The Montegancedo Astronomical Observatory

The first free remote observatory for learning astronomy

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Abstract—**This paper describes the first open robotic observatory available to the public on the Internet (http://om.fi.upm.es), interactive and completely free access through a Web 2.0 application, which lets users manage professional astronomical devices and collaborate with other amateur users through a web browser. Its main goal is to open the astronomy to the society and that people learn informally about the cosmos by means of experimenting with real remote devices.**

Its architecture is made up by common collaborative Web 2.0 tools (such picture gallery, wiki, forum, chat, voting and discussing systems, etc.) and services and policies to offer meritocratically the observatory and its observing time.

The paper presents an innovative approach which proposes a reputation system for sharing an online resource to encourage high-quality contributions, and the initial outcomes obtained since the observatory started in December 2008.

This paper also describes the first experience using the observatory for carrying out online practical assignments in an Educational Innovation Project within the Technical University of Madrid during academic year 2008-2009 and using it for three subjects of these different degrees: Computer Science, Industrial Engineering, and Topography.

Keywords - informal collaborative e-learning; meritocracy; social networks; web 2.0; web laboratories

I. Introduction

In 2004 the term Web 2.0 was coined by Tim O'Reilly [1], describing the trend in the use of WWW technology and web design that aims to enhance creativity, information sharing, and, most notably, collaboration among users. These concepts have led to the development and evolution of web-based communities and hosted services, such as social-networking sites, wikis, blogs and folksonomies [2]. Wikipedia, YouTube, Facebook, eBay, Flickr or MySpace are only some famous sites as a result of the Web 2.0 [3][4].

Society have new habits, people spend more time on the Internet and access more frequently than a short time before. It is obvious it is happening a revolution around the Internet, in all the fields [5]. E-democracy, e-goverment, e-science, e-learning or e-portfolio are a few new concepts appeared in few years. The Internet has grown to currently become one of the most important ways for voluntary collaboratorion. It was the way used to develop successful systems like the GNU/Linux operating system, Apache server and other meaningful contributions through the Free Software movement. Everyday, thousands of people participate in some site on the Internet, from a simple suggestion in a recommendation system like Amazon, to the classification of a galaxy in an astronomical website like GalaxyZoo [6]. Other people donate their computing power to scientific research projects, through platforms like BOINC [7]. These and other collaboration ways are only possible thanks to the Internet nowadays.

However, the Internet lacks online websites for real experimentation, like the web laboratories where people practise and control resources through a web browser. This issue and the idea of taking advantage of the knowledge of thousands of volunteers collaborating day by day, were the motivations for carrying out the project presented in this paper. The aim of the research was to design a new methodology for creating collaborative projects and citizen participation, focused on education and based on real experimentation. This was supposed a new approach to create open web applications for society to promote the informal learning, the social constructivism and the generation of knowledge through collaborative, self-organized and meritocratic systems.

For this reason, to prove these ideas, it was necessary to develop a concrete example to apply the methodology. Authors opted for the Astronomy because it is a science with a huge number of amateur people. This is the origin of the Montegancedo robotic astronomical observatory.

The Montegancedo observatory is an informal e-learning Web 2.0 platform whose aim is to open Astronomy to the society in order to people learn and collaborate creating and supervising astronomical knowledge through the Internet. This remote observatory pretends to be a way of real experimentation in Astronomy, collaborative learning and, in general, dissemination of Astronomy.

Nowadays, there are hundreds of robotic telescopes, with different sizes and purposes, working autonomously without an operator. Some of these telescopes offer services through the Internet, both an interactive and non interactive way. However, up to now, in the most of cases it is required to pay for using these systems or are available only for few organizations, like schools or associations. Also it is appreciated that there is low interest in using these scenarios for informal e-learning and citizen research. So, in opposite direction, Montegancedo observatory meant being the first open observatory to the

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public through the Internet, interactive and completely free access (http://om.fi.upm.es).

This paper describes the Montegancedo observatory and the experience gained through its teaching approach. The document is organized as follows: Section II describes globally the system. Section III presents some of the most relevant collaborative services. Sections IV shows the experience in higher education context. Section V describes results in the first months of working. And finally, sections VI and VII present the conclusions drawn and the direction and priorities of the future work of the project, respectively.

Figure 1. Location of the Montegancedo astronomical observatory. Campus of the Computer Science Faculty (Technical University of Madrid)

Figure 2. Montegancedo astronomical observatory

II. Description Of The System

Montegancedo observatory is located in Madrid, Spain, at the roof of one building of the Faculty of Computer Science, as shown Figs. 1 and 2. From December 2008 up to now, the first remote experiment through the Montegancedo observatory is running. This experiment lets users watch the Sun and control a high-quality professional camera for astrophotography, as will be detailed later.

Any Internet user has free access to this observatory from a browser. It is worth mentioning that, dated November 2009 (only eleven months running), its community is composed by a total of more than 600 users.

The observatory is controlled through a web application. As said above, an advantage is that anybody can access to an professional astronomical observatory from anywhere. Consequently, people learn to control the devices, from simple webcams to powerful astrophotography cameras and telescopes. The control software developed for remote observatories, called Ciclope Astro, is scalable and adaptable to a large number of devices. Also it includes the potential of Web 2.0 services [8], which promote and make the collaboration and communication between users easier.

Next the most characteristic aspects of the system are described. Mainly it is based on a social network of virtual anonymous users and includes a great number of collaborative services, such as wikis, photo galleries, news publishing systems, suggestions, discussion and voting systems, and folksonomy or collaborative tagging, among others.

Social meritocracy is another important feature of this system by means of a reputation/karma users system. Besides promoting user participation, this is an innovative approach which lets schedule observing time in an original way described later.

A. Architecture

The infrastructure is composed by a server software, end-user applications, content syndication formats, instant messaging and astronomical devices control protocols.

It requires a client/server architecture, summarized in the Fig. 3. It is worth mentioning that the system combine leading technologies, such as Google Web Toolkit framework to develop AJAX applications in the Java programming language, and the iBatis persistence framework with a MySQL database.

B. Astronomical experiments

The main component of the Montegancedo observatory, and which is really appealing to users, is the set of astronomical experiments that users can do online. An experiment is referred to a set of objects, actions, devices and guides for its execution. An experiment could consist on observing the Moon, moving the telescope around the Moon's surface, taking photographs and building a mosaic with the photographs taken. Another experiment could consist on observing the Sun and calculating the Wolf number, that is, counting sunspots.

There are specific interfaces depