4.4. Create an Earth and Jupiter model from the playdoh: Students had to make best guesses at the scale size of these objects.

4.5. Incorporate the size of the Sun to the Playdoh model of Earth and Jupiter.

4.6. Scale size of objects and distances in the solar system: Measure sizes of objects with Salsa J, and then create a more accurate model of the solar system.

4.7. Formation of the solar system: how and why planets are their sizes, in their locations, and compare orbit distances.

4.8. Sunspot and solar flare sizes relative to the size of Earth: How big are solar flares in kilometers? How many Earths could fit into one solar flare?

4.9. Moon crater size estimated from the size/mass of other objects (e.g. stainless steel balls): How big is a moon crater, say compared to your town or state?

4.10. Candy ratios, compare to constellations and star size: Find the correct size candy to represent the correct astronomical objects.

4.11. Paper tape car model and linear equations: Using toy electric cars, on level ground traveling at constant speed, students create and understand the position of the cars as a function of time, make graphs of the position, and use cars with different speeds to create lines with different slopes. 4.12. Asteroid speed across successive images – linear equations. (the asteroids motion over short distances is very close linear in pixels/sec): Students use similar methods from the previous (paper tape/electric car) activity and plot asteroid position as a function of time across a star field.

4.13. How many solar systems in (Pillars of Creation-Eagle) Nebula or how many galaxies across the Hubble Deep field? How big of an angle is the Hubble Deep Field? (area of 2.5 arc minutes = tennis ball at 100 meters, scale down to grain of sand): If HDF was a football field (100 meters), how big would a galaxy be? Students use proportion and ratio to understand angular and physical size in these beautiful Hubble images.

5. ASAMI evaluation

Rockman et al, a San Francisco-based independent evaluation and research firm conducted ASAMI's external evaluation.

5.1 Methods

The goal of the evaluation was to assess the effects of students' participation in ASAMI on their attitudes toward mathematics and science and their understanding of proportional reasoning. To measure these outcomes, evaluators developed pre- and post-program content tests and surveys.

The content tests contained five proportional reasoning items taken from four sources: (a) the California STAR test database [9]; (b) the National Assessment of Educational Progress (NAEP) item database [10]; (c) the New England Common Assessment Program [11]; and (d) the Silicon Valley Mathematics Initiative's Mathematics Assessment Collaborative project [12].

The attitude surveys included questions about students' past experiences learning mathematics and science (e.g., "Have you ever attended a science camp or special science program?"--"Have you ever had a teacher who made it exciting to learn math?"), and items from the personal confidence and usefulness subscales of the Modified Fennema-Sherman Scale for Math and Science [7].

In addition to these pencil-and-paper measures, evaluators observed two ASAMI sessions and conducted end-of-program student interviews.

5.2 Results

The evaluation was hampered by a delay in receiving human subjects approval from UC Berkeley's Internal Review Board and a subsequently low return rate for study consent forms. Only two students completed the student assent and parental consent necessary for inclusion in the evaluation.

The data collected from this year's program provides some very initial proof-of-concept evidence of the effects of ASAMI on student understanding and attitudes. Since the findings come from such a small sample, they must be considered extremely tentative and will need to be verified with a larger population.

5.2.1 Evidence of student engagement and attitudes

Interviews and informal observations suggest that students found the ASAMI activities to be highly engaging and quite different from typical classroom practices. Students worked diligently in groups on complex mathematics and science problems, persisting on new and challenging tasks with the help of their ASAMI leaders. During one session, for instance, evaluators observed students using SalsaJ software to calculate astronomical distances. A group of four students sat or stood in front of a computer, with one student running the program and others providing assistance. The students were so engaged in the activity that they only wanted a brief snack break before returning to their work.

The root of ASAMI's appeal may be its "soft sell" approach to mathematics. Rather than teaching proportional reasoning as an abstract skill, ASAMI embeds it into science problems to pique students' interest. In fact, one student described the program as "an astronomy program which sneaks in math," noting she often didn't "realize how much you're doing it {math}" until later. It was only in the hours after ASAMI that she felt the full impact of what she had done: "My brain's tired. I've done too much math."

Another student praised the ASAMI activities, calling them "Math in a fun way." "You don't know you're doing math but you are," she said. "I liked how they put the math. They didn't just give you like a paper with math problems and say do this. It was in a way where it was math but it wasn't just math, it was something else like astronomy."

This same student commented that ASAMI was very different from her regular math classes:

"Most of the time now in school the teacher's on the whiteboard, we do problems, we do our homework and our work, but it's nothing like this, with measuring, with astronomy, with ratios, you know, it's not like how they put it. "

Before ASAMI, she didn't think that mathematics had much to do with one another. "I didn't really think I needed science to do math. I just thought science was science and math was math and they were two different things." Now that she's been through the program, she wishes that all students could have the same experience.

"By them {math and science} being joined together it makes it more interesting and more fun because you're not just doing math and you're not just doing science, but you're doing both of them at once. "

5.2.2 Evidence of student learning

One student's pre and post tests represent the kind of change in understanding we hope ASAMI can produce at scale.

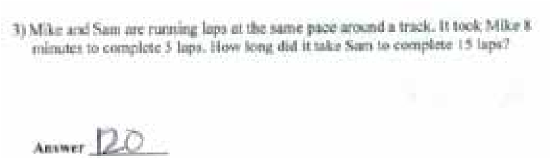

Figure 2. *Problem 3, Pre-Test*

Figure 3. *Problem 3, Post-Test*

On the pre-test (Fig.2), the student solves Problem 3 by multiplying 8 and 15 (the number of minutes for Mike times the number of laps for Sam). On the post (Fig. 3) the student has constructed a table to diagram the relationship between laps and minutes directing her to the correct answer.

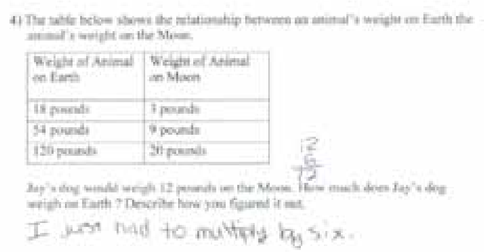

Figure 4. *Problem 4, Post-Test*

The student whose work is represented in Fig. 4 didn't attempt this problem on the pre-test; she left the question blank. At the end of ASAMI, she answered the problem correctly recognizing that the ratio of Earth weight to Moon weight was six to one 5.3.

6. Conclusion

The initial evaluation of ASAMI suggested that students found the activities engaging and unique. The program seemed to give students a new perspective on mathematics, and may have even improved some students' understanding of ratios and rates, and their proportional reasoning skills. From our pilot work, we feel that ASAMI can motivate students to learn. The question becomes whether they actually do and sustain that understanding In the future, we plan to examine project work and conduct interviews to track students' mathematical reasoning over the course of the program. We would also like to follow students over time to see what skills and knowledge they retain from the program. This research will not only speak to ASAMI's effectiveness, but also contribute to the larger body of literature about how best to improve middle schoolers' achievement and interest in mathematics and science.

7. Next steps for ASAMI

The content and practice of ASAMI, on a small scale, was successful. We will pursue additional funding and others interested in testing the ASAMI model, including those in other GHOU nations.

8. Acknowledgements

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Application of the Internet in the promotion and popularization of astronomy

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Abstract

The development of the Internet has contributed to eliminate time and space barriers and to the improvement of education. Through the Internet a lot of information and useful content from various fields of science have become available to the general public. The development of technology improved the promotion of astronomy and made possible for astronomy enthusiasts to deal with observational astronomy and astronomy as a science from their homes. In this paper the Virtual Telescope Project and online course Introduction to Astronomy on the Coursera will be described.

Keywords

Astronomy from the chair, Virtual Telescope, Coursera

1. Introduction

As a source of long-term economic growth since the industrial revolution, knowledge is now emerging as a new „generator of growth“. Influenced of information and communication technology and application of new knowledge accelerates the transformation of modern societies. Contemporary Economic flows are based more on the use of new ideas, information and new knowledge and skills and less on material resources. Production based on knowledge seems „untouchable“, superior and „moveable“, making it more competitive in the global market of products and services. Therefore, the economy based on knowledge is the future of any society and economy in the world and the globalization process.

One of the major products of economy based on knowledge, and factor in its further development is the Internet. The Internet is an international network made up of many computer networks that is commercial and public. This network provides an extremely flexible platform for sharing informations, because digital information can be distributed with the minimum cost to millions of people around the world. A large number of people are working in science, education, government and businesses using the Internet to exchange information or execution of transactions with other organizations around the world.

The possibilities that the Internet provides to users are:

1. communication and cooperation
2. access to informations
3. to participation in discussions
4. finding wanted information
5. finding fun (videos, games...)
6. business transactions [1]

The emergence of the Internet and e-business (especially the possibility of performing financial transactions and the emergence of virtual money) led to the appearance of a number of new products and services. The emergence of the Internet and e-commerce improved the educational process. The implementation of information systems and communication technologies made it possible to achieve better results in the teaching and scientific research.

The application of modern information and communication technologies made it possible to improve conditions for the promotion of astronomy. A large amount of information in astronomy is now available online for free. There are groups that allow their astronomical equipment to be used for observing night sky and organizing online observation events. Amateur astronomers can get involved in the implementation of some of the projects called Citizen science such as: Galaxy Zoo, Moon Zoo and Planet Hunter. Also, it is possible to organize seminars and online courses in astronomy, where people all over the world can attend classes and do homework, communicate with other members of the seminar, as if they were actually physically in the classroom. All the above can be brought under one name „Astronomy from the chair“.

2. Astronomy from the chair

“Astronomy from the chair” is the name for a concept where amateur astronomers can deal with astronomy from their homes using the Internet. This concept includes the possibility that an amateur astronomer can:

1. learn particular astronomical topic accessing large knowledge base available on Internet,
2. be involved in space explorations,
3. send observational data and photographs,
4. analyse available data in virtual observatories,
5. perform observations using distant robotised telescopes,
6. write and publish papers,
7. discuss in Internet forums,
8. attend on-line courses and seminars (webinars) [2].

This concept is a practical example of the impact and contribution of the Internet in the development of new products and services, the development of existing and creation of new forms of organizations. It means that the problems of geographical borders which made international cooperation difficult vanished, as well as equipment problem (which are inaccessible for many individual astronomers due to high prices). In this way communication and cooperation with professional astronomers is also improved.

The concept can be divided into four sections depending on the content being offered in:

1. Robotic Observatory
2. Virtual Observatory
3. Online astronomy broadcasting
4. Online courses

Robotic observatory is defined as an astronomical instrument and detection system that enables efficient observation without the need of a person's physical intervention. In astronomy telescope is considered robotic if observations can be performed without operator's intervention on the equipment (even if one has to start and finish a monitoring session on it).

Robotic telescopes are complex systems consisting of several subsystems. These subsystems include devices that allow: 1) control of the telescope, 2) managing the detector (CCD camera often), 3) control of the dome (roof), 4) control of the telescope focuser, 5) tracking of celestial objects within a few arc seconds to a few arc minutes, 6) to avoiding wrapping the cord around the mount, 7) obtaining special points in the sky (meridian, zenith, celestial pole), 8) knowledge of the horizontal limits movement of the telescope, 9) initial "parking" position of telescope, 10) exposure control and camera temperature, 11) filter control, 12) storing images and their subsequent processing using the dark frame and flat field, 13) synchronizing movement of the telescope with the sky and so on [2].

Thanks to the Internet, robotic telescopes are becoming an important element in teaching astronomy. They also provide opportunities for communication, exchange of data obtained by observation and testing of data between research teams. It can be concluded that the Internet is becoming an important tool for dealing with astronomy today.

There are many groups that offer the possibility of renting a telescope for online observing. One of the most successful is the Virtual Telescope Project from Italy. More detail of the work of this group will be discussed below.

Virtual Observatory is defined as a collection of databases and software tools that use the Internet as a platform for scientific research. Virtual Observatory consists of data collection, each with unique collections of astronomical data, software systems, and processing capabilities. The main objective is to provide transparency and access to data to users worldwide. This allows scientists to discover, access, and analyze database. There are many groups of sites on the Internet that allow amateur astronomers to take advantage of virtual observatories and get involved in scientific research. One example is the Zooniverse.

Online broadcasting is part of concept "Astronomy from the chair" which gives users the opportunity to get directly involved in astronomical observation organized by an amateur astronomer from somewhere in the world. All that is required is that the emitter connects to the Internet and uses one of the available channels for broadcasting their shots that have been recorded using one of the available cameras (web camera, DSLR, or CCD). During observing event, users can communicate with the operator at the telescope, and also with each other. One such project is the project "Astronomy from an armchair" in Nis.

Online courses are groups of sites and organizations that provide the opportunity to amateur astronomers to attend lectures, save and watch video materials from lectures, do homework, communicate with other seminar participants and in that way become familiar with the various areas of astronomy. Modern technology makes it possible to follow lectures in a virtual environment, i.e. via the Internet. Attendants can save videos on their computers. Participants also can get study materials in electronic form or use free materials that can be found on the Internet (Wikipedia for example). One of organizations that organizes these courses in astronomy is Coursera.

More detail of the work of the Virtual Telescope Project and Introduction to Astronomy course, which is realized by Coursera will be described.

3. Virtual Telescope Project

Virtual Telescope (VT) project was launched at 2006. It was one of the first projects that organized astronomical observations using modern information and communication technology. The aim of project is to provide access to a wide array of professional astronomical equipment to amateur astronomers so that they can perform astronomical observations, recording, and processing of obtained images.

Astronomical equipment at VT is used for research purposes, but also for the purpose of amateur astronomy. The system is adjusted to give the best results in terms of photometry but can be used for other purposes as well. Also, people without any experience with telescopes can use equipment with the assistance of staff members who are also successful science communicators.

VT project uses equipment from Bellatrix Observatory, which was founded at 1997 in Ceccano (FR) in central Italy. The observatory has two telescopes, the Celestron 14" and PlaneWave 17", both on Paramount ME robotic mount and CCD cameras with supporting components. Equipment can be used to observe deep sky objects, binary stars, star clusters, planets, the Moon, comets, asteroids etc. Software packages used in observatory are The Sky X, CCD Soft, Iris, IDL and Astrometrica. The Observatory occupies a surface of 14m2. [3]

The creator of this project is astrophysicists Dr. Gianluca Masi.

The activities organized by the VT project are:

1. Telescope Control
2. Exclusive public observation events
3. Public observation events

Besides the opportunity to attend to public observation events or to take control of the telescopes, familiarizing with the telescope usage. Using video posted on YouTube and website users in a simple and easy way can learn ho to use software and how to perform astrophotography with the equipment of Virtual Telescope. Also, visitors can learn more about the project, past and future events, see a simulation of the night sky above the observatory, learn about research and results achieved at VT (observation and tracking asteroids, variable stars, supernovae, light curves of extrasolar planets, gamma-ray bursts). From this year, Virtual Telescope will start with research in the field of spectroscopy and has already launched a project called ViTeSSe for supernovae survey. [4]

During public observing events visitors have the opportunity to save images taken during event on their computer, and to join the chat. In this way, the promotion of astronomy is done at the highest level, but also an opportunity for astronomers enthusiasts all over the world to get to know each other better.

In addition to online events, Virtual Telescope organizes public observing event in Rome regularly.

The project has new website at http://www.virtualtelescope.eu/ since 3rd September 2012, while the previous website address of the project was http://virtualtelescope.bellatrixobservatory.org/. From September 2012 the project site was visited by over 2300000 people worldwide in more than 200 countries. The largest number of visitors of online event is over 25.000 people who observed asteroid 1998 QE2 from more than 137 countries worldwide.

Project activities are regularly promoted using social networks. Virtual Telescope has two groups on Facebook with over 6000 members and a Facebook page with 8079 members.

The reasons for the great success of the project are:

1. Idea and aim of Project
2. quality of used technology
3. Experience and enthusiasm of VT team

4. reliable system for remote control of the telescope

5. form of communication and cooperation with visitors

6. modern methods of promotion service (Facebook, LinkdIn, Twitter, blogs, members ...)

4. Introduction to Astronomy course at Coursera

A large number of amateur astronomers around the world have a desire to share and expand their knowledge of astronomy. This can be done by reading professional literature in the fields of astronomy, at public lectures and conferences or courses. The Internet provides the opportunity for all people worldwide to attend these events. One of the groups that organize such activities is Coursera.

Coursera is an educational company that partners with the top universities and organizations in the world to offer courses online for anyone to take, for free. Their technology enables our partners to teach millions of students rather than hundreds. Coursera team envisions a future where everyone has access to a world-class education that has so far been available to a select few. Aim is to empower people with education that will improve their lives, the lives of their families, and the communities they live in. [5]

In the field of astronomy Coursera organized several interesting courses such as: Galaxies and Cosmology, Introduction to Astronomy, Confronting The Big Questions: Highlights of Modern Astronomy, Analiyzing the Universe, etc.. In this paper will be described Introduction to Astronomy course.

The course was organized in the period from 27th November to 23rd December 2013. The course was held by Prof. Ronen Pleser at Duke University, along with his assistant Justin Johnsen. The course was attended by over 5000 people worldwide, of which over 2100 people successfully mastered the subject matter of the course and passed with distinction grade. [6]

The aim of the course is to familiarize participants with astronomy. The areas covered with this course are: Positional Astronomy, Newton's Universe, Planets, Stars, Post-Main-Sequence Stars, Relativity and Black Holes, Galaxies and Cosmology. In order to successfully pass the course participants needed high school knowledge of mathematics and physics, but for those who didn't have it regularly clarification of certain areas and additional literature that could be used to overcome these areas were provided.

The main literature was Wikipedia, which is a great advantage, because it was available to all participants of the course, as well as additional astronomical software and simulations that helped to clarify some concepts and phenomena. Software is free for downloading from the Internet.

The lectures were organized in the form of video clips attached to a website. Participants were able to watch the video or to download and save video and presentations. Each week a homework was given that consisted of mathematical and theoretical questions. Some questions were of multiple choice type and for some mathematical and physical calculations were required. The system automatically checked the results and each participant had 20 attempts to complete the homework. The aim was to practice and by using method of trial and error to learn better elements of astronomy.

During the course several Google Hangouts were organized which helped in sharing impressions of the course with organizers and thus actively assist in the further development of this form of learning.

Website also has a forum where participants could discussed about topics specifically related to the elements of the course, as well as topics in general astronomy. The course aims not only to organize lectures, but also to bring together groups of people who share similar interest and connect with each other to exchange their experiences and knowledge.

The course has achieved great success and all participants who successfully completed the course received their certificates for successfully completing the course.

5. Conclusion

In this paper we presented the application of the Internet in promoting astronomy and explained a new concept in amateur astronomy called “Astronomy from the chair” closer.

Thanks to the rapid development of the Internet a new channel for communication and tools for people to engage in amateur astronomy is created. Based on the above examples we see that the Virtual Telescope uses the Internet in the proper manner and brought the world of professional astronomy maximum closer to amateur astronomers around the world. Also, the Internet is one of the factors that connect people and the emergence of the concept helps to used more efficiently astronomy resources. It also allows more people to be involved in astronomy and actively begin to deal with it.

By using the Internet it is possible to organize online courses in Astronomy. One of these is the Introduction to Astronomy organized by Coursera organization and prof. Ronen Pleser. Modern technology has made it possible for people from all around the world to attend these courses. It allows unlimited communication with people around the world who share the same interest via forum and chat, presence at lectures, solving of specific tasks and problems, as well as the simultaneous verification of results. Internet makes it possible to efficiently master the matter, because studies have shown that the man could remember about 20% of the data if they had only heard it, 40% if they had seen and heard, and 75% if they had seen, heard, and actively used. We hope that further development of this type of technology will improve the promotion of astronomy and ways of dealing with astronomy, but the further development of this concept will be based also on the enthusiasm and energy of the promoters of astronomy such as Gianluca Masi from Virtual Telescope and Ronen Pleser professor at Duke University who have their will for astronomy successfully transferred to thousands of other astronomers enthusiasts.

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Astronomical activities for all

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Abstract

We have developed a series of astronomical activities and tools specifically designed to help when teaching or communicating Astronomy to people with different kinds of disabilities. In particular, we will consider materials for people with cognitive disabilities, motor disabilities and vision impairments. We will present our most recent project: "A Touch of the Universe", a kit for the visually impaired. We would like also to note that all these materials are useful in regular astronomical activities, as they can help anyone by enhancing the learning process, regardless of their particular abilities.

Keywords

Astronomy, educational material, special needs audiences.

1. Introduction

Since 2003 our group has been developing astronomical outreach activities for groups of people with different disabilities. Here we will present a short description of the different tools we have created so far. The ones related to the International Year of Astronomy 2009 (IYA 2009) can be found in [1].

2. Interactive talks for public with cognitive disabilities

These were the first activities we developed and they were mainly short powerpoint presentations and hands-on activities related to those.

One of the presentations is mainly about astronomical images and the physical senses, and it is to be watched with sensorial stimula, the public touching cold, warm, soft things according to the presentation: touch ice when showing Europa's surface, or a baloon with warm water when showing Venus images. In this way thay make a connection between tha images and what they feel, smell or touch.

A second one is a trip from the Sun to the Cosmic Microwave Background, with images from the spaceships that travelled to the various planets. These two presentations are better shown with some relaxing music.

A third presentation is about a trip to the Moon and which means of transport one needs to get there. A few persons in the public are given a picture of different vehicles which they will be told later to append on a large poster for discussion.

Figure 1. *Building cardboard sundials and constellations with luminiscent stars.*

Along with the presentations we also organise some hands-on activities related to the topic covered. They include building a cardboard sundial, drawing constellations with luminiscent stars or building an astronomical mobile, depending on the abilities of each person and the topic of the presentation.

Figure 2. *Ladies showing their impressions about the life cicle of the stars*

Finally, we also created another talk, "The life of the Stars", in which the cicle of life of three different stars is told, from their formation in a protostellar cloud, to its final death, in an explosion, or quietly. The participants were told to make some drawings about the life of the stars, at the talk's midpoint. Those were lately used to make a book for people with cognitive problems [2]. Participants were also invited to observe the nearest of stars, the Sun.

Figure 3. *Observing the Sun*

3. Open source software for people with motor disabilities

Some people have motor problems, like those suffering from cerebral palsy or brain injury. Even speaking can be difficult for these persons.

A way to establish communication with the external world is through the use of a computer attached to the wheelchair, with a special software. The existent codes are not open source and have standard settings, so they cannot be adapted to the special characteristics of each person.

We have developed an easy-to-adapt open source software - “Astroadapt” - as an alternative to the regular market codes. In addition, our software includes astronomical contents in order to make astronomy more accessible to this group of people.

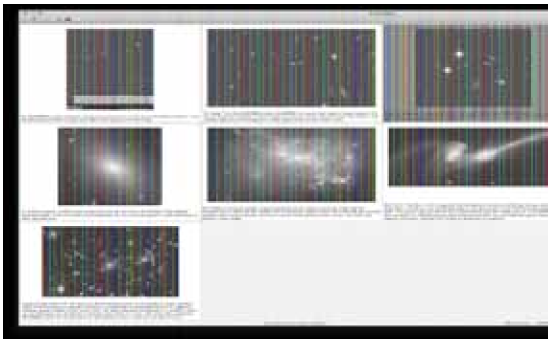

Figure 4. *Astroadapt: screen capture. The boxes are sequentially enhanced in colour.*

Figure 5. *Astroadapt: screen capture. When the user presses any key on the computer, the enhanced box is enlarged and a short explanation of the picture is provided.*

The software is on a multilingual platform, easy to translate into other languages. One can select the scan speed, colours, fonts, etc., according to the user preferences. It can save and reproduce sound files, and automatically read the texts.

4. Activities for people with visual impairments

Astronomy is a highly visual science, but there are ways to make it accesible to a visually impaired public. Here are some of the projects we developed in this field.

4.1 The Sky at Your Fingertips

Back in 2000, the Astronomical Observatory of Padova had the wonderful idea of creating a web page about astronomical concepts that could be read by the computer voice processor, along with figures specially designed to be printed in relief [3].

On occasion of the IYA2009, the site was renewed and we translated the web page into Spanish and printed a book with their contents, that was sent to different blind organizations, libraries and universities.

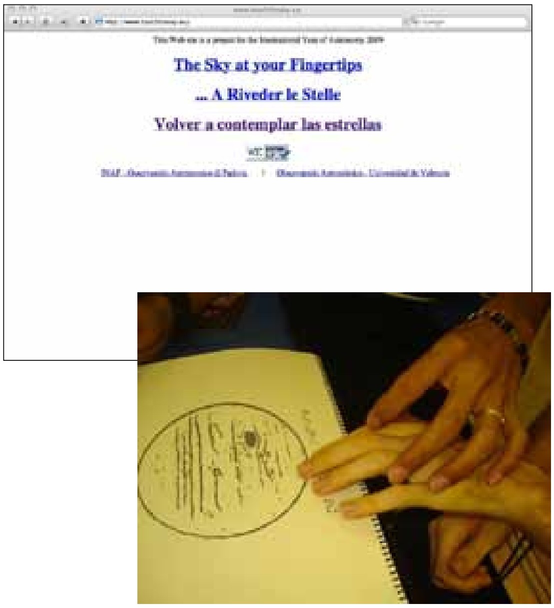

Figure 6. The Sky at Your Fingertips website (top) and the book in an exhibition at the University of Puerto Rico (bottom).

4.2 The Sky in Your Hands: a planetarium show for the visually impaired

Based on a previous experience by Sebastian Musso in Argentina, we wrote an original script, and every constellation or object was linked to its own sound effect. The soundtrack has seven channels and in this way we can have the sound of a particular object coming from the position on the dome where it is being projected.

We also designed a tactile hemisphere with constellations engraved in a way such that the person holding it could touch the shape of the constellation and follow the script throughout the sky (see Figure 4). For this we used different sizes of ``stars" and kinds of lines engraved on the spheres.

Therefore, we needed two narrators, one for the Astronomy program, the other one to guide the public through the half-sphere so they could find the sequence of objects that were explained in the program.

The show has been shown so far at planetaria in Valencia, Porto and Lisbon and some other small venues, like inflatable planetaria. It has been recently translated into English too and we are open to more people who wish to translate it into their own language.

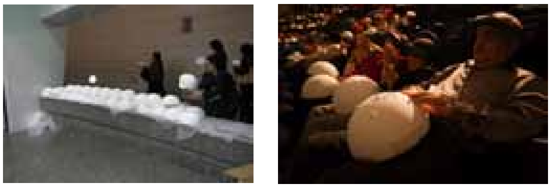

Figure 7. *Premiere of the planetarium show "The Sky in Your Hands" at the Hemisfèric theatre in Valencia.*

The hemisphere has been selected to make part of the IYA 2009 Legacy collection at the Museum of Sciences in London

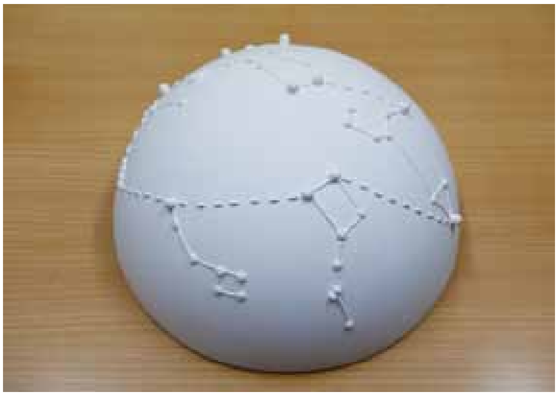

Figure 8. *Half-sphere for the planetarium show "The Sky in Your Hands".*

4.3 A tactile experience of the Moon

The Moon is, together with the Sun, the very first astronomical object that we experience in our life. As this is an exclusively visual experience, people with visual impairments need to follow a different path to experience it too. We have designed and tested a tactile 3D Moon sphere whose goal is to reproduce on a tactile support the experience of observing the Moon visually.

We have used imaging data obtained by NASA's mission Clementine, along with free image processing and 3D rendering software. This method is also useful to produce other artifacts that can be employed in the communication of astronomy to all kinds of public.

Our goal was that of conveying the visual impression that we have when looking at the Moon. We did not look for a mere topographical representation. Therefore, we build a model in which visual features were enhanced (regardless their real relief, like crater rays), smoothing out less important features for the sake of clarity. We associated a Braille letter to a selected number of terrain accidents, and an acompanying document in Braille lets the user know what does each letter stand for.

The North pole has been marked by a 'T', and the vertical line of this 'T' is pointing to the near side of the Moon. A meridian marks the separation between the near and far sides. The South pole is marked by a smooth cap.

Figure 9. *Tactile moon (left) and the document with the moon's map legend (right).*

We made the Moon in an easy to share format to make the model available worldwide - a standard 3D printing format "stl" that we can easily send anywhere.

As this was a completely new project, we conducted several tests before coming up with the final design. The tests were carried out all over the world by Gloria Maria Isidro (University of Puerto Rico, Puerto Rico), Raquel Rodrigo and Maria Jose Espinaco (University of Valencia, Spain), Deirdre Kelleghan (Astronomers without Borders, Ireland), Sebastian Musso (Centro de Estudios Astronomicos, Argentina), M. Mani (AID-India), Virgina Mello Alves (Brazil), Peggy Walker (Astronomers without Borders, USA), Emilio Garcia Caro (Instituto de Astrofisica de Andalucia, Spain), Caterina Boccato (Osservatorio Astronomico di Padova, Italy), Monica Sperandio and Stefano Sandrelli (Osservatorio Astronomico di Brera, Italy).

A more detailed description of the project can be found in [4].

Figure 10. *Tactile moon testing in India. Screen capture from the VideoTube video "3D Moon Journey for Visually challenged...!" by Makkal Sevagan.*

The tactile Moon project for the blind has been funded partially by the 2011 Europlanet Outreach Funding Scheme and FECYT.

4.4 "A Touch of the Universe"

In 2012 we were awarded some funds from the International Astronomical Union's Office of Astronomy for Development to create a kit of educational astronomical materials for blind children that was to be delivered to educators in developing countries. So, the "A Touch of the Universe" project was born [5].

Our goal is to produce 30 kits for the non-profit "A Touch of The Universe" project under the framework of Universal Design of Learning (UDL) and distribute them among educators and teachers in underdeveloped countries in the Americas, Asia and Africa. We seek to help children and young adults in these countries to learn about astronomy, specially if they are visually impaired. Our mission is to alleviate the lack of inclusive educational materials in these regions.

The kit contains several items: (1) Half-sphere and soundtrack of the planetarium show "The Sky in Your Hands" (2) Tactile moon (3) Booklet with activities to be carried out with the half-sphere and the tactile moon (in Braille and normal print) (4) 30 sets of "From Earth to the Universe (FETTU)" tactile Braille prints (5) Book in Braille about the Moon, in Spanish and English, "The Little Moon Phase Book", by Noreen Grice.

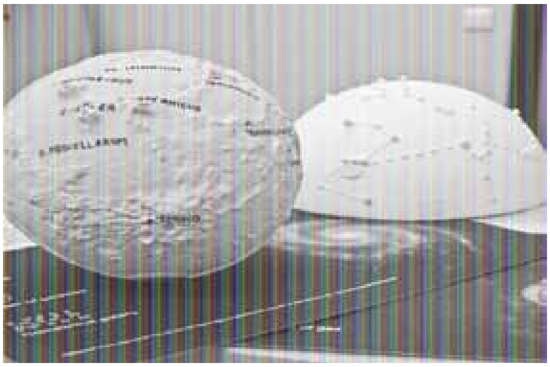

Figure 11. *Some of the materials included in the "A Touch of the Universe" kit: Chandra's braille prints, half-sphere with constellations and tactile Moon.*

The project is funded and/or supported by the IAU, Astronomical Observatoy of the University of Valencia, Universe Awarness (UNAWE), European Union, Galileo Teachers Training Program (GTTP), Astronomers without Borders (AWB), Osservatorio Astronomico di Brera and Osservatorio Astronomico di Padova (both INAF centres), the Astronomical

Spanish Society (SEA), EurAstro, the Galileo Mobile project, and the Chandra X-ray Observatory (NASA).

5. The future

We have recently won an ESA challenge on 3D printing with a tactile model of Mars. The prize was a tactile printer, and we expect to start using it soon, to 3D print this Mars globe.

6. Conclusions

We have developed and used different tools to reach a number of publics with various special needs. Appart from the Braille texts, all these materials can be used to support the learning in any kind of audience: the goal is to produce materials that can be used by a wider range of publics, accessible in differet ways simultaneously.

We also seek to help educators who might not have had any previous experience with this kinds of public, or who lack educational resources of this type. All materials here outlined have been created under a Creative Commons license and are freely available to download from the Astronomical Observatory of the University of Valencia webpage (http://observatori.uv.es) or upon request to amelia.ortiz@uv.es.

7. Acknowledgements

The IAY2009 projects were carried out thanks to two grants from the Fundanción Española para la Ciencia y la Tecnología (FECyT), under projects FCT-08-0638 and FCT-09-216, and funding from the ALHAMBRA project and the University of Valencia.

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Project MAST, A Route to Quality Teacher Professional Development

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Abstract

The Mississippi Academy for Science Teaching (MAST) is a professional development, and undergraduate teacher scholarship program, that prepares teachers from under-performing high-schools to teach physical science. This program initially was funded by Mississippi Department of Education for 4-8 grade teachers and then evolved to a program for 9-12 grade teachers with funding from National Science Foundations. Our primary goal is to improve teacher content knowledge, teaching efficacy, and, ultimately, improve student content knowledge and attitudes toward science. Rockman Et al the program's external evaluator designed a framework to evaluate the program after determining the program's logic and underlying program theory of change.

Keywords

Professional Development, STEBI

1. Introduction

This document presents the findings of the National Science Foundation funded professional development program for high school teachers of the physical sciences, the Mississippi Academy for Science Teaching (Project MAST). Project MAST is currently providing services to its fifth cohort of 60 teachers. Data for this study were collected from members of the third cohort in 2011-2012. Project MAST's professional development program is intensive and content-driven. Teachers attend a three week summer institute consisting of day long workshops at the university where Project MAST is based. They return during the academic year for five Saturday workshops. Workshop sessions are guided by the state curriculum framework for physics, chemistry, Earth and space science. Numerous content and pedagogy experts from a variety of academic and scientific institutions conduct the workshops. In addition to workshop instruction, participants receive lab equipment worth approximately $2000 and three classroom support visits during the academic year. One visit brings an inflatable planetarium to each participating school. Another provides students with a workshop on using iPods to access science related podcasts. The third visit provides each teacher with feedback on her/his implementation of a lesson plan introduced in the Project MAST workshops. The mixture of content, various instructors and workshop topics makes teacher implementation of program activities complex.

Desimone [1] argues that core features of processional development such as content focus and collective participation lead to increases in teacher knowledge, changes in attitudes and finally to changes in teacher practice and student learning. The path from professional development to outcomes is mediated by various contextual factors including teacher and school characteristics and district policies. Project MAST evaluation capture quantitative changes in attitude, teacher efficacy and teacher and student content knowledge. It also provides description, analysis and interpretation of how the intense activities of the summer and fall workshops are translated into actual teaching practice and how the local context facilitates or impedes this translation [2]. Given that there is some quantitative evidence indicating positive trends in teacher content knowledge, efficacy and attitudes towards science teaching.

2. Data Analysis, Quantitative Outcomes and Annual Benchmarks

This section lists the impact benchmarks that were evaluated during the third year of the project and provides evidence that each benchmark was or was not met. This evidence comes from five data sources: (a) teacher pre and post surveys; (b) teacher pre and post lesson plans; (c) teacher pre and post science content tests; (d) administrator surveys; (e) student pre and post surveys; (f) student science content data. In this document only (a) and (b) have been analyzed.

2.1 Teacher Outcomes

Evaluators measured teachers' efficacy for teaching and learning science using surveys that combined internally-developed items with scales from published instruments. They constructed three sets of items to measure teachers' confidence around the following MAST-specific outcomes: (a) their knowledge of physical science subjects; (b) their ability to teach physical science subjects; and (c) ability to implement pedagogical strategies covered in MAST (e.g., integrating technology, differentiating curriculum). They also used items from the two subscales from [3] Riggs and Enoch's' Science Teaching Efficacy Beliefs Instrument (STEBI) in order to measure (a) the "Personal Science Teaching Efficacy Belief" and (b) "Science Teaching Outcome Expectancy" scale. The former scale focuses on teachers' efficacy for personal behaviors, while the latter scale assesses teachers' efficacy for influencing student behaviors. During the first year of the project, evaluators selected items with the highest loadings on each STEBI subscale rather than giving teachers the entire measure. This was done to reduce the number of items given to participants and mitigate survey fatigue.

There is strong evidence that Project MAST enhances teachers' confidence in their ability to teach science subjects, teachers' confidence in their knowledge of science subjects, as well as teaching efficacy. Summary findings for each of the two subscales will be presented in turn.

2.1.1 MAST-Specific Efficacy Outcomes

Teachers' confidence in their knowledge of physics/physical science, earth science, chemistry and astronomy/space science was greater on the post survey, with most feeling at least somewhat confident by the end of MAST. While teachers felt the least confident about their astronomy knowledge, even on the post survey, this was also the subject area with the greatest pre-post gains. A paired-samples t-test was conducted to evaluate teachers' confidence in science content knowledge. Mean scores for teachers' confidence in their knowledge of physics/physical science, earth science, astronomy and chemistry all showed statistically significant gains from pre to post. These findings are a clear indication that the MAST workshops are increasing teacher confidence with regards to science content.

Teachers' confidence in their ability to teach all four science subjects was greater on the post survey, with most feeling at least somewhat confident. A paired-samples t-test was conducted to examine changes in teachers' ability to teach science. Gains in teachers' confidence teaching chemistry increased the most, showing small but significant gains. Gains in confidence teaching physics and astronomy were also significant.

Teachers also reported significant gains in their confidence using pedagogical strategies that they had learned in MAST. A paired-samples t-test indicated significant pre-post gains, as well as a small effect size.

2.1.2 Science Teacher Efficacy Beliefs Instrument Results

The STEBI instrument gives a more global picture of science teacher self-efficacy than the program-specific measures. Items for the Personal Science Teaching Efficacy Belief construct were scaled (a = 0.83). A paired-samples t-test indicated significant gains when pre and post scores were compared.

The Cronbach's alpha for the five items from the "Science Teaching Outcome Expectancy" (STOE) was low (a = 0.51), so pre-post means were compared for individual items instead of scaling these items together. Most items from this scale showed slight losses from pre to post; no changes were significant.

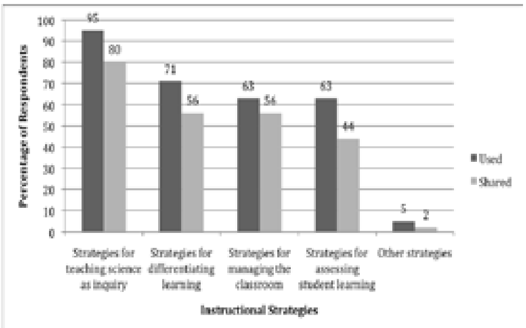
Evidence of improvements in teacher practices comes primarily from two sources: (a) a survey administered at the end of the school year, and (b) lesson plans submitted at the beginning and end of the MAST program. Collectively, the data replicates previous evaluation findings by documenting the ways in which teachers are using the materials and strategies they learned in MAST to enhance their science teaching.

2.1.2.1 Survey Analysis

As in previous years, most if not all teachers reported using MAST materials and pedagogical strategies in the subjects they teach. Sixty percent of teachers responded that they used at least some of the materials they received in MAST from all four subject areas (physics, astronomy, chemistry and earth science) to which they were exposed. Across subject areas, almost all teachers most frequently reported using at least some of the physics and chemistry materials. About a third of the teachers didn't use the astronomy or earth science materials at all. Teachers either kept the unused MAST materials in anticipation of a future need, or shared the items with others in their school who were covering the standards the materials were designed to address.

Teachers also reported implementing the pedagogical strategies they had learned in MAST and sharing ideas with fellow teachers (Fig. 1). Inquiry strategies topped the list, with nearly all teachers reporting doing it, but techniques for differentiating instruction managing the classroom and assessing learning had also been incorporated into teachers' repertoires.

Figure 1. *What Kinds of MAST Instructional Strategies Have You Used and/or Shared This Year? (N=41)**



**Note: Teachers could select more than one answer.*

Why were MAST activities and ideas so widely used? Teachers' impressions of the materials provide some answers. Respondents agreed that the activities were at an appropriate level of difficulty for their students and were received in a timely fashion. There was greater disagreement among teachers about whether they had enough activities to teach all of their standards in a hands-on manner.

In order to implement the MAST materials and activities with greater ease, teachers would have liked to have received more materials (e.g., class sets) and had more time during school to plan for how to use them. A few teachers suggested adaptations to the MAST professional development that would have facilitated later activity implementation.

2.1.2.2 Lesson Plan Analysis

An examination of teachers' lesson plans allowed evaluators to capture evidence of changes in practice beyond self-report. At the beginning of the summer professional development, Project MAST participants were asked to submit a typical science lesson they had taught in the past year. Teachers received a list of six physical science topics from which they could choose: periodic table; matter – (substances / atoms/ molecules/ compounds); force, motion and/or Newton's Laws; electricity and magnetism; rocks, minerals, and fossils; or solar system. They were asked to select their own topic if they did not teach any of the listed subjects.

Teachers received a template, instructions and an example to ensure that their plans contained information about: (a) the objectives and standards they covered; (b) the materials they used and procedure they followed; (c) any strategies they used for differentiated instruction, assessment and extension; and (d) personal reflections on the strengths of the lesson and areas for improvement. They resubmitted those lesson plans – preferably on the same topic if they taught it that year - after their MAST training was completed. If the teachers had not taught that same lesson, they were asked to submit a plan on any of the six physical science topics listed previously. The post lesson plan template was identical to the pre, except for one additional question about what (if anything) teachers had changed in their lessons as a result of their participation in Project MAST.

The 41 teachers who completed Project MAST in 2011-2012 submitted 17 lessons that covered the same topic pre and post, and 12 lessons that covered different topics. The total of 29 lessons was nearly twice the number of pre-post lesson plans received the previous year (15 pairs from 32 teachers). Most lessons came from physical science classes, but four came from biology courses in which teachers covered chemistry topics (e.g., the periodic table). Seven additional teachers submitted the exact same lesson plan pre and post, having made no changes to the information, including their reflections or even the date when the lesson was taught. Evaluators assumed that these teachers had not followed instructions (as opposed to having not changed the lesson when they taught it to their students that year) and excluded their lesson plans from the analysis.

Evaluators studied the lesson plans for evidence of changes in: (a) Big Ideas, (b) materials used, and (c) pedagogical strategies employed. Results differentiate between lesson plans on the same and different topics because the levels of inference vary between the two. Evaluators could compare the lesson plans on the same topic directly and identify differences. For the lesson plans on different topics, however, evaluators had to rely on teachers' self-reports of changes substantiated by evidence in the lesson. For instance, if the teacher claimed she had modified her approach to assigning students to small groups, there had to be information about group assignment in order for evaluators to give credit for that change having taken place. The lesson plans on different topics consequently required more inference from the evaluators and are therefore a somewhat less reliable data source. With that in mind, they are still included in the analysis as examples of the kinds of changes that teachers say they are making in their science teaching practices.

About three-quarters of the post lesson plans displayed at least one change aligned with the content of Project MAST's professional development. Nearly a third of the post lessons demonstrated the application of a MAST activity, while an additional 20 per cent of lessons added a non-MAST hands-on activity where none had been before. Some teachers acknowledged this change by adding state inquiry standards to the list of Big Ideas they intended to cover. Finally, a quarter of teachers added cooperative groups, usually by changing a teacher-led lecture to a student-driven exploration activity.

In their post lesson plan reflections, teachers revealed additional improvements they wanted to make to their teaching. One-third wanted to add more hands-on activities or refine existing ones, while nearly the same number struggled with how to teach specific science and math content. Still other teachers wanted to better target their lessons to the needs of specific learners (e.g., students with low reading levels).

3. Evaluation Findings

This section describes the implementation and effects of Project MAST with its third cohort of teachers. Project MAST is primarily intended to improve teacher content knowledge and teaching efficacy in high school physics, chemistry, earth science, and space science classrooms. It is also intended to improve the students' content knowledge and efficacy for learning science. The project is designed to achieve these outcomes through: (a) two graduate level courses in physical and space science content and pedagogy, (b) instruction by diverse instructors (experts in their fields from across the country) and (c) access to class sets of materials for distribution.

In their evaluation, evaluators collected data about program implementation and impact in an effort to validate or revise the project's theory of change. Specifically, they wanted to know about the quality of the professional development and the extent to which it contained features of effective professional development described in the literature. They also wanted to know if and how teachers were using the materials they received. Finally, they wanted to collect evidence of changes in teachers' knowledge, practices, and teaching efficacy, as well as any changes in the knowledge or science-learning efficacy of their students. The teacher content knowledge analyses are still ongoing, but as seen in the previous benchmarks section, they have collected and analyzed data on efficacy and practice.

In order to assess the quality of the Project MAST professional development workshops, the evaluators created an observation protocol to suit Project MAST's goals and setting [4]. They can triangulate these observations with participant surveys and interviews to create a comprehensive description of the defining characteristics of the professional development and the quality of its implementation.

3.1 Professional Development Workshops Observations

The observation protocol was created by first identifying constructs from the theory of change and the professional development literature, and then transferred those objectives into measurable indicators relevant to the MAST context. The evaluators trained physical science professors at Jackson State University to serve as observers because one of the goals of Project MAST is to improve university faculty members' attitudes toward teaching science. Not only were faculty members enlisted as professional development instructors in the program, they were also paid to attend and take notes at Project MAST sessions. The program developers expected that giving faculty the opportunity to observe exemplary instruction would give those faculty members a greater appreciation for high-quality teaching, as well as strategies they could apply to their own college courses.

In 2011-2012, thirty five observations from 29 sessions were collected. Each session was offered twice, and a few were observed more than once. Last year's observations, and data from the previous years, indicated that the morning and afternoon versions of each session were nearly identical, and observers had the opportunity to document any significant differences in post-session instructor interviews.

During this cohort, evaluators met with workshop observers to discuss ways to revise the observation protocol. Workshop observers each had unique ways in which they would like to see the protocol improved, indicating the variety of ways in which one may interpret course session activities. Each observer also stressed the importance of having a glossary of terms used when completing the protocols, which may encourage inter-rater reliability within the data. Evaluators are in the process of revising the current protocol in an effort to make course observations more comprehensive.

Analyses of the professional development observations suggest that the program is being implemented in a very similar manner to previous years. The hands-on activities that have been a hallmark of MAST in years past continue to be at the forefront of the professional development. Teachers first carried out the activities as if they were learners and then discussed them from a teacher perspective. Cohort 3 teachers also had many opportunities to reflect on their learning, even more than in years past. Sometimes reflection took the form of a class discussion about how to use the materials in the classroom, or how to transform a hands-on activity to emphasize inquiry. In one session that was new to the 2011-2012 professional development, teachers were introduced to "blogging," and asked to reflect on what they learned following a session on how to integrate technology into the field of science teaching. The instructor asked teachers to share their blog topics, blogging sites, and notes with the group. Reflection and idea exchanges were known to continue far past their scheduled stop time.

3.2 Participants Perspectives

Another way to assess the quality of program implementation is by documenting participant reactions [5]. Teachers completed a brief survey at the end of each session and at the end of the entire course to assess how well Project MAST had advanced their understanding of science content and pedagogy. Across sessions, participants tended to agree that the sessions were informative, motivating and relevant to their needs.

Open-ended comments were also very positive, praising the hands-on activities in particular. The word cloud included here highlights these themes (Fig. 2). The size of each word corresponds to how often it was mentioned by the teachers.

Figure 2. *Most effective components of Project MAST*

Several respondents noted that no changes were necessary in various sessions. When teachers did suggest changes, they often recommended additional hands-on activities and teaching strategies that mimicked actual classroom settings and could be directly imported into their classrooms. Given that the survey data was overwhelmingly positive. The majority of recommendations appear to have been made in the spirit of making a strong program even better.

Teachers valued not only the summer and fall sessions at Jackson State, but the three classroom visits they received from Project MAST staff: (a) a demonstration in the SkyLab portable planetarium; (b) a lesson using podcasts on iPod to introduce students to current topics in the physical sciences; and (c) classroom observation and mentoring of participant teachers' implementation of instructional materials.

3.3 Summary of Implementation Results

Observations, surveys and interviews portray the MAST professional development course as one where teachers learn creative (yet feasible) hands-on activities and teaching strategies for a broad spectrum of standards-based physical science content. In nearly every session teachers engaged in the process of science inquiry as learners themselves, while reflecting on how they could take what they'd learned back to their classrooms.

Session content was almost always delivered with an awareness of teachers' prior knowledge, and personal and professional experience. Because there was such a variety of science topics and instructors, the material could conceivably have been taught as parade of different activities, all very engaging but without a clear thematic structure or connection to teachers' classroom contexts. Instead, instructors frequently related material to teachers' prior knowledge and experiences, helping them make connections with the material while modeling a pedagogical strategy they could use with their own students. Furthermore, because the course was grounded in the Mississippi Science Standards (a point made explicitly in about half of the sessions) teachers reported that they became more familiar with the state's Science Frameworks as a result of their MAST participation.

3.4 Summary of MAST Outcomes

The Cohort 3 outcome data reinforces the trends seen last year: MAST gives teachers strategies and materials that they use in their classrooms in an effort to engage students in hands-on learning. Evaluation measures during this cohort included analyses of teacher attitudes towards science, student attitudes toward science, and student test results.

The results showed improvements among teachers in the following areas:

• Confidence in knowledge of physics, earth science, astronomy and chemistry

• Confidence in ability to teach physics, astronomy and chemistry

• Confidence in using MAST pedagogical techniques (e.g., inquiry)

• Personal science teaching efficacy

• Use of MAST instructional materials and pedagogy

While teachers showed significant gains in confidence, efficacy, and utilizing MAST techniques, the results showed significant losses in student outcome expectancy (i.e. "The teacher is generally responsible for the achievement of students in science").

Evaluation findings have shed light on MAST's implementation and impact, and have helped generate further research questions, such as:

1) To what extent does teacher participation in MAST PD demonstrate change in teacher and student learning of science content knowledge?

2) What different patterns of teacher and student content knowledge, learning, and efficacy emerge that are evident in the data?

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Tackling the decline: shaping the future of Physics through a collaborative curriculum

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Abstract

In England, the further education (FE) course for Physics, the 'A-level', has reached its lowest level of popularity in thirty years and currently only 10% of A-level students begin studies in Physics (or a Physics related subject) at University. In this paper I identify the roots of this decline and how the scientific community, stakeholder organisations, and teachers might respond to it. The primary outcomes are a rationale for the collaboration between Physics organisations to produce curricula that tackle the decline by developing the UK's first 'national curriculum' for FE that is innovative, future-focussed, and inspires students to pursue Physics.

Keywords

Physics Education, Further Education, Higher Education, Collaborative curriculum development, Social justice.

1. Introduction

In A-level Physics education in the UK there have not been the same discourses on curriculum that have been seen in other areas of curriculum theory, development and application in recent times. The primary reason for this is the nature of A-level education itself. There is no formal curriculum set by either the Department for Education (DfE) or the Department for Business, Innovation and Skills (BIS). Instead, there are only 'specifications' that are approved by the Office of Qualifications and Examinations Regulation (Ofqual). These specifications are written by examination boards and effectively determine what is taught in institutes of Further Education in the UK. Notably absent are the epistemological and axiological arguments that take place within educational discourses that are often seen in the creation of curricula. Without a formal curriculum, Physics A-level teachers have only an accredited specification and their own pedagogies to create educational experiences for their students. This places Physics teachers in an awkward false dichotomy, issues arising within Physics teaching are both blamed on the teaching profession and expected to be solved by it, without any formal assistance. There are three main areas that I wish to consider in which Physics educators need to respond to within curricula, they are minority groups within Physics, the destinations of A-level Physics students, and the view of Physics education in society.

2. Inclusion in Physics Education

In terms of raw numbers the Physics A-level curriculum serves approximately 28,000 students per year, of this number only 23% are female. While there has been a considerable decline in numbers over the past 25 years the percentage of girls studying Physics has only varied from a maximum of 23.5% in 1985 to a minimum of 21.8% in 2006 [1]. In terms of A-level subject choice Physics is 4th nationally for boys but 19th for girls [2]. It is the Institute of Physics' claim that "many girls across the country are not receiving what they're entitled to – an inspiring education in physics" [ibid] and that this leads to a poor representation of women in the field and denies girls future individual opportunities. This statement by the Institute of Physics (IoP) is an interesting one from a social justice perspective. It assumes an egalitarian outcome in which both sexes should have equal representation in terms of numbers but, more intriguingly, that it is the fault of Physics education, the Physics curriculum, and Physics teachers that girls do not study it beyond their compulsory science education. The representation of gender in society, 'gender-specific socialisation', can be held largely responsible whereby parents, teachers and peers consciously or subconsciously steer girls away from Physics because it is perceived as an unfeminine discipline [3]. An analysis of A-level candidates shows that girls are two and a half times more likely to go on to study A-level physics if they attend a girls' school yet this effect of single-sex education in Physics is not found in the other scientific disciplines where there is far less of a gender imbalance [2]. This is attributed to the dominance of Physics classrooms by both male students and male teachers, which can be off-putting to those girls who may consider studying Physics [4]. Further data analysis shows that the average 20% female to 80% male ratio amongst Physics A-level students [5] is replicated in the proportion of female to male Physics graduates and Physics faculty holders [6]. This would suggest that there is not an intentional male hegemony being propagated within the scientific community itself but an issue of engagement of girls in Physics at a much earlier stage in their education.

The question to be asked is 'What can be done?' Suggestions generally include altering the curriculum to be more appealing and promoting the benefits of a career in Physics to girls. Female gender roles in Physics can be seen as a demonstration of the hidden curriculum, a curriculum model described by Kelly [7] as anything that a student learns during their school-life whether or not it is intended. If girls do not see women within Physics then they may gain the view that there are no women in Physics or that Physics is not a subject for them. If there is a bias in gender representation in Physics throughout a child's experience of school then girls may harbour negative views of the subject from a young age. One solution from this is that it is female role models within science, in Physics classrooms and on television that would inspire girls. In highlighting the women who have played a part in Physics and who are doing so now, this implies that we may be able to promote Physics to girls without adapting the Physics specification's content, merely focussing it in a slightly different way.

Of course gender is only one aspect of inclusion that must be considered by Physics educators. Fraser [8] discusses injustice in terms of recognition, stemming from cultural domination, the non-recognition of sections of society and disrespect towards groups and/or individuals. It was during the 1980s and 1990s that education broadened its concerns to include "social differences and inequalities, notably gender, sexuality, 'race', and disability." [9] and it is altogether likely that these too result in students from minority groups not deciding to study Physics.

While scholars such as Anthanases & Martin

[10] are advocates of placing the resolver of injustices within the classroom, others believe that a co-ordinated approach would be more just as it would be able to reach more students than single teachers and make it easier for teachers to act on issues of inclusion and the promotion of Physics to all groups within society.

3. The future of A-level Physicists

In 2011 the number of students who received Physics A-levels in the UK was determined to be 32,860 students; that September 31,845 applicants to first-degree courses held a Physics A-level [11]. While these data sets cannot be directly compared, it is clear that the majority of students who sit a Physics A-level go on to a University course.

Of those students who entered University with a Physics A-level in 2011 only 9.7% went on to study Physics [12]. Physics is the largest percentage subject destination individually however it is only marginally so; Mathematics and Mechanical Engineering were similarly popular and more than 30% of students began courses with no direct relation to the material covered in their Physics A-level course [13]. Much of the course content that is taught to students is therefore unused directly or of only tangential relevance suggesting that, for some students, it may be a strategic subject choice to ease access to Higher Education than through a genuine interest.

The IoP [14] suggest that the wide range of destinations of A-level candidates indicates that Physics stands as a subject known for being a 'strong' A-level. With it students demonstrate that they have a particular set of skills that are useful in many subjects outside of Physics: mathematical ability, problem solving, abstract concepts, etc. Young identifies acquisitions such as this as 'powerful knowledge', information which is of paramount importance to social mobility and not easily gained outside of educational institutions [15]. Young may be satisfied that Physics A-level students gain access to 'powerful knowledge' because the majority of them go on to University. However, this does not nullify the suggestions that education should be accessible to all; instead it presents a different question that is not widely considered outside of Physics [16]. If students have access to the 'powerful', socially prosperous Physics knowledge and gain the qualifications they need to go on to Higher Education then why do they not go into Physics?

Even though Physics appears to be declining in popularity it is in demand by society in terms of use by the general populace and the consequent economic advantages. A balance needs to be struck between students finding Physics interesting (and thus wanting to study it) as well as it having the best outcome for society (which requires it to remain a challenging subject and act as a conduit to Higher Education). As society is increasingly dependent upon advanced technologies it is imperative for young people to learn the skills that can allow them, and us all, to flourish in the future. Here the view of society's common good means that Physics cannot sacrifice its challenging curriculum content and skills in order to be more appealing to young people.

In 2007 the IoP commissioned a report by Greg Rowland Semiotics to investigate what will "make physics a more attractive option for young people at A-level and degree level" [17]. They concluded that the IoP should promote Physics through specific terms: image, popular culture, and what draws young people to careers; primarily how Physics can be more appealingly presented. The IoP quote the report extensively in their subsequent publications, specifically this statement:

"While lay-people go about their lives understanding little of the world, physicists have access to a greater understanding of the universe that everyone else merely occupies" [ibid]

In a separate report 'Why Study Physics?' the IoP attempted to describe to students the opportunities available to them if they chose to study Physics at A-level and University:

"Science and engineering are key to renewed economic growth, and to meeting the challenges of the 21st century, from sustainable energy and global security to lifelong health and well-being. To rise to these challenges we need to ensure that our educational system is producing enough people with the right skills – and physics is an essential step in training for most science and engineering disciplines" [14]

While many high-school students are unlikely to read publications by the IoP it is exposure to these ideas that best serves them. In A Teacher's Guide to Action Hollins [18] states that the main influences on the way students view Physics were:

• Self-concept – that is, student's sense of themselves in relation to the subject

• How students experience physics at school

• Teacher-student relationships – that is, how personally supportive students find their Physics teacher

These three influences are important in the sense that all involve the teacher in some form but also such that the first two can be assisted through an appropriate curriculum and exposure to Physics in a positive manner via the involvement of Physics organisations. It is this exposure, and the involvement of teachers that I will now examine.

4. Physics in Society

The peak number of students studying an A-level in Physics was in 1985 when 46,606 students completed the final examinations, in 2006 the number reached its lowest of 27,368 and has remained less than thirty thousand in each year since [1]. Of similar concern is that Physics has plummeted from the most popular science course throughout the 1980s to the least whilst Chemistry has stayed at broadly stable entrant numbers and Biology has increased by 40%. Clearly this drop is a consideration for the Physics curriculum and the view of Physics by society. Already noted is the importance of Physics to the future of society but demonstrating this beyond mere conjecture is difficult.

In 2010 only 2,200 of the 3,637 students who began a University Physics course in the UK graduated from that course. 11% of those graduates were unemployed 6 months after their graduation and only 3% were employed in a STEM related job [11]. These statistics are concerning for several reasons; when students are considering future career paths for Post-16 education the employment statistics are not enticing and, despite a shortage of students with Physics qualifications, they are more likely to steer students away from the field. This data is more of an issue for the Higher Education sector however BIS [19] noted that to increase the status of science within society a vital factor was learning. Following their report they formulated the 'Engaging the public in science and engineering' policy recognising:

"Science and research are major contributors to the prosperity of the UK. For our prosperity to continue, the government believes we need high levels of skills in science, technology, engineering, and maths (STEM), and citizens that value them." [20]

The BIS has primarily undertaken the promotion of science in events that involve secondary school and FE students but mainly by funding organisations and events in order to widen participation. This funding for Physics is an important one when analysing socially just educational practices; this funding is not in addition to the department's budget and requires it to be taken from other areas (and potentially other subjects) in order to be given to the promotion of Physics. This could be considered in line with a view of social justice as being the ‘common good’ where society will benefit more from government spending in Physics and STEM than in other subjects but this is a delicate path to tread.

Young describes the most just forms of schooling are ones where the school enables students to gain the powerful knowledge from the internal structures (like individual subject disciplines) and external structures (the link between schools and professional or academic communities) [21]. If powerful knowledge is to be gained by pupils then local, national, and international groups of specialist teachers must be involved with University-based (and other specialist) selection, sequencing and inter-relating of knowledge to construct appropriate curricula [15].

5. Taking charge of the education sector

I have discussed several issues that affect Physics A-level education. It may appear that there is greater flexibility in A-level teaching because of the lack of a national curriculum but this is not the case. Further Education specifications provide the knowledge and skills that teachers need to impart but many educators, especially new or inexperienced teachers, find it difficult to flexibly accommodate issues of social justice that arise in their classrooms [22].

Of the three issues that I have identified there is a common thread that runs throughout their potential solutions. When considering gender and other minority groups it is to highlight the diversity of Physics. For the lack of students who go on to study Physics at University the solution was to avoid the temptation of lowering the level of knowledge within the curriculum and instead focus on the benefits of Physics to society and to inspire children from an early age with the wonder of Physics. Finally, I considered the concerning trends that signify a decline in Physics within society, despite an increase in its prevalence; here it was trickier as there are many different angles but overall my conclusion was to forge more powerful links between the Physics community and Physics students.

Such links do already exist; the Institute of Physics currently funds 100 scholarships of £20,000 for graduates with “outstanding knowledge of school-level Physics and the potential to become an inspirational Physics teacher” [23] and, while mandated, they run the selection process independently. For current Physics teachers the UK has many options available through organisations such as the National Science Learning Centre and the British Council. Both organisations fund Physics teachers to receive training that will benefit their students, be it visiting CERN to gain ideas on teaching particle physics or providing basic physics courses for non-specialist science teachers (to give only two examples of many opportunities). Most UK universities with Physics departments run outreach programmes to local schools and through public events either funded by their institution or through other grants from Physics organisations like the IoP. Similarly STEM employers and educational charities offer programmes run in schools, focussing on National Science Week, that are often free or have heavily subsidised costs. This identifies a clear willingness for those within the Physics community, as employers, educational organisations, and research institutions to engage with the public and especially with young people. Unfortunately, despite the extensive involvement of stakeholder organisations in educational outreach to students and teachers the effect on STEM employment and transitions to Higher Education is still concerning and, unless more can be done within schools, more of the same is unlikely to result in improvements.

The common thread throughout this paper is the presentation of Physics to students. Students need to understand what Physics is, what Physicists do, but most of all they need to be able to see themselves as Physicists. This is possible within a classroom and the potentials offered by e-infrastructures are large and allow a more direct involvement in actual Physics by students rather than simple modelling and experimentation within the classroom. This does, however, still require teachers to be the driving force behind the initiatives and ensuring a consistent approach by all teachers of Physics is unlikely. It is my view that a more engaged approach is needed and that, despite objections that would likely arise, it may be time to consider more radical solutions.

The Institute of Physics have already been involved in the design of new specifications with exam boards in the UK and have acted as advisors in the development of new national curricula however the result was out of their control. It is my suggestion that Physics organisations could attempt to improve all of the situations that I have highlighted by a direct creation of curricula to be taught in schools. Such curricula could not only assist teachers by providing access to more impactful resources than they could create themselves but also provides a conduit to facilitate this to all Physics teachers and, in turn, all students. As well as resources such a system would also allow the Physics community to actively respond to its needs rather than act as advisors to exam boards or government education departments in the hope that they have sufficiently synchronous educational ideologies.

6. Summary

Within the educational discourses there are fundamental aspects that arise from the suggestion that the control of curricula could be given to an organisation instead of a government however the Education Act 2011 [24] already designates a regulatory body (Ofqual) to interpret legislation and control the specifications and content created by exam boards. While technically charities, they do compete between themselves financially and over A-level qualifications. As such, the principle could be no different between competing, or collaborating, Physics bodies like the Institute of Physics or collaborations between academic institutions.

While involving large changes in approach and commitments it is my suggestion that unless Physics organisations attempt to tackle the decline in Physics education on a much larger scale than they currently do both the Physics community, STEM employers, and society as a whole, will begin to suffer the decline as well.

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Creating an Effective Educational Activity for Teachers

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Abstract

From traditional to non-traditional methods, many government and non-government institutions around the world produce more and more educational activities for teachers. With the availability of internet throughout the world, large repositories of resources are emerging. But how effective are these activities? How do we determine what goes into creating an effective educational activity? This paper will discuss Methodology, Readability, Visualisation, Audience, Skills and Interface which are the key elements of an effective educational activity.

Keywords

Astronomy, Peer-Review, Repository, Resources.

1. Introduction

With the availability of internet (Table. 1) from desktop to mobile, from classroom to playground, the content accessed daily has increased astronomically during last ten years. This has lead to change the way education perceived throughout the world. Over the years numerous projects and groups have and continue to contribute creating both effective and poor educational resources. Keeping in mind that teachers have limited time to find the right educational resources they need, the availability of large number of resources could be confusing. The need of quality educational resources is there today more than ever before. In order to create a balanced, quality educational resource, there are few factors to consider such as Methodology, Readability, Visualisation, Audience, Skills and Interface. Once a resource is created, sending it through a peer-reviewed system will help to increase the quality further more.

	2005	2010	2013
World population	6.5 billion	6.9 billion	7.1 billion
Not using the Internet	84%	70%	61%
Using the Internet	16%	30%	39%
Users in the developing world	8%	21%	31%
Users in the developed world	51%	67%	77%

Table 1. *Worldwide Internet users*

2. Components of a resource

Resources crated for online or offline usage, classroom or outdoor, or a mix of these platforms. Regardless of these platforms, every resource includes few key components which improve the quality. Each component is to be carefully looked into and implement.

2.1 Components: Methodology

Majority of the resources nowadays tend to use an Inquiry-Based Learning (IBL) method for activities as it is a learning that is based on the investigation of questions, scenarios or problems. Students or participants (inquirers) identify the problems themselves and research on the issues to find solution with the help of a teacher (facilitator). Open learning is an important part of IBL. It allows the inquirers to experiment and go beyond the conventional and structured learning environment.

Classic activities such as "Water Rocket" is based on Action Learning where team of students will experiment with the model they create to get the best results. This also relates to one of the basic human fundamental method of solving problems - trial and error learning - where each failure is learning.

Whether it is IBL, Action Learning, Open Learning, Discovery Learning or Process Oriented Guided Inquiry Learning, the method use in the resource is important. Highlighting the method helps the teachers to consider the resource to be used or not as some curriculums restrict to certain methods.

2.2 Components: Readability

Many content creators pay less attention to the language used in the resources. Proper usage of words and phrases helps to create user-friendly content. Majority of the English speakers are non-native, therefore the language used should be simpler (Fig. 2). Running the text content of the resource through a Readability [1] test could increase the quality. Another option is to make the content available in different languages.

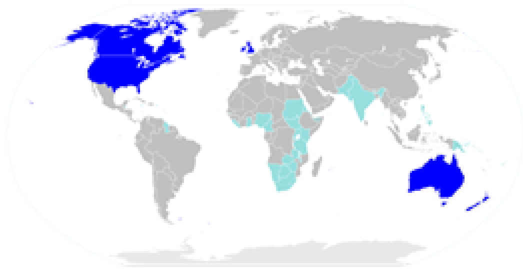

Figure 2. *Countries where English is an official or secondary language.*

2.3 Components: Visualisation

Many people enjoy astronomy as a hobby because of its visual appeal. Human visual perception helps to grasp initial understanding of the surroundings or situations. Same method could apply to creating resources. Showing the content with a visual appeal [2] will not only help towards the better, faster understanding of the activity, but also the content will be user-friendly.

2.4 Components: Audience

Another important component is the audience. The content created appeals to two levels of audience: teachers - primary audience who use the resources in and out of the classroom and the students - secondary audience who use the resources under the observation and guidance of a teacher. It's important to keep both level of audience in mind when creating resources. It eases the implantation of the activity by primary audience to the secondary audience.

2.5 Components: Skills

A resource has two categories of skills (or knowledge areas). Skills which are needed to use the content and skills gained by using the content. Identifying these two set of skills helps the teacher to determine whether the activity is suitable for the need and applicable to the secondary audience.

2.6 Components: Interface

Educational interfaces have evolved over the years from offline, online, virtual and softwares to apps, teleconferences and Hangouts. This also made it possible to access content across borders, especially from developing countries. It's important to identify which interface to use. Identifying the audience helps towards this. For an audience from a developing country, offline, online and apps interface would be better suited than teleconferences due the limited access to internet.

3. Peer-Reviewed Resources

Availability of large number of educational resources and repositories make it difficult to find quality content. Setting up a quality assessment platform would help determine best resources.

Scientific papers get peer reviewed thoroughly to ensure the standards of quality before publication. Similarly astronomical educational resources could be filtered through a quality assessment to maintain a standard of quality.

4. Conclusion

Astronomy educational resources are being created by various projects and groups quite often and increasingly. When creating resources, it's important to consider all the components in order to create a quality product. Method used, checking the readability, implementing a good visualisation, identifying the audience, highlighting the skills and considering which interface to use will ensure the quality of the resource. Implementing a peer reviewed system will help to keep a standard of quality.

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Telescopes to Tanzania

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Abstract

Telescopes to Tanzania is a program initiated by Chuck Ruehle in 2010 to use Astronomy as a vehicle to teach science, technology, engineering and math to the Meru community in northern Tanzania.

The program has moved from teaching students-- to preparing teachers in using hands on educational methods in presenting their lessons---and now will focus on the development of center for science education.

There are three major challenges: 1.Limited resources: in classrooms and the Tanzanian economic poverty. 2. Teachers who have never had "hands on" experience in learning. 3. Locations that lack a regular power source and little internet access.

Keywords

Tanzania, Astronomy, Center for Science

1. Introduction

In 2013 Telescopes to Tanzania began a major shift in focus and intensity. The emphasis will be on creating a Center for Science education (The Center) in Tanzania with leadership that is based in the community and native to Tanzania and East Africa.

2. Rationale

The creation of the Center for Science and Observatory is based on an understanding of the critical role of astronomy in teaching science, and the importance of building the curiosity of students for the love of science subjects.

"At the 6th Science Centre World Congress convened in Cape Town, South Africa from 4-8 September 2011 delegates from 56 countries assessed the impact of science centers worldwide and formulated plans that will ensure that they continue to play a constructive role in addressing global issues at the interface between science and society." With this beginning of the Cape Town Declaration it is clear that a science center approach to addressing the need for hands on, "smart play" education is an important community resource.

The recent year's national examination results in Tanzania have shown poor performance in science subjects as well as a decreasing number of students who are taking science subjects. There are number of reason for this trend, but teaching methodology is one concern according to the assessment report. "While lots of things are important, we need to prioritize on the most important factors that make a big difference in quality learning, such as motivating teachers and holding them accountable, and creating an environment for children that is engaging and interactive ."

"The Quality of Teaching, Learning, and Application of Science, Mathematics, and English in the Education Sector" of 2012 by Tanzania Education Network

3. Partnership

Intrinsic to the development of the Center for Science in Tanzania is that it is sustainable. Partnership with governmental agencies, leaders in the educational structures, local authorities and both private and public institutions will be essential for the work to continue. Partnership also with the scientific community is essential.

Since 2011 a Tanzanian partner in the work has been UNAWE (Universe Awareness)-Tanzania, lead by Mponda Malozo. UNAWE Tanzania is a registered non-profit organization initiated by volunteers working with Tanzanian youth. Its aim is to awaken science curiosity among Tanzanian children from very young ages. It works mainly with primary school pupils and teachers in Tanzania, and also partners with different national and international organizations. It offers teaching materials to teachers, children as well as interested individuals and collaborates with other organizations to conduct teachers' trainings for primary school teachers in Tanzania.

TtT has worked in close collaboration with Astronomers Without Borders (AWB), the International Astronomical Union (IAU), Office for Astronomy Development (OAD), Galileo Teachers Training Program (GTTP), Global Hands on Universe (GHoU), Café Scientific and the Meru Diocese of the Evangelical Lutheran Church in Tanzania.

UNAWE-Tanzania and its partners are now working hand in hand with TtT to make sure the initiatives deployed reach a wide audience in Tanzania while continuing to provide leadership in future centers in the East Africa region. The establishment of a Center for Science and an observatory is the strategy which shall serve the common purpose of astronomical organizations in the region.

4. The need for a Center for Science

The Telescopes to Tanzania Teachers training conducted at Mwangaza Education for Partnership Resource Center in Arusha in November 2012, included 50 primary and secondary school teachers. Teachers learned to employ new ways of teaching science using astronomy as a tool. They learned how to create their own models based on readily available materials, and experienced researching material on the internet. The entire program focused on how to integrate astronomy into the national syllabus/curriculum as outlined by The United Republic of Tanzania Ministry of Education and Vocational Training.

Most teachers were not aware that astronomy is part of the national curriculum. This is largely because of the lack of training in applying hands on tools and lab style classrooms. Even the national exams fail to ask questions related to astronomy due to a limited understanding of its possibilities. There is still a widespread misunderstanding that our solar system is all there is to the universe. Without further learning and teaching this will continue to be all that is taught.

The establishment of the Center for Science and Observatory will create a path to learning that will help teachers, education officers, students and amateur astronomers understand what astronomy can offer science education in Tanzania through the capacity building activities it will offer.

5. Specific goals of the Center

1. To conduct astronomical and science training for teachers and students as outlined in the preceding rationale.

2. integrate astronomy in the teaching curriculum as outlined in the national syllabus.

3. To develop and disseminate hands on science and astronomy teaching resources.

4. To create a model science laboratory and observatory with telescopes computers, a portable planetarium, internet capacity and global connections to other observatories around the world.

5. To serve as an equatorial dark sky observing center for tourists, this will serve as a source of funding.

6. A description of the Center

The Center shall be a non-governmental organization based in Tanzania with majority of its members and teachers being Tanzanians who work hand in hand with astronomy or are connected to science education and affiliated members in other East African countries and the international astronomical community.

It shall be located in Northern Tanzania off the Moshi-Arusha tarmac road which is the major tourist circuit of Tanzania, near or close to secondary schools which have already worked with and have established relationships with TtT.

The Center shall consist of science demonstration laboratory, roll off observatory for the scope(s), guest accommodations for up to 12 persons, library and administration offices. The laboratories shall be fully equipped with resources necessary for doing astronomical demonstrations and provide hands on science, math, and geography training that will be in line with the national curriculum.

The Center is intended to be financially sustainable through astro-tourism activities and other relevant legitimate aids. Once operational, the money generated shall be used to sustain the center on a daily basis. Minimal support from external sources will be necessary for its day to day operation. By being located in the tourism circuit within Tanzania it shall be an attraction for those who wish to observe equatorial dark skies from Africa.

7. Expectations and hopes

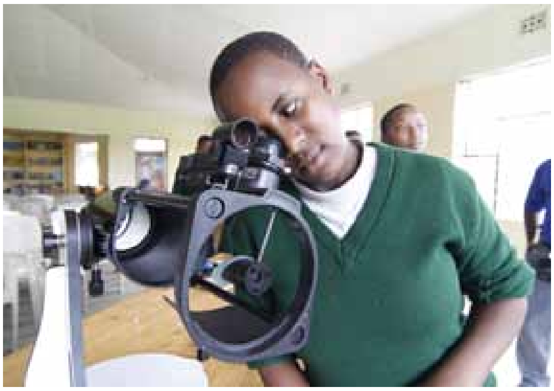
The sincere intention of this project is to insure that the young people of Tanzania and their teachers are not "left behind" in the pursuit of scientific inquiry. With the further development of the East African Economic Community the quality of education must be at a level that students can compete in a more technical and science based job market.

We have seen that computers in most schools are used as a writing or record keeping tool or as a tool to teach computer classes with little if any understanding of the power of teaching or researching using the internet or even using a program as simple as Stellarium to introduce astronomy subjects.

We have seen that many teachers are currently using notes they recorded during their own education. They have not had the resources to access current materials or ideas.

And, we have experienced that most science education is done from a perspective of "giving the right answer". Teachers were not prepared to have discussions on: "Why Pluto is or is not a planet"; or "How the number of moons of Jupiter may change as scientists gather more information". The notion that "what we know now" rather than the definitive all time truth answers was totally new to many of the science teachers.

With these observations and experiences we are developing techniques, materials, and ideas to help teachers change how they approach teaching not just in hands on experiential techniques…but with the ability to encourage students to explore, learn and discover on their own.



8. Sustainability

The project will collaborate with relevant people, institutions, companies and the ministry of natural resources and tourism to bring astro-tourism as one of the major components in the development of the Center. With increasing light pollution in most parts of the world Africa still possesses a dark sky beauty which creates a growing astro- tourism market in Africa.

Currently one of the most important assets of North East Tanzania is its dark skies. As it has developed a viable tourism based on safaris into the national parks, the potential for Southern Hemisphere dark sky observing is significant.

We are currently working to build a sustainable business model for the ongoing work of the Center. The importance of astro-tourism is not only to serve those who desire to be exposed to the great skies of Tanzania, but to raise the awareness of sustaining a dark- sky environment.

It is our hope that teachers in Africa and astronomers from around the world will be able to meet and share the wonder of the night sky, the importance of astronomy as a gateway to science and build relationships that will further science education around the world.

9. Request for help

GHOU will be an important event for Chuck and his wife Sue Ruehle this summer in exploring the many possibilities of the science center. We are seeking to:

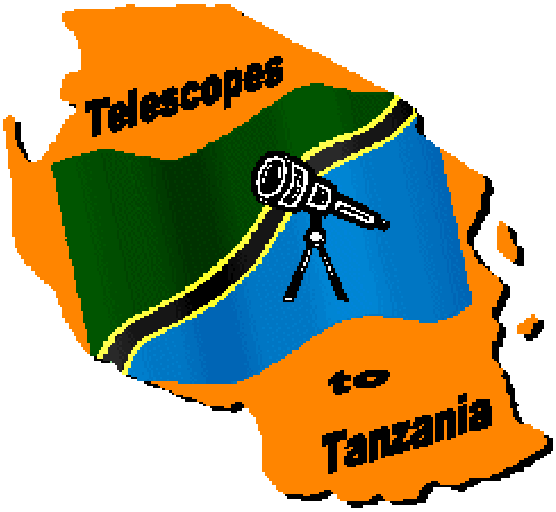
1. gain insights and ideas for teaching science

2. learn how others have worked in science centers with both teachers and students

3. gain insight into materials and resources that are needed or that may be available for the center.

4. gain support for the project both financially and with those committed to teaching science through astronomy.

5. build a network of people who will support and help in creating a strong base for science education in Tanzania and East Africa.



Project “Astronomy from an armchair” in Nis

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Abstract

The project “Astronomy from an armchair” was initiated by five students of physics in May 2012. The aim of the project was to build the first observatory in the City of Nis and to make an opportunity for wider population to become interested in amateur astronomy and scientific research. Also, using modern Internet services and Web 2.0 technologies all astronomy enthusiasts who understand Serbian language will be able to attend an interesting popular astronomy talks and observations. In this paper we will present the results of the current implementation of the project, popularization of astronomy and plans for the future.

Keywords

Amateur astronomy, popular science, observations, Internet

1. Introduction

“Astronomy from an armchair“ is a project realized by a five-member team of students from the Faculty of Science and Mathematics, Nis, in cooperation with members of the Astronomical society “Alpha“ from Nis. Members of the team are: Zoran Tomic, coordinator, Milan Milosevic, Marko Rancic, Sasa Rancev and Nenad Zivic. The mentor of the project is Prof. Dr. Dragan Gajic. The aim of the project is to promote astronomy and opening the first astronomical observatory in Nis, on the roof of the Faculty. The obseratory, apart from the possibilities of quality astronomical observations and astrophotography, is equipted for the observations to be made over the Internet utilizing the concept of “Astronomy from an armchair“. Its services are available to high-school students, faculty students, and all others interested. The idea is also to demonstrate a new concept in amateur astronomy called “Astronomy from the chair”. Astronomy from the chair is the name for a concept where amateur astronomers can deal with astronomy from their homes using the Internet [3].

The observatory is equipped for night-sky and Solar observations. Complete equipment is controlled over a computer and observations are performed over the Internet. Handling the equipment will be simple and will not require significant prior observational experience. In the following period, video instructions will be made for future users. The members of the team will be available for users in need of help and instructions.

The progress on the project can be followed at a website of the project [4].

2. Equipment at Observatory

In the spherical-shaped observatory, 2.5 meters in diameter, a Meade LX200R GPS telescope is installed. This telescope posesses a GPS device which enables precise evaluation of the geographical coordinates, time and time zone at the position of the telescope. Good polar alignment and levelization is essential in order for the equipment to work properly and to provide precise tracking of the observed objects. This process is of particular importance for telescopes with equatorial mount. For the telescopes with Alt/Azm mount, as the one used in this procect is, polar alignment and levelization is needed to minimaze the pressure exerted upon the motors that enable tracking of astronomical objects. The telescope itself posesses a compass and levels according to which it automatically locates North and levelizes itself, so presence of an operator who would manualy do this is not needed. The telescope also performs calculations of the ephemeris based on its current location, thereby enabling precise location and tracking of astronomical objects. The objective radius is 203mm, the focal distance is 2000mm, f/10 with Ritchery-Cretien optics, which is excellent for astrophotography. The telescope is fully computer-controled, by its own computer, meaning that an external computer is not required for the operator to manipulate the telescope. The telescope's database contains roughly 145000 entries of diferent astronomical objects. The database is regularly updated with information of newly found objects. The operator is also given the possibility of making manual updates himself [1].

For astrophotography a Meade DSI III Color CCD 1.4 megapixel resolution camera was acquired. This camera allows a high quality, almost no noise photograph to be taken, and it also allows the photographs to be used in photometric research of the observed objects, by converting them to FITS format. This is an advantage comparing to the DSLR cameras with higher resolution. Auto Star Suite software which goes along with the camera is used for controlling the telescope and the CCD camera. The software automatically removes the noise from photographs during the exposition. Expositions can last from 1/10000 s up to 1 h. High Sensitivity Colour Sony EXview HAD™ CCD Sensor is built into the camera. The selected camera instantly outputs high-quality color photographs, so that it would be easily used with a minimal amount of prior experience. A monochromatic version of the camera also exists, however it requires additional filters to be provided, as well as processing with an apropriate software to finally obtain a complete color photograph of the observed object. This CCD camera can be used for photographing deep space objects like galaxies, stellar clusters, planetary nebulae, but objects like the Solar system planets and the Moon also. There is a very interesting possibility of taking a series of Jupiter photographs which after an Auto Star Suite processing can result in an animation of Jupiter's rotation [2].

Lunt solar telescope with a diameter of 60mm and a focal length of 500mm was obtained so that the Sun can also be observed and photographed. This telescope is made specifically for this purpose. It contains an H alfa filter, which reduces the intesity of Solar radiation and allows observation of the Sun. Aside from sunspots, Solar prominences, Solar flares, flocculi, etc can also be seen on the surface of the Sun [2]. With this telescope on-line observations of Sun will be conducted.

NEQ5 mount was purchased in order to be able to organize observations in other locations outside the observatory. Plate will be used mainly for setting Lunt Solar telescope and Vixen 100/1000 for night observation. This mount has a database of celestial objects, which can be updated over the Internet and controlled with hand controller. Mount can also be controlled through the Stellarium application.

Currently team is working on developing software for the control of both telescopes remotely, via the web the interface

3. The Current Project Activities

Apart from the construction of the astronomical observatory, popularization of astronomy is also a crucial part of the project. Observations of astronomical objects were organized on a regular basis for general public, where people interested in astronomy had an opportunity to see for themselves how the telescope is used and how the objects are seen through it. Aside from night-time observations, Sun observations were organized. Two of the mentioned activities have already been succesfully organized. The first being a two-day activity named „Dani Sunca i Meseca“ (in English „Days of the Sun and Moon“) and the second during the international project „Noć istraživača“ (in English „Explorers' Night“) – Jupiter and the Moon observations were carried out, the activity named „Pogled u Zemljin svemirski komšiluk“ (in English „A look to the Earth's neighbourghood“). The team also managed to observe the Venus transit through the Solar telescope on the sixth of June 2012, in the early morning hours.

Team regularly monitored the interesting astronomical events. In addition to the transit of Venus, the team successfully filmed and PanStarrs comet in 2013. Team had regularly informed astronomy lovers in Nis on all of these events.

Figure 1 *- Transit of Venus*

Number of popular lectures were organized a at the the Faculty. Some of the lectures were: "Istina je tamo negde" (in English "The truth is out there"), "Odlaže se smak sveta do daljneg" (in English "End of the world is postponed until further notice"), "Komete (ni)su tako strašne" (in English "Comets are (not) so terrible"), "Žene definitivno (ni)su sa Venere" (in English "Definitely women are (not) from Venus") etc. For each lecture a large number of citizens attended and always had a number of interesting questions for the speakers.

Since the goal of the project is to enable as many people to attend the lectures that take place, lectures can be followed on-line. Thus creating the conditions those other astronomy lovers from Serbia and beyond can follow astronomical happenings. The same system is used today for on-line observations events. Statistics show that there is great interest in this type of lectures, but still a significant part of the audience prefers to personally attend the lectures. Recordings of all lectures are available on the YouTube channel of the project.

Team has been a participant at two conferences: IEEESTEC 5th student projects conference at Faculty of Electronics in Nis and XXXI Republic Seminar about teaching Physics in Vrnjacka Banja.

Project was also presented at Science Festivals in Nis and Krusevac. In Nis, project idea and achieved results were presented, but due to bad weather conditions there wasn't observing. In Krusevac team together with AS "Eureka" organized observing of the Sun during the festival. Many people saw for the first time how Solar telescopes looks like and were able to see how the details on Sun's surface.

In May work on Observatory was finished. The equipment was installed in the dome and last test were done. The observatory was fully prepared for the opening ceremony, which was held in May 2013.

4. Opening of the Observatory

On May 30th, 2013 was the grand opening of the first astronomical observatory in Nis. At the opening ceremony attended the dean of the Faculty of Science and Mathematic and representatives of University of Nis, Program „Pokreni se za buducnost", Philip Morris Operations a.d., the SEENET-MPT Office Nis and the Section of Serbian Physical Society – Nis Official opening of the observatory accompanied national media and many local media. Just before the opening of the observatory, solar flare was successfully captured with equipment in observatory. The opening ceremony was broadcast live over the Internet.

Figure 2 *- Zoran Tomic and TV reporter*

In the evening part of the ceremony the audience had the opportunity to attend a lecture titled „Koliko su daleko zvezde" (in English "How far away are the stars?") and „Astronomija iz fotelje" (in English "Astronomy from the armchair"). The audience also had the opportunity to visit the observatory.

5. First on-line Observing Event

First on-line observing even from Observatory took place on June 20th. For the first observation Saturn and Moon were chosen. Observing event was broadcasted over the Internet where public could also communicate with the operators of telescopes via chat. Observing lasted for just over an hour and around 400 people, not only in Serbia but also from abroad attended this event On the Internet immediately after observing was released a video of the entire event so that all interested people can view it, while on project website photos taken during the event were published.

Figure 3 *- Saturn taken during first on-line observing event*

In the future a greater number of observing events will be organized and they will always be thematically organized.

6. Observatory Visitors

Apart from organizing on-line events, observatory is open for visitors. Since the opening of the observatory until June 25th Observatory had about 50 visitors. For each group of visitors observing with telescope is organized and also interesting presentation regarding the night sky. The biggest success is that many young children want to visit the observatory and for the first time have the opportunity to observe objects through a telescope.

On website of the project is an on-line application that interested gropus can fill to visit the observatory. Based on the number of applications received it can be concluded that there is great interest of the citizens to visit observatory.

7. Plans for the Future

In future more public lectures will be organized at the Faculty of Science and Mathematics. Public observations over the Internet will also be organized. The advantage of such program is the usage of modern equipment for observing events and astrophotography , which enables us to distinguish far more details of the observed object than the human eye can with just looking through the same telescope. Hence, the public will get a more detailed perspective of known astronomical objects and to store the photographs on their computers during observations.

Figure 4 *- Prof. Dr Dragan Gajic and the youngest visitors in front of the observatory*

The team of students will, as a part of the project, set up an astronomy and astrophotography course, where applicants can learn the basics of astronomy as a science, the celestial sphere, coordinate systems, observable objects, observational techniques and photographing techniques. The goal of the course is to create an additional group of trained volunteers to be involved in the further development of this and feature projects.

There will also be an open possibility for research for students, particularly in the field of photometry.

At the end of the project, a display of astrophotographs taken during the realization of the project will be organized.

8. Acknowledgements

The team is very grateful to the Program „Pokeni se za buducnost“ (PZB) and the Philip Morris operations a.d. company, the Faculty of Science and Mathematics, Nis and the astronomical society „Alpha“, Nis on their help and support in the realization of the project.

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Training teachers for Astronomy teaching in Southern Brazil

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Abstract

We describe the actions directed to improve the quality of Astronomy Teaching and Science Education by two Brazilian universities in Southern Brazil that are partners of GTTP: Federal University of Rio Grande do Sul (UFRGS), and Federal University of Pelotas (UFPel). We show how these institutions included the GTTP sessions in their activities, getting better public involvement through teacher´s valorization of Astronomy.

Keywords

Astronomy Teaching, Brazil, GTTP, Science Education.

1. Introduction

The need to better prepare teachers to address astronomy contents with their students is a subject that began to draw attention in the context of science education in Brazil in the late 1990s, when the importance of Astronomy for scientific literacy of the population was recognized, and Astronomy topics were included in the official curriculum of basic education in Brazilian schools. At present, the Brazilian scientific community is well aware of its responsibility in improving basic education in the country and the almost 700 professional astronomers currently existing in Brazil [1] know it's time to share with the population the knowledge resulting from the great development of Brazilian astronomy in the last 40 years.

The celebration of the International Year of Astronomy in 2009 boosted some existing training programs for science teachers and led to the development of others, including the still timid Brazilian partnership with the Galileo Teacher Training Program.

In this paper we describe the actions taken in this direction at Federal University of Rio

Grande do Sul (UFRGS) and Federal University of Pelotas (UFPel).

2. Activities developed by Federal University of Rio Grande do Sul

The Department of Astronomy of Universidade Federal do Rio Grande do Sul is part of the Physics Institute and is linked to the Astronomical Observatory, that includes the Central Observatory, the Morro Santana Observatory and the Itinerant Observatory. It is composed of 12 professors and about 20 graduate and 10 undergraduate students, with research in Stellar Astrophysics, Galactic and Extragalactic Astronomy; the professors teach in undergraduate and graduate levels, and are also engaged in many outreach activities, such as extension courses for teachers or general publics, production of multimedia texts, public talks, promotion of Astronomy exhibitions. Some relevant activities of the involved people are:

2.1 Galileo Teacher Training Program

The partnership of the Universidade Federal do Rio Grande do Sul with GTTP started officially in 2009, when UFRGS hosted

the first Galileo Teacher Training Program (GTTP) session in South America, that was held in Porto Alegre (RS-Brazil) on July 22-24 2009 (Fig. 1) within the program of the 2009 GHOU Meeting. It was attended by 12 school teachers (most of them high school physics teachers), 6 undergraduate students preparing to be physics teachers and a few invited astronomy educators.

In that occaison, eleven instructors from Portugal, United States and France trained these in-service and future teachers in the use of softwares SalsaJ, Stellarium, Universe Quest and Google docs, and showed how to apply them to the school curriculum with activities such as Measuring distance to Cepheids, Hubble expansion, and Discovering extrasolar planets. The attendants had the opportunity to learn how to access robotic telescopes, how to use a celestial planisphere, how to use a digital camera for capturing images of the night sky and how to participate in the GHOU Asteroid Search Campaign. There were two observing sessions with telescopes.

Figure 1: Participants of the first GTTP session in South America.

The second GTTP session promoted by UFRGS was held again in Porto Alegre, on July 2010, with duration of three days. It was attended by 18 school teachers, and 6 undergraduate students preparing to be physics teachers. This time all the 8 instructors were professors at UFRGS or other Brazilian Universities, but the program was very similar to that of the first session, with few exceptions: instead of Google Docs and Universe Quest activities the teachers learned how to build sundials and models to study lunar phases and eclipses. The Discovering Extra-solar planets and the Hubble expansion activities were made with the Brazilian-Portuguese versions of the original study guides. The workshop ended with a lecture on Cosmology.

The third GTTP session promoted by UFRGS was held in Gramado, on October 2012 (Fig 2), and was attended by 20 school teachers and 5 undergraduate students. The workshop took place in parallel with an international symposium of Astrophysics, and several astrophysicists professors at the Astronomy Department of UFRGS who were present at the symposium contributed to the GTTP workshop giving lectures on Cosmology, Galaxies, Black Holes, Stellar evolution, Solar system and Search for extraterrestrial life. The workshop had duration of 4 days, with the lectures happening in the morning, the hands-on activities on the afternoon, and telescopic observations at nigh. These activities included Salsa J, Stellarium, celestial planispheres, model for the apparent motion of the Sun, sundial, lunar phases and eclipss, solar system to scale, expansion of universe . The program also included 14 hours of complementary distance learning activities.

Figura 2: Participans of the GTTP session in Gramado, Oct 2012, measuring the angular size of an object in the solar system to scale activity.

The GTTP – Porto Alegre website (http://www.if.ufrgs.br/cref/gttp/gttp.htm), contains the program, photos and other details of the GTTP sessions, links to softwares and also a modest but varied list of activities for Astronomy teaching.

2.2 Itinerant Educative Observatory (OEI)

This is a permanent program of the Department of Astronomy since 1999. It aims to lecture Astronomy to teachers of fundamental and middle levels, using attractive resources such as telescopic observations, audiovisuals, and multimedia. The material resources are a van, Meade 12” telescope, binoculars, experimental kits, and computer and data-shows. The are requested by different cities of Rio Grande do Sul and nearby states, and are organized by a local committee of the requesting city. The OEI goes to the city taking the instructors (professors and graduate students of the Department of Astronomy) and the instructional material. The courses last between 24 and 45 hours (3 to 5 days) depending on the availability of the attendants and the costs of travel and lodging. The program includes a hypertext that can be accessed online at (http://www.if.ufrgs.br/oei/index.html).

OEI was recently selected by the federal government to receive funds in 2014. The funds will finance 10 training courses, outreach activities and scientific literacy for teachers and the general public of the southern states of the Brazil.

2.3 Adventurers of the universe: University + School treading together new paths”

The Adventurers are a recent program promoted by the Department of Astronomy. It develops transdiciplinary didatic sequences where Astronomy is the central focus to motivate different processes of teaching and learning. Targeting teachers from high schools and elementary schools located on socially vulnerable communities, considering different learning levels, designed for direct use in the classroom. The sequences use both new educational technologies and traditional materials. Undergraduate students preparing to be physics/mathematics/biology and geography teachers act directly with the teacher to gain experience. Furthermore undergraduate students participate in national scientific meetings presenting the achieved results.

The objective of the program is to contribute in the didactic transposition through of the discussion about how to relate astronomy with other science and non-science disciplines. Actually, it should be highlighted that astronomy does not consist of observing a static Universe – the Universe is ever changing and its observation involves its transformation. Hence, for the purposes of this project, which is intimately related to empowering socially vulnerable students to transform their own (social, political, environmental) context, we focused on three major questions: (1) How does the Universe look like and what is my place in it? (2) Is the Universe always the same? What changes in it? (3) How do we participate in the transformation of the Universe? Once we understand how each discipline contributes to answering these questions in their own fields, Astronomy's contribution for designing the transdisciplinary curricula is straightforward.

The program performs activities in collaboration with other programs and projects like OEI, GTTP, and Globo Local (http://www.globolocal.net). The Adventurers began in 2012, when, through collaboration with 20 teachers of one school, were developed didactic sequences and outreach activities that impacted 900 students. In the current year, the collaborations were expanded to include teachers and students of 3 other schools.

Figure 3: *Top: Observation of Equinox (left) and science fair (right). Bottom: Student discusses about Solar System (left) and how can to launch pet bottle rockets in Porto Alegre (right).*

2.4 Astronomy for the Community

This program, promoted by the Astronomical Observatory, consists of daily public visits to the Observatory, open to schools and general public. The visitors learn about the most important astronomical events at the time, and, if the weather is good, they can observe the sky with the Gautier (7.5 inch) and Meade (10 inch) telescopes.

2.5 Exploration of the Universe

This is an undergraduate introductory astronomy course directed to science and non-science major students at the University. It is also offered as extension course to teachers of fundamental and middle levels, in collaboration with the Planetarium of UFRGS.

2.6 Observations of Equinoxes and Solstices

This activity initiated as part of an international project Brazil-Uruguay-Argentina for joint observations of equinoxes and solstices, measuring the shadows cast by several gnomons and materializing sun rays passing through the top of the gnomons with line threads (Fig. 4).

Figure 4. *Observations of equinoxes and solstices in Porto Alegre.*

3. Activities developed by Federal University of Pelotas

The teaching and outreach activities developed at UFPel are done by the Laboratory of Astronomy at the Physics and Mathematics Institute (IFM). The laboratory group is composed essentially by one astronomer, one physicist and twelve students from different undergraduation courses. Also the group is supported by a local amateur astronomer mainly at observations activities. Since the International Year of Astronomy (AIA2009), when the Laboratory was a local organization node, the activities get improved with support of other Brazilian institutions, like Federal University of Rio Grande do Sul (UFRGS), Brazilian Olympiad of Astronomy and Astronautics (OBA) and Brazilian Astronomy Society (SAB). UFPel acquired a mobile planetarium and the fixed planetarium equipment.

3.1 Expositions

The Astronomy Laboratory has three expositions: “Astronomic objects observed by Galileo Galilei”, “At Home, at the Universe” and “Cosmic Landscapes – Brazilian version of ‘From Earth to the Universe’“(Fig. 5). The last two can be lent by schools and are exposed at the Laboratory places.

Presently the first exposition will be enlarged to focus on astronomic image improvement, comparing Galileo’s’ drawings to Voyager’s and present images.

Finally the Astronomy group are preparing a new exposition with full accessibility, about what is a today observation, focusing on the “astronomy blindness”, as it is done by the book “Hidden Universe” [2].

Figure 5. *Brazilian version of “From Earth to the Universe” exposition.*

3.2 Astronomy observations

Monthly, during first quarter Moon Wednesday nights, telescopes and binoculars are brought to downtown city to show people the moon, visible planets, nebula and other visible objects. Twice a year, mainly at meteor shower, are organized dark place observations (Fig. 6) The group has participated on simultaneous observations of solstices and equinox, as well as international campaigns, such as “Globe at Night!” and “International Observe the Moon Night”.

Figure 6. *Monthly first quarter Moon Wednesday observations.*

3.3 Planetarium sessions

While the fixed planetarium building is not constructed, the mobile planetarium (Fig. 7) is fixed at UFPel because most schools do not have places which fit its size (6m diameter). Also the mobile planetarium can be bought to local and academic events. A Brazilian government program which is supporting the planetarium activities will provide a vehicle to turn itineration a reality. As an academic place, the project comprehends students from different undergraduation courses, like movie and art design, in order to produce new programs for the planetarium sessions.

Figure 7*. School students visiting the mobile planetarium.*

3.4 Galileo Teacher Training Program and Carl Sagan Lecture Cycle

UFPel has got engaged to Galileo Teacher Training Program through UFRGS efforts. After participating at the second version of GTTP in Porto Alegre in 2010, and understanding the general structure of its sessions, UFPel held its own session in 2011(Fig.8). It was also considered as a national teacher meeting of Astronomy, called "XXII Local Meeting of Astronomy Teaching" (EREA in Portuguese), sponsored by OBA. The meeting was organized together with a public and private schools of Pelotas.

With support of OBA, GTTP general organization, UFRGS and UFSCar, the program was composed by invited talks, hands-on activities, software workshops, local teachers presentations and observations activities. It was attended by 34 teachers (Physics, Geography, Science and Primary first years), 29 undergraduation students and some high school students which were participating at OBA.

The periodicity of GTTP workshops is biennual because the group also organizes the "Carl Sagan Lecture Cicle", in which invited researchers come to talk about Carl Sagan's interest subjects, like Cosmology, Planets Exploration, Exobiology, Outreach, etc. The first cicle occured in september 2010, celebrating the Cosmos Series'30 years. In 2012, the second cicle was in november celebrating the Carl Sagan's day. The second GTTP workshop will be held in this year.

Figure 8. *First GTTP workshop at UFPEL.*

As can be seen, the GTTP partnership provided to UFPel Astronomy Laboratory the possibility to develop the continuing formation of teachers who intend to insert Astronomy at formal education, complementing the outreach activities also available to the teachers..

4. Final Comments

There is a variety of actions under development in Brazil aiming teacher training for astronomy teaching and popularization of astronomy; we showed in this work only those that are organized by the universities we are affiliated to. At UFRGS, for example, the projects GTTP and OEI have basically the same goals, and in order to preserve both of them we must unite efforts to facilitate obtaining financial funds and collaborators for the training sessions. The last two GTTP workshops, in Pelotas (out 2011), and Gramado (Nov 2012), have been organized collaboratively with different projects (OEI, Adventurers of Universe, EREA).

At this time, we lack an effective evaluation of the impact of these actions in the practice of teachers, but we know that, at least with respect to GTTP, we are far from achieving the goals initially proposed. Most teachers that participate in the training sessions feel motivated by the lectures, by the activities, by the new resources they are presented to, but are not confident enough for applying them in their classes, or because do not understand clearly the subject, or because do not know how to use the resource, or because the school does not have the necessary infrastructure, or for all these reasons. This is especially true with those activities that make use of technologies of information.

Thus, until now, the multiplicative effect of the training sessions is very small. A factor that contributes to this is the lack of structure to give support to the teachers after the workshop in order to incentivise them to use the new resources with their students.

In the last GTTP session we had, in Oct. 2012 in Gramado, the proposal of complementary credit hours to those teachers who proved the application of some learned resource in the classroom, served as a great stimulus to the course participants, and allowed the certification of several Galileo Teachers. The enthusiasm demonstrated by most teachers in doing the proposed tasks, posting in the internet and commenting on each other posts, all these seems to point to that we are on the right way.

At present we are planning a new workshop to be held in Pelotas or in Florianopolis, during the Latin America Regional IAU Meeting, in November 2013.

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The GalileoMobile Handbook : Interactive astronomy activities with low-cost materials

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Abstract

GalileoMobile is an itinerant outreach project to share astronomy with young people in regions lacking educational resources, to foster a will of learning through the wonders of the Universe and exchange different views of the cosmos.

All the activities and teacher workshops performed during our school visits are based on the "GalileoMobile handbook", of which we leave an exemplar to each visited school. This handbook comprises 21 activities inspired by multiple online sources, adapted to a common classroom-friendly format.

The activities are tailored for primary, middle and secondary schools and cover topics ranging from Stars and constellations, the Solar System, Galaxies and Optics.

The activities use low-cost materials to be doable anywhere in the world, and are as interactive as possible to convey a feeling of "learning together under a same sky".

The handbook is free to be shared with the community, English and Spanish versions being currently available to download on our website (Portuguese and Hindi versions are in progress): www.galileo-mobile.org.

Keywords

Primary education – Secondary education – Hands-on – low-cost

1. Selection of the Activities

The 21 activities composing the GalileoMobile handbook are the result of an extensive search through various didactic sources devoted to teaching physics and astronomy (UNAWE, GTTP, Stanford Solar Center, NASA, NOAO, National School's Observatory UK, ESO, among others).

They have been selected according to the following criteria. First the activities have to use only low-cost and easy-to-find materials, in order to be doable anywhere in the world including developing countries. In addition, this criterion also conveys the message that scientific experimentation and (personal) discoveries can be done without the need of costly facilities.

Second, the activities have to be hands-on and playful, for the students to "learn by doing" while enjoying the fun side of science.

Third, most of the activities (except the "teach yourself" ones, see Sect. 2) require interactivity among the students and between students and the teachers. This not only encourages a didactic shift from a more "frontal" and traditional way of teaching to a more interactive one (through analysis questions, team work, inquiry-based learning), but most importantly instigates a feeling of "learning together under a same sky", which is at the core of the GalileoMobile spirit.[1]

Finally, for the sake of an itinerant project having restricted time in schools, the essential part of each activity can be carried out in a relatively short time (30-60 min), even though the handbook contains enough background information and deepening parts for the teachers to expand the activities to several didactic hours.

Note that the criterion of using low-cost materials implies that all activities but one do not absolutely require a computer. However, the appendix of the handbook contains several accompanying images and movies that can be conveniently projected via a computer and a beamer, and the deepening parts of some activities also encourage the use of free softwares such as SalsaJ or Stellarium.

2. Adaptation and Format of the Activities

After their selection, all the activities have been cast into a common classroom-friendly and print-friendly layout, including a cover page (see Sect. 3) and illustrations.

Additional explanations of background concepts have also been included, since previous knowledge is often required to understand the activity in detail. In general the concepts described in the GalileoMobile Handbook are treated in a simple and clear way. However, if you find that topic or concept is not sufficiently explained, we hope the information we provide can serve as an inspiration to find out more about it in other ways (e.g., books, internet, or by asking experts of the field).

An analysis section was also added to each activity, as a deepening part where the main concepts are treated in greater detail. This section includes questions that the participants should answer after doing the main body of the activity. Answers to the questions are included in italics.

All the activities have been translated to common languages are currently available on our website in English and Spanish (Portuguese and Hindi versions are underway).

3. Structure and Contents of the Handbook

From the 21 activities of the handbook, 10 are tailored from primary schools, 4 to secondary schools and 7 to middle schools.

The handbook is structured in four parts according to the following astronomical topics:

1. Stars and constellations
2. Solar system (Sun and planets)
3. Beyond the solar system (nebulae, galaxies)
4. Light and optics

Each activity in the GalileoMobile handbook features a cover page with a short and concise description of the activity. It contains a table summarizing the activity basics: the intended age group, the activity duration, necessary materials, and methodological category.

The methodological categories are:

1. Experiments
2. Creation
3. Teach-yourself
4. Inquiry-based

[1] During our expeditions, this spirit permits to show that science can overcome social and cultural boundaries and can therefore be used as vector of unity between people.

Activities belonging to the Creation category involve some creativity parts in, for instance, adding colours, cutting pieces in various shapes etc. Activities belonging to the Teach-yourself category can be performed without the need of a teacher. Inquiry-based activities involve parts of a research process (such as designing a measurement strategy, building a model and making predictions, explaining one's results to peers, etc.).

Following the activity cover page is a page listing "Learning goals". These are intended as hints for school teachers about the concepts, process skills (know-how) and attitudes that can be taught through the activity. These goals can be used as benchmarks to evaluate the success of an activity.

4. Examples

To illustrate the format and contents of the handbook activities, we will give examples taken from the "Equatorial sundial" activity, which can be carried out with primary school students as well as with secondary.

In this activity, students realize a simple equatorial sundial made out of paper. The original sundial design was taken from Sky&Telescope. The sundial template was modified to be useable at any latitudes from 0° to 50° and in both northern and southern hemispheres.

The cover page of the activity is shown in Figure 1 and the procedure part of the activity in Figure 2 (how to mount the sundial).

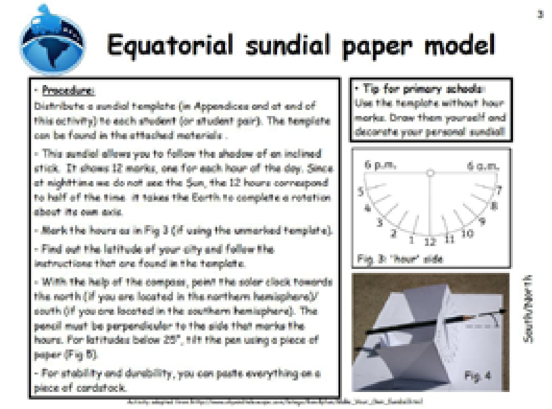
1

Equatorial sundial

- By playing with the shadow that the Sun projects on an object, you can measure the time of the day without having to look at a common clock.
- You will learn how to build your personal solar clock out of a piece of paper and a pencil, based on the apparent movement of the Sun that is tracked by the pencil's shadow.

Age	From 8 years old (building sundial) From 12 years (understanding equatorial sundial principle)
Duration	~45 mins
Activity Type	Experiments / Creation
Materials	- Sundial Templates (in Appendices) - Scissors - Pencil - Cardboard and tape or glue - Compass (to locate north/south direction)
Optional materials	- Earth globe - Paper solar disk

Figure 1. *Cover page*



3

Equatorial sundial paper model

- Procedure:
Distribute a sundial template (in Appendices and at end of this activity) to each student (or student pair). The template can be found in the attached materials.
- This sundial allows you to follow the shadow of an inclined stick. It shows 12 marks, one for each hour of the day. Since at nighttime we do not see the Sun, the 12 hours correspond to half of the time it takes the Earth to complete a rotation about its own axis.
- Mark the hours as in Fig 3 (if using the unmarked template).
- Find out the latitude of your city and follow the instructions that are found in the template.
- With the help of the compass, point the solar clock towards the north (if you are located in the northern hemisphere)/ south (if you are located in the southern hemisphere). The pencil must be perpendicular to the side that marks the hours. For latitudes below 25°, tilt the pen using a piece of paper (Fig 5).
- For stability and durability, you can paste everything on a piece of cardstock.

- Tip for primary schools:
Use the template without hour marks. Draw them yourself and decorate your personal sundial!

Figure 2. *Procedure part*

4

What's the time?

- Let's analyse:
- What time does the sundial show? Is it different from the time shown by your wristwatch?
- The time officially used is the product of a "Fictitious Sun" that moves through the sky at a uniform speed. In contrast, the "true Sun" does so with small variations in time (these are due to the fact that the Earth orbit is slightly elliptic and its orbital speed therefore varies).
- In some countries, due to their non-equatorial latitude, the official time is changed during the year to take advantage of the best sunlight. One hour is moved ahead in summer with respect to the sun.
- Finally, you are located at a longitude which is different from the one officially used to set the time of your time zone.

- Teacher tip: Use an Earth globe and a printed solar disk to demonstrate the apparent motion of the Sun and the revolution of the Earth around the Sun.

Figure 3. *Analysis part 1*

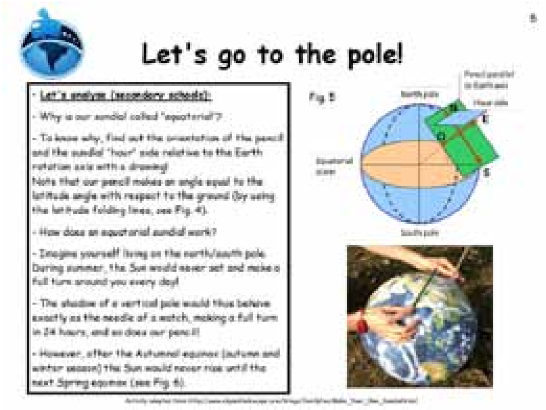


Figure 4. Analysis part 2

Figure 5. One deepening part

The learning goals of this activity are:

Concepts:

• The rotation of the Earth causes the Sun and stars to have an apparent 24h-periodic motion.

• We can use the periodic motion of the Sun to measure the time of the day by following a shadow.

• Latitude and angles

• The revolution of the Earth around the Sun throughout the year.

Science process skills:

• Build an instrument with simple materials

• Make explanatory drawing with angles (secondary students)

Attitudes:

• Realize that complex and precise instruments can be made out of simple materials.

• Raise one's awareness for the genius of our ancient civilizations who designed such clocks

This activity belongs both to the Experiments and Creation methodological categories, as youngsters have the possibility to use unmarked templates that they can decorate at will (e.g. marking the hours in different colours).

While primary school students will feel the awe of realizing a simple clock (that works!) and understanding how to use of the apparent motion of the Sun (Fig. 3), secondary school students can try to find out the principle of an equatorial sundial by working out the angles and orientation of the gnomon (pencil), cf. in the analysis part shown in Fig. 4.

With all students, this activity can be used as an introduction to the other apparent motion of the Sun, i.e. in the course of the year. It can then be concluded by discussing the use of sundials and solar observatories in ancient civilizations (Fig. 5). During GalileoMobile expeditions, valuing and raising awareness for the achievements of the ancestors has always proven a vector of exchange and unity between the students and our team.

A selection of pictures of running activities in Bolivia, Peru and India is given in Fig. 6.

5. Improvements Based on Lessons Learned

The activities composing the current handbook were chosen and compiled for the first time in 2009, prior to our first expedition in the Andes during the International Year of

Figure 6. *From top to bottom: mimicking the formation of Saturn rings (India), building paper sundials (Bolivia), identifying the Moon's features through a puzzle (Peru), building a scaled Solar system with the Earth as a peppercorn (India).*

Astronomy [1,2]. The handbook has then be the main didactic resource of the project, supporting the activities that we performed in schools during our two major previous expeditions in 2009 and in 2012 in India [3]. The handbook format of the activities proved very practical to be left in each visited school (especially after the teacher workshops), along with a CD containing the Appendices in electronic format. Since 2009, the GalileoMobile activities task group has continuously kept working on it by adapting and complementing contents according to our experiences on the field.

We will not discuss here practical tips regarding the implementation and organization of the activities during school visits (since these are rather dependent on the time constraints of a specific school or expedition), but rather present a few examples of lessons learned in the field that allowed us to incorporate crucial additional details, tips, use of materials or content in the handbook and to enhance the original activities. The topic of the example activities is always given in italics.

Building an equatorial sundial with a sheet of paper: The principle of the equatorial sundial and the orientation of the gnomon (pencil) can be investigated and/or demonstrated using an inflatable Earth globe such as the Earth Ball (of which we always carry several exemplars to give in schools, thanks to UNAWE) [4], cf. Fig. 4.

Measuring the rotation period of the Sun from the motion of sunspots: A captivating way to start the activity is by telling the story of Galileo discovering spots on the Sun and the dilemma he was confronted with (are they clouds, asteroids?). Also, the initial activity was proposed only with magnetic maps (magnetograms) of the Sun to track the sunspots, but these were replaced by more recent continuum images to avoid raising immediately the question of the magnetic origin of spots and the polarity of the magnetic fields.

Investigating the shape of the Earth orbit from the Sun's diameter: The mathematical notion of ellipse can be illustrated with a paper cone and a rubber band (better than with drawings).

Building a heliocentric model with Styrofoam balls: When modelling the appearance of Venus in the course of its orbit, it is easier to separate the problems of the varying apparent size and of phases (only the second requiring lights off and a torch lamp).

Reproducing the formation of Saturn rings: Initially the activity used salt dispersed on a rotating plate to mimic cosmic dust and ice, but it is much easier to use slightly wetted sand.

6. Future Work

We are currently in the progress of translating all the activities in Portuguese and Hindi, but more languages are envisaged (French). The versions in various idioms will not only permit their common use by the international education community, but will also allow the development of GalileoMobile local hubs in different parts of the world (where local educators and astronomers would perform expeditions and follow-up).

Following a spirit of exchange beyond borders under a same sky, our team is also collaborating with projects such as “A touch of the Universe” [5] and “Meet our neighbours” [6], in order to develop complement material to share our activities as well with the visually-impaired youth.

7. Acknowledgements

To the authors of the activities we adapted. Thanks also to UNAWE, GTTP and other institutions that developed these activities. Thanks for your global initiatives on education and rising awareness on astronomy and for being an inspiration to us.

We also thank all the institutions that sponsored us and all our donators to help making this project happen throughout the years.

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HOU Courses and Activities in Chinese Schools

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Abstract

We will introduce HOU courses and activities in Chinese primary schools, Junior high Schools and high schools in this presentation. We have developed a curriculum that contains the basic knowledge of astronomy, for different ages. We also lead students to participate in more and more practice activities such as Pinhole imaging measurement, Foucault Pendulum experiment, GLOBE at Night observation, variable star observation, astronomy show, International Astronomical Search Collaboration (IASC), and Eratosthenes measurement. Cooperation and development of HOU education in China will also be discussed.

Keywords

Hands-On Universe, astronomy course, activities, thesis

1. Introduction

Hands-On Universe (HOU) is a good educational program which enables students to investigate the universe while applying tools and principles from science, math, and technology. HOU program is actually an educational program that takes advantages of the modern technology, which helps students to learn knowledge by doing some simple projects, e.g. astronomical research including selecting objects, practicing observation, data processing and composing thesis.

China HOU has been set up since 2005. We have been teaching HOU Course in high schools since 2007, in junior high schools since 2008 and in primary schools since 2009. We have also done a lot of lectures and organized astronomy shows to the public during Science Festival, Institute open day and Summer Camp.

Collaborating with Beijing Distance Education Committee and educational companies, we are developing a distance learning system to help more students learn HOU courses at the same time. We also have been developing a series of syllabus for HOU courses designed for students with different levels of knowledge.

In addition, we have organized some activities for teachers and students, such as Galileo Teacher Training Program (GTTP) workshop Beijing 2012, Galaxy Forum Beijing 2011, All China International Astronomical Search Collaboration (IASC) 2008-2013, All China GLOBE at Night 2010-2013, and All China Eratosthenes measurements 2010-2013, etc.

2. HOU Course in Chinese Schools

1. Teaching HOU Course in Primary School

For primary students, we teach them relatively simple knowledge including Celestial-Constellation, Earth and Moon, Time and Calendar, Solar System, small telescope and simple skills such as visual observations, image processing, photography and essay writing. We also guide students to observe Sunrise/Sunset, shadow, Foucault pendulum, Moon phase, and constellations and to make simple measurements of height of the Sun, north-south direction, noon local time and so on.

A student from Beijing Zhongguancun No. 2 primary school made an easy Foucault pendulum by himself. In his experiment, it can be seen that the swing angle changes clearly after a short period. During this experiment, he observed and recorded the marks on the ground. Thus the rotation of earth can be justified (see Fig. 1). His Paper Hands-On Foucault pendulum awarded the gold prize in Astronomy Essay Contest among Beijing primary school students.

Figure 1. *An Easy Foucault pendulum Experiment*

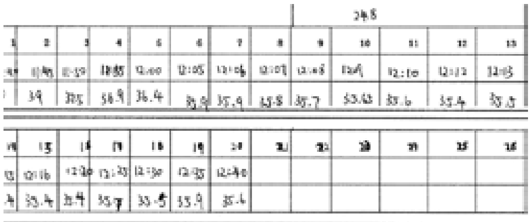
2. Teaching HOU Course in Junior High School
In this level, we basically have the same course setting with primary schools. Besides we teach some courses that involve more astronomy background knowledge and skills, which include celestial coordinate system, telescope observation, astronomy software (e.g. SalsaJ), data acquisition, calculating and analysis.

We also guide students to join observations of Sun tracks, Foucault pendulum, Moon phase change, constellations, and four seasons star. We also encourage students show their observations by painting or by photography. Measurements of pinhole imaging, north-south direction, noon local time, and Eratosthenes are important practice activities for junior high school students.

We chose a group of students and instruct them to do thesis. The topics include Asteroid Search, Light Pollution, shadow measurement, and so on.

One of the student for instance, from The School Affiliated to Beijing Institute of Technology who complete a thesis with title of measuring the summer solstice shadow length parameter for understanding the Earth. During the measurement, he recorded a series data (see Fig 2), analysis the error and modified the tools.

His thesis got the Second award of Beijing high school student Astronomy Thesis Contest.



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[illegible]	35.4	35.4	35.7	35.5	35.9	35.4						

Figure 2. *Data of Eratosthenes measurements*

We have leaded more than 300 students from 100 schools join the International Astronomical Search Collaboration (IASC) since 2008 and have got 36 main belt discoveries and 21 confirmations.

3. Teaching HOU Course in High School
We mainly teach high school students about astronomy history, achievement, new progress, and more technical abilities such as telescope operation, object observation, astronomy software, image processing, data analysis, paper

writing and presentation preparing. Those courses help students understand scientific works deeply.

We also encourage high school students to learn basic astronomy by reading and via the internet. We just teach them the important conception such as stellar systems, the universe, star revolution, variable star, telescope technique, and celestial coordinate system.

Finally, we instruct students to do thesis. For instance, a group of students from Beijing No 35 high school have completed a thesis with title of Observation and Light Analysis of the Binary Star DS Psc. They studied variable star observation and the characteristics of the W UMa-type eclipsing binary star, analyzed the light curve (see Fig. 3) and the profile of its orbit with WD program. Some fundamental parameters are obtained. In addition, by comparing the difference of the minimal epochs between the model and observation, i.e. the values of O − C, they concluded that the period of DS Psc is stable. In the work, some innovative methods were used to derive the physical parameters of the star. This paper has been published and got the first Prize of 33rd Session of the Beijing Youth Science Creation Competition, the highest high school student's competition.

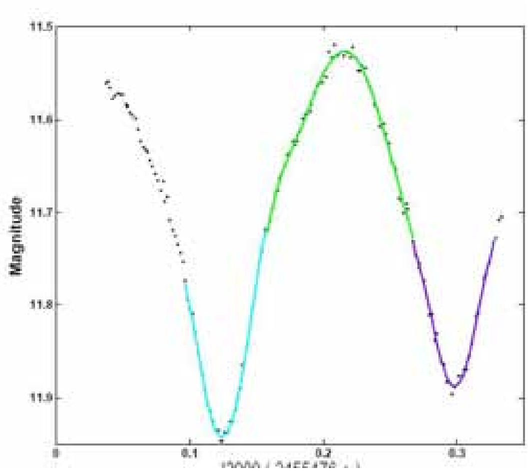

Figure 3. *Light curve of DS Psc*

3. HOU Activities after Schools

We organize many activities to help students get deeper understanding of principles and improve skills.

1. GLOBE at Night

The Global Learning and Observations to Benefit the Environment (GLOBE) at Night is an annual campaign in winter and spring. We have organized Chinese students to join GLOBE at Night since 2010. We not only guide students to participate in this meaningful international activity, but also encourage student to go to different places and have many local observations, then do analysis about light pollution for a specific area.

The following is an essay from one of our student group. They said that they came to a hill at suburban area of Beijing. On the top of the hill, they could find many stars very clearly and could see the brightest Orion that they had ever seen. When they were on the half way down the hill, only a few of stars could be found. When they came back to the downtown Beijing, it was very hard to see any star (Fig.4). They analysed the data and got a statistical result to show the degree of light pollution in the area (Fig. 5). They felt the light pollution was very serious at urban areas in China. Thus they call for reducing excessive lighting at city center.

Figure 4. *Urban and city image series*

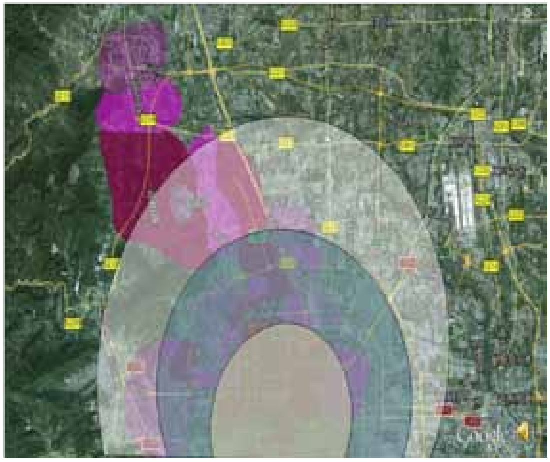

Figure 5. *Statistics of light pollution in the areas*

2. I-Collaboratory

I-Collaboratory is a student's Online communication system developed by Northwestern University. We encourage students to join this program to make their own webpage and share their stories and images with students all over the world. One of our students' painting, Moon Phase Series was chosen and shown on the top page (see Fig.6).

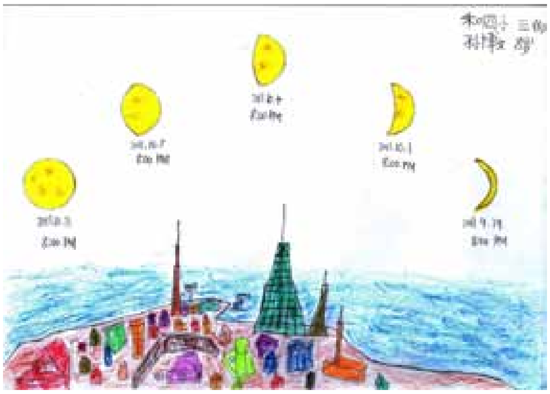

Figure 6. *Moon Phase Series*

4. Conclusion

From all the activities that I discussed above, we can safely conclude that HOU developed very fast in china during these years. By the hard work of teachers and our colleagues, many students and schools were benefited. So far, people in China have recognized the importance and advantage of Hands-On courses and many schools, parents, and organization want to join us and help add it to the school-based teaching system.

5. Future Work

In the future, we need a program description for primary school, junior high school, and high school period. It will include the knowledge that we teach and the abilities that those courses can practice.

6. Acknowledgements

China HOU Thanks the following helps from Global Hands-On Universe for providing resource, EU-HOU for offering SalsaJ software, Hardin-Simmons University for IASC service and Northwestern University for I-Collaboratory system, and France and Japan HOU for teaching material. We also very appreciate other personal helps.

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Importance of Teachers Training and Impact of Galileo Teachers Training Programme in Nepal

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Abstract

This paper presents a review of the training programmes for science teachers in Nepal by different local, national, regional and international institutions. Teacher Training programmes of Nepal Academy of Science and Technology (NAST), an autonomous apex body established in 1982 to promote science and technology, B.P. Koirala Memorial Planetarium, Observatory and Science Museum Development Board, established in 1992 by the Government of Nepal (GON) in order to establish Planetaria, Observatories and Science Museums in Nepal, are highlighted in brief. The initiation of Galileo Teachers Training Programme (GTTP) by Nepal Astronomical Society (NASO) in 2012 and successful implementation in the year 2012 and 2013 will be discussed. The problems encountered during the planning/execution of GTTP and their impact to the science teachers' community will be discussed in detail.

1. Introduction

Nepal Academy of Science and Technology (NAST) is an autonomous apex body established in 1982 to promote science and technology in the country. The Academy is entrusted with four major objectives: advancement of science and technology for all-round development of the nation; preservation and further modernization of indigenous technologies; promotion of research in science and technology; and identification and facilitation of appropriate technology transfer [1]. Government of Nepal has established B.P. Koirala Memorial Planetarium, Observatory and Science Museum Development Board (BPKMPOSMDB) in

1992 in order to establish Planetaria, Observatories and Science Museums in Nepal & conduct research activities in the area of Astronomy, Astrophysics and Cosmology [2]. The pre-down year of the Transit of Venus (TOV) in 2004 brought enthusiasm among Nepalese students and teachers to establish Astronomy Clubs in different parts of Nepal providing better opportunity for people who love astronomy [3]. The momentum gained through the TOV in 2004 could not remain for a long time and the clubs established in the year 2003 and around became obsolete in the following years.

The Government of Nepal (GoN) has been frequently organizing teacher training programs for secondary school science teachers with the establishment of NAST in 1982 and BP-KMPOSMDB in 1992 in different regions of Nepal. The Science Teacher Training Program held in Kathmandu in 2007 motivated a group of students to establish Nepal Astronomical Society (NASO) as an umbrella institution promoting science education through astronomy and space science outreach in Nepal [4]. The celebration of International Heliophysical Year in 2007 and 2008 and International Year of Astronomy (IYA) in 2009 stimulated the youths of Nepal towards astronomy education in Nepal [5]. Now NASO is extensively celebrating beyond IYA with strong alliance with the existing and active astronomy clubs in Nepal and abroad [6]. Though GTTP was conceived since IYA2009, the implementation to the Nepalese astronomical community comes in reality only in the year 2012.

2. Methodology

NASO in association with ESPRO Foundation and GHOU-Nepal Chapter along with other institutions have been organizing Galileo Teacher Training Program (GTTP) since 2012. In 2012, GTTP was organized in Kathmandu and proved successful to attract 33 secondary level science teachers from 7 different districts of Nepal covering eastern to western Nepal [7]. In 2013, the training was organized in Pokhara in order to provide more opportunity for the science teachers and communicators from Western and Mid-Western Regions of Nepal [8]. With the two sessions of GTTP in 2012 and 2013, NASO produced Galileo Teachers in 12 districts in 4 development regions of Nepal. Nepal has 75 districts in 5 development regions.

Figure 1, *Participants geographical distribution for GTTP2012*

Figure 2, *Participants geographical distribution for GTTP2013*

The black circles in the above maps represent the districts that were represented by the Certified Galileo Teachers.

Besides the annual GTTP sessions, NASO has been organizing several GTTP sessions for special occasions or groups in Nepal. During Transit of Venus 2012, NASO organized GTTP session as a part of AstroFest-ToV2012 Nepal at Russian Center of Science and Culture where Science Teachers from 7 different schools participated with their students to learn on safe observation of ToV from Nepal [9].

Figure 3, *Participants for group photo at Eureka high School during GTTP2013 in Pokhara*

Figure 4, *Dr. Rishi Shah, Academician-Nepal Academy of Science and Technology (NAST) addressing the GTTP participants at Eureka High School in Kathmandu*

3. Conclusion

With the organization of GTTP sessions in 2012 and 2013, so far seventy six 'Galileo Teacher' in twelve districts of four development regions of Nepal has been produced. With the presence of Galileo Teachers in more than fifty schools in Nepal, students are encouraged to study astronomy with hands-on activities from the available local resources and online tools. A legacy for the continuation of the GTTP sessions in future has been justified.

4. Acknowledgements

I would like to express my sincere thanks to Dr. Rishi Shah, Academician-Nepal Academy of Science and Technology (NAST), Mr. Sudeep Neupane, GHOU-Nepal Chapter Coordinator for their valuable inputs. My sincere thanks go to Prof. Dr. K.P. Dahal, Depart of Physics, Prithvi Narayan Campus, Pokhara for his valuable time and moral support during the preparation of this paper.

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Hands-on Activities as a medium to introduce Science in Indonesia

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Abstract

Science is fun! And it is something doable by all. This is what we want to share. In this paper we will talk about hands on activities that involve teachers and students to learn basic science. Telescope training, sun activities and water rocket activities are few project that we use to raise awareness and increase passion for science among students and teachers. For example the water rocket activities are not only about science but also a team work as well as creativity to build their own rocket. Here we would like to share our hands on project and activities we did in Indonesia and the network we build through this activities.

Keywords

astronomy, hands-on activities, games

1. Introduction

Astronomy is an unusual scientific discipline to pursue because of it has virtually no impact on daily life. Daily calendar is already set up and we don't have to make any calculation. In Indonesia, astronomy "seems to be needed" by the time of Ramadan to set the first and last day of fasting month.This become hot issues every year which make people realize that we need astronomy to set up the time by observing the moon. Other than that, astronomy become well known for its beautiful image from the skies. These raise curiosity on many people about astronomy and they started to look for community and activity to join. Online or offline, we have so many enthusiast astronomy who wants to know more and learn more about astronomy but they don't really know where to start. To fill the gap since 2007 we provide astronomy news, article and material through online media. The website acts as the resource base while social media become the place where we share and discuss about all the material. And implementation has been done when we have school visit as well any other offline activities with teachers and students.

2. Hands-on Activities Material

langitselatan is an astronomy communication and education online media. And online resources become our main activities. Among the news and basic astronomy articles we have in the site, hands-on activities material and question & answer section become more popular among students. We received question from children to adult about astronomy and the hands-on material being use by schools and families. All hands-on activities in langitselatan has been build and modified by Aldino Adry Baskoro who also work as elementary school.

We started to post hands-on activities in 2009 when people look for a guide on how to build a telescope. The idea was to build astronomy tools using everyday material around us and to give the basic knowledge about astronomy tools to the public and to build awareness of science among students as well as to build their creativity.

Telescope making, water rocket making and its development became our popular hands-on material. Aside than that we also feature sun observation tools guide which is a little bit less popular. All based on ideas that science is doable and it can be build using material around us that can be found in local market except for the lens and solar filter of course.

The telescope making that we provide build using pvc pipe and 2 lenses, while water rocket build using pvc pipe and soda bottle. The solar observation tools in our sites includes venuskokker we received from Professor Jos van der Broek (Leiden University), pinhole projector, planisphere, snake and laddeer board games, eclipse glasses, solar filter for telescope using pvc pipe cover and modified venuskokker.

We provide all the guides and material in an article and several of them in the form of ebook that can be downloaded.

Among all of them, water rocket become very popular and has been develop into several mechanism including parachute water rocket, firework water rocket, and modification of the launcher into 3 models.

From all the material we provide, lens for telescope and solar filter became the "hardest part to find especially in the small city". Lenses can be found in big city especially in a store who sells laboratory tools. But solar filter can't be found in Indonesia. So to build eclipse glasses we use black and white film which can be found more easily in photo studio even though nowadays most photo studio using digital camera instead of the old camera with film. Or the most easiest way to build tools for solar observation is pinhole projector.

3. Online Sharing

All material has been share online since 2009 in langitselatan website and has been view and downloaded thousand times.

The most popular one is water rocket book 1 and 2. Both contain how to build a water rocket launcher and its modification. The 1st water rocket ebook has been downloaded 7958 times while the board games have been downloaded 753 times.

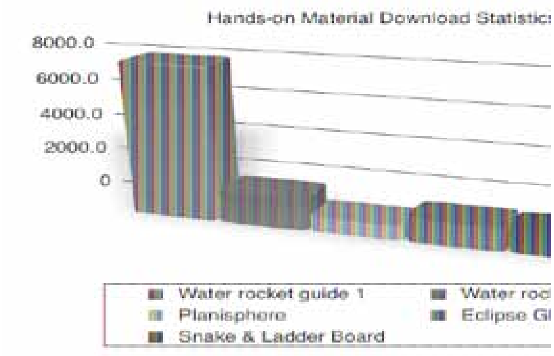

Figure 1. *Hands-on material download statistics Credit: langitselatan*

Each article also has been accessed widely by public and shares in many media such as twitter, facebook and copying in another websites.

Telescope making and online skymap became the most popular activities reaching 30000 page views while building your own rocket launcher 1 and its modified launcher (the marsiano type) reached more than 7000 and 4000 page views.

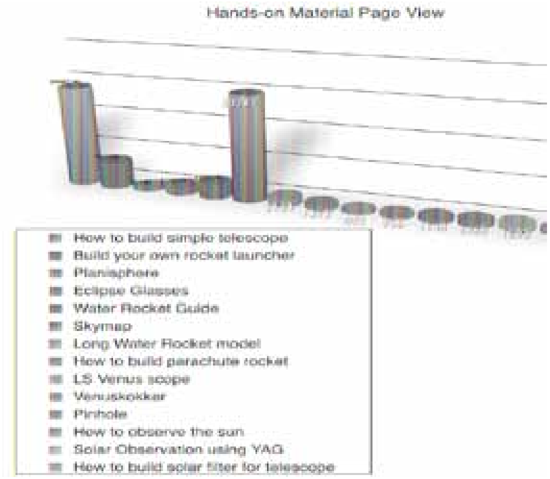

Figure 2. *Hands-on material page view. Credit: langitselatan*

Along with this, we also receive email to do water rocket workshop in schools and universities. And it become one of the most popular activities we have conduct since 2008.

4. Water Rocket Activities

Since 2008, we started to launch water rocket as well as doing workshop with students here. Aside than water rocket workshop we also conducted a planisphere and telescope making workshop using You Are Galileo telescope and shares the concept and material to build telescope using PVC pipe and lenses. Solar observation tools workshop has been done during Venus Transit in 2012.

Every time we conduct the workshop we also encourage the students to build their own community to keep in touch with us. During Venus transit we managed to support the local community to build their astronomy club which has a regular meeting of twice a month. The club is led by physics students from local university. langitselatan is involved in providing astronomy curriculum for the club. which will be evaluated this year.

All activities inspired students to build their own tools with their own creativity and modification. We provide the basic guidelines while they can improve it in their own way.

We have been several areas and worked with communities in each area to provide them hands-on activities workshop in Indonesia including Refrigeration and Air Conditioning (HIMRA) Politeknik Indramayu (POLINDRA), Jong Situbondo (young people in Situbondo), Hekaleka Foundation the founder of Amboina Astronomy Club) and SD Alam Bandung (elementary school). SD Alam Bandung is the school where Aldino Adry Baskoro has been worked as teacher and build the Water Rocket since 2008. The students also work to build the water rocket with him and have been tested many water rocket variation and modification. On November 2012 and May 2013, the water rocket guideline has been presented in Southeast Asian Young Astronomer Collaboration meeting in Puerto Princessa, Philippines and Building the Scientific Mind Meeting in Bandung, Indonesia and started the collaboration between langitselatan and other countries.

Figure 3. *Water Rocket Workshop. Credit: langitselatan*

Figure 4. *Water Rocket Launched. Credit: langitselatan*

Figure 5. *You Are Galileo Workshop*

Figure 6. *Rover modification by elementary school students to land the egg without break it. Credit: Aldino A. Baskoro*

Figure 7. *You Are Galileo for Solar Observation. Credit: langitselatan*

Figure 8 *Water Rocket in SEAYAC 2013. Aimee Jose*

Figure 9 *Aldino A. Baskoro, Jerome Pitogo de Leon and The Water Rocket in SEAYAC 2013. The beginning of collaboration. Credit: langitselatan*

Figure 10. *Preparing parachute rocket launched on BtSM 2013. Credit: langitselatan*

Figure 11. *Preparing parachute rocket launched on BtSM 2013 with SD Alam Bandun students. Credit: langitselatan*

Figure 12. *Parachute water rocket in the sky. Credit: langitselatan*

5. Conclusion

Since 2008, we have build a network of our hands-on activity guide and we keep maintain the network regularly to provide the material and guidelines as well as workshop in each province if needed. The aim of the project is to build students creativity and science awareness. It also helps teachers to provide more activities instead of teaching only theories in the class.

We will continue to provide more material as well as translate the material into English to reach more people in the world.

6. References

[1] langitselatan.com statistics; 2013.

“Meet our Neighbours – a tactile experience”

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Abstract

Astronomy is a very visual science and the current resources and activities for visually impaired children, although increasing, are still costly and scarce. Therefore there is a paramount need to develop more low cost resources that can reach all, even the more socially deprived communities. The project provides resources for a set of tactile Solar System schematic images for visually impaired children and their non-visually impaired peers from the ages of 6 to 12 through hands-on low cost activities. Here we describe the project’s overall experience, assessing and evaluating the improvement of the materials and the implementation process with children and educators.

Keywords

Inclusive astronomy, blind and visually impaired, tactile resources

1. Introduction

Planetary science is a key field in astronomy that draws lots of attention and that engages large amounts of enthusiasts. On its essence, it is a visual science and the current resources and activities for the inclusion of visually impaired children, although increasing, are still costly and somewhat scarce. Therefore there is a paramount need to develop more low cost resources in order to provide experiences that can reach all, even the more socially deprived communities.

“Meet our neighbours! - a tactile experience”, promotes and provides inclusion activities for visually impaired children and their non-visually impaired peers through the use of astronomy hands-on low cost resources. Is aimed for children from the ages of 6 to 12 years old and has produced a set 13 tactile images of the main objects of the Solar System that can be used in schools, science centres and outreach associations.

2. Implementation

2.1 Resource production

During the initial planning of the production of the tactile images the first thing to be addressed was which objects would be featured and the selection of the main features on each celestial object. For the planets the tactile images produced were: Mercury, Venus, Mars and Earth for terrestrial planets and Jupiter, Saturn, Uranus and Neptune for gas giants. To exemplify the presence of other types of objects in our solar system, other objects were also produced such as our Sun, asteroid Vesta, the Moon, dwarf-planet Pluto and comet Halley. Targeting visually impaired children from the ages of 6 to 12 years old, the team, composed by scientists and educators, had to decide which features should be addressed for each object. There was a special care in which features we'd like the children to recognize. Features such as craters, rocky surfaces, with mountains and depressions, rings in the different giant planets, and the presence of different types of gas were addressed. During the process one other thing to keep in mind the importance of keeping a degree of consistency in the different textures used to exemplify each of the characteristics.

Figure 1. *Each tactile feature texture was chosen using lo cost materials.*

One other aspect that was carefully addressed was the general cost of each material used for the images. All the textures used to portrait the different features present in each object were chosen minding the overall cost, keeping the different chosen textures affordable for an overall low cost resource.

2.2 Testing Phase

In order to avoid misconceptions due to the schematic nature of the images, several tests were conducted by children and educators in thirteen different countries. At the time they are still being tested and the feedback is still being compiled. There are many aspects to address in this testing phase such as the different textures and if they are easily recognizable by children and distinguishable from other different features. For instance craters were portrayed by different sized curved sequins, volcanoes were portrayed by buttons, and gaseous planets were portrayed by fabric of different textures, addressing different compositions. The feedback is being collected through questionnaires to the children and addressed to tactile resources experts. As feedback arrives there are many characteristic that were already improved from the initial images and a second testing phase is being implemented as we reach the necessary quality for the images.

Figure 2. *Tactile material expert analysing the different features present in comet Halley.*

Each of the different images is accompanied with a text written by planetary scientists, addressing and explaining the different features.

As the texts intent to support the educators and provide a help to aid them and the children in their exploring, these texts are also being improved from feedback received by the educators.

2.3 Activities

Groups of visually impaired students and their sighted peers are invited to use daily basis items and recycled materials to build a tactile schematic image of a celestial object from our solar system. In a group they are encouraged to research about our celestial neighbours and its main characteristics.

Groups of children from 6 to 12 years old are gathered in groups of five children (for example: 3 sighted children and two visually impaired). The activity can be implemented at three stages that can be done separately: research the celestial object prior to the activity; build the tactile image in a hands-on activity performed by the sighted children closely interacting with their visually impaired peers; tactile exploration of the final schematic images produced by children from other groups. In all stances it is strongly advised to stimulate interactions between sighted children and their visually impaired peers.

Variations of the activity can also be conducted. For instance promote activities for sighted children in which they learn about the celestial object and build the tactile images and then promote explanatory sessions to their visually impaired peers or to other visually impaired communities. The educators can also individually follow each group and explain each of the tactile elements and their correspondence to the each object feature.

3. Final images

All materials were distributed for free to all educators willing to participate in the testing phase of the project. Based on the input collected so far, there are several changes to the original tactile schematic images produced, such as texture consistency related to the different astronomical features they represent and additional schematic 3D objects to help the tactile exploration. Focusing on the essential features of each object and relating them to each texture keeping the consistency through all 13 images. Based on the analysis of the scientific texts produced by scientists to support the educators on the different celestial objects, the different definitions and terminology was carefully evaluated and rewritten, having in mind the questions and answers given by the educators and children when presented with this scientific astronomy background.

Figure 3. *Shipping the material of the initial schematic images to different countries.*

4. Conclusion

Accessing several common problems through tactile resources, with this project we present ways to provide low cost solutions (avoiding the expensive tactile printing costs), promote inclusion and interactive hands-on activities for visually impaired children and their non-visually impaired peers and create dynamic interactions based on oral knowledge transmission between them. As we continue to receive feedback from the educators collaborating on the project the materials are being improved. By the end of the project all the resources (such as schematic images and guidelines) will be available online for free to all, distributed in different platforms. A second shipment of the materials will also be sent to all that collaborated with the project and local replacements for the textures chosen will be determined to reduce even more the costs on production.

5. Acknowledgements

We would like to thank all the organizations that supported this project and made it possible such as Europlanet Outreach, Galileo Teacher Training Program and GalileoMobile. All the educators and scientists involved in the project that have provided us precious feedback on the images produced.

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GTTP Medellín 2013: GTTP/Planetario de Medellín-Parque Explora/Universidad de San Buenaventura

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Abstract

The Colombian government issued Presidential Decree 2442/2006 to create the Colombian Space Commission (CCE) [1], which seeks to consolidate access to knowledge of the country, Earth and space through the creation and execution of research and management programs of knowledge.

Led by the National Development Plan, CCE seeks to promote the attainment of knowledge in astronomy and related areas, and to support the emergence of the aerospace industry.

As a legacy of the International Year of Astronomy (IYA2009) [4] Colombian public and private institutions have decided to support the Galileo Teachers Training Program (GTTP) [2].

In this document we report the experience of GTTP Medellin 2013, the summary of the content, the evaluation of the event and some of the new pedagogical approaches that Galileo Teachers presented as final work.

It will review the processes towards formalizing teacher preparation in science education and technology, especially astronomy and new strategies linking Colombian astronomical community, looking to participate in global initiatives.

Keywords

education, GTTP, knowledge, pedagogical mediation, Regional Office of Astronomy for Development.

1. Introduction

The teachers who seek tools to use astronomy in their classrooms, whatever discipline they teach, are now receiving a special training in GTTP Colombia, to become Galileo Teachers. This program is currently coordinated by Luz Angela Cubides González (Planetarium of Medellín/Explora Park) and GTTP Colombia´s coordinator, León Jaime Restrepo Quiros (Sociedad Antioqueña de Astronomía / University of San Buenaventura).

2. Taking astronomy into the classroom

In an effort lead by the Explora Park- Planetarium of Medellín and the University of San Buenaventura, 34 teachers were certified as GTTP Medellín 2013 attendants, during the teacher meeting in astronomy didactics "A classroom amongst the stars". This event was intended to gather teachers from the city, region and the country to share their strategies and findings while teaching astronomy in their classes. The event was held in Explora Park and Planetarium of Medellín on the 4th, 5th and 6th of July of this year, receiving support from the Metropolitan Technological Institute, the University of San Buenaventura, Colombia´s Galileo Program and the Education Ministries from the city and the state, that provided 48 allowances consisting of tuition fees, daily meals and travel financial support.

Between April 13th and the 1st of June, in schedules from 1:00 to 5:00 pm, teachers from the city and the region were taught in astronomy didactics by local experts. All the sessions were recorded and posted on social networks such as facebook and google+ for GTTP Iberoamerica.

The 32-hour long couse is part of the GTTP Colombia strategy, that together with the Teacher Network of Explora Friends (MAE - Maestros Amigos de Explora) and teachers interested in astronomy education in the region and the country, became a reality.

Following GTTP program´s global objectives, the participants are now able to effectively use simple hand-made tools, or open source software to strengthen their learning and teaching processes in astronomy for their classrooms, and to transfer their experiences to other teachers in their surroundings. Astronomy gains a powerful view as an opening door to interdisciplinary knowledge. The evidence of the process can be found at:

http://www.facebook.com/groups/gttp.iberoamerica/

Google+: GTTP Iberoamérica
gttpiberoamerica@gmail.com

3. Content

The topics covered in the course were:

-General perspectives of GTTP

-¿Why is it important to teach astronomy?

-Learning from our surroundings: The solar system

-Practical tools to get oriented at night

-Basic tools to facilitate orientation and ideas on astronomy instruments. Practical exercise.

-Software, hardware, materials, data bases (practical).

-Hands-on activities on digital astronomy exercise using Google Earth [3], Stellarium [6] and World Wide Telescope [7].

-Introduction to astronomy for children and teenagers.

-Teaching resources in astronomy and space sciences.

-Local astronomy vision from a cultural perspective. Topocentric astronomy (Hands on)

-Teaching resources in astronomy in local communities.

-¿How do stars work?

-Our place in the universe.

-Social network tools in astronomy, citizen science programs, software practice.

-Hands on activity: The museum as a classroom - special tour in Planetarium with dome show.

-Review of space exploration building a ship.

-Panel: Astronomy as a unifying discipline in multiple areas.

4. Course Evaluation

The course attendants performed a quantitative evaluation that included the following topics:

-Speakers: 4,8

-Learning Goals: 4,9

-Program Design: 4,8

-Attendant´s satisfaction: 4,7

-Program pertinence: 88%

5. First results and conclusions

GTTP Medellín 2013 attendants presented their posters during “A classroom amongst the stars”, where new methodologies were presented to incorporate astronomy in the classrooms. Amongst the proposals were mentioned:

- A program for early childhood learning through songs including astronomy topics.

- Flotation experiments to study topics in high school.

- School libraries, covering astronomy literature, to facilitate learning processes.

Several proposals will be put in practice during this year.

Speakers and attendants to the event “A classroom amongst the stars” mentioned the need to place more attention in astronomy topics covered in the curricula.

6. Colombian plans to enroll local activities in global astronomy projects

The Colombian government issued Presidential Decree 2442/2006 to create the Colombian Space Commission (CEE), which seeks to consolidate access to knowledge of the country, Earth and space through the creation and execution of research and management programs of knowledge.

Led by the National Development Plan seeks to promote the attainment of knowledge in astronomy and related areas, and to support the emergence of the aerospace industry.

One of the CCE´s technical groups is for Astronomy, astronautics and aerospace medicine. This group aims to incorporate astronomy in primary and secondary education curricula in the country.

Masters and PhD programs in Astronomy, or Physics with an enphasis in astronomy exist in Colombia. Since 2009, the University of Antioquia created the first undergraduate program in Astronomy existent in the Andean region, whose first graduates will start working in 2013.

There are also local institutions working together with Bolivia, Chile, Ecuador and Venezuela to host an Andean Regional Node that represents these countries in the Office for Astronomy Development, from the IAU [5]. This initiative has been lead by the University of Los Andes, Planetarium of Medellín and Planetarium of Bogotá.

Other proposals want to include astronomy topics and teacher training for the future teaching graduates.

7. Development Proposals

Considering the experience received with the Galileo Program (coordinated by the Sociedad Antioqueña de Astronomía), and the interinstitutional support received from the Planetarium, Explora Park and University of San Buenaventura, some initiatives to continue working are:

-Courses offered in local universities to facilitate new pedagogical tools from astronomy.

-Review the Colombian curricula and the presence of topics in space sciences, joining efforts with private, official and government institutions.

-Elaborate a new line of research in Science and Technology Didactics in the Masters of Education and the Masters of Science didactics and Technology in the universities mentioned above.

-Group or line of expertise in pedagogy considering the aerospace environment impact on human psychology.

-Research groups in Education and Teaching Training programs.

-Support in professional areas requiring research in astronomy, astronautics and aerospace medicine.

8. Acknowledgements

We appreciate the support of workers and managers of Explora Park/Planetarium and University of San Buenaventura.

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Space Awareness Activities in Nepal

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Abstract

Advancement in space technology has presented the modern world with many opportunities for extraction and analysis of required information from various fields. It is the need and necessity of every country to apply modern science and technology for growth, development and substance. Many governmental organizations, nongovernmental organizations (NGO), international non-governmental organization (INGO), private consultants and universities are using space technologies in different fields such as education, agriculture, forestry, biodiversity, tourism, health and medicine and research and development etc. but required attention is not given on the space education for the school in Nepal. This paper deals about the space education activities for school children in Nepal. Particularly the activities of water rocket event for school children and poster contest by the school children on the theme of "Our Universe - Great discoveries" with the highlights of formal and in formal education relating to space activities , future plan and proposal for educational initiatives relating to space activities.

1. Introduction

Nepal is a small mountains land locked country in South Asia located between latitudes 260N to 300N longitude 800E to 880E lying between India and China. It has an area of 147,181 square kilometers and a population of 23.5 million according to 2061 census. It has a rich human culture and natural biodiversity with more than 61 ethnic groups and almost 70 spoken languages. The length in the east west direction is about 885 km and width in the north south direction varies between 145 km to 245 km. The country is divided into five physiographic regions. They are Terai (plain area 60-300 m). Siwalik Hills (200-1500m), middle mountains (800-2400m), high mountains (2200-5000m) and Himalayas (5000-8848m). Land is the only immovable property which can be used as a means for agriculture production as well as a means for financing industrial or commercial enterprises. Space technology plays an important role in managing our land, water resources and natural resources.

Space technology could address to resolve the major issues such as population growth, environmental degradation, resources management, poverty reduction, urbanization etc.

Many governmental and non- governmental organizations private consultants and universities are using space technologies in different fields in Nepal. Kathmandu university with the collaboration with the government of Nepal, Ministry of Land Reform and management, Land management training Centre has the Bachelor of geomatics Engineering education program since last six years and Purbanchal university and Tribhuvan University and various educational institutes are also engaged on the development of human resources on the use of space related products. Similarly different organization like Space Generation Advisory council Nepal, Nepal Astronomical Society Pokhara Astronomical Society, Nepal scientific activities and Research centre and GHOU- Nepal Chapter conducts programs related on the space awareness activities [1, 2].

Nepal Astronomical Society (NASO) in association with Pokhara astronomical society (PAS) has taken initiative for the space education awareness program at the school level by organizing water rocket events and poster competition. Water rocket events at the school level have encouraged the children to compete among themselves on making and launching of the water rockets and know about the space science and its application [3].

2. Methodology

NASO in association with PAS and GHOU-Nepal Chapter along with other institutions have been organizing space awareness activities. Space awareness activities were conducted in Pokhara, Tanahun and Syangja district where more than 400 participants from 10 Secondary schools successfully participated. With these programs PAS formed some astronomy clubs in secondary schools [4].

Figure 1 *Water Rocket Event in SOS School, Pohara, Nepal*

A program of water Rocket event was organized at SOS Herman Geminer School, children with their parents and teachers were invited on the event. A talk program was also arranged prior to the water rocket event to highlight the importance of water rocket event and space education [5].

Figure 2 *Poster Competion*

Poster competition activities are very effective. This will motivate the students to promote the space science technology and more professional students will be available on the higher studies of the space education and be available for its development.

Figure 3 *Awareness Program*

Awareness program are the crucial part to enhance the knowledge on space science. Initiation will be taken to conduct the international and national seminars and workshops with help of different relevant agencies and the users of space information in Nepal. This will help to educate the students, teachers, planners and user community of the space science. Ultimately this will also help to include the subject on the school syllabus of science education [6].

3. Conclusion

It is cleared that the space application in Nepal is not developed well. Organizations working on space technology should changes its working strategy and develop the system to accommodate the latest technology as far as possible. The future prospects in space education in Nepal and its space activities are highlighted on the following points.

• Poster Competition activities is very beneficial to enhance space science activities for small children and will be continued.

• Activities on the use of space information for schools will be continued.

• Water rocket event helps to enhance the knowledge on space science and will be continued.

4. Acknowledgements

I would like to express my sincere thanks to Dr. Rishi Shah, Academician Nepal Academy of Science and Technology (NAST), Mr. Sudeep Neupanne GHOU- Nepal Chapter Coordinated for the valuable inputs. My sincere thanks goes to K. P. Dahal, Department of Physics, Prithvi Narayan Campus, Pokhara for his valuable time and moral support during the preparation of this paper.

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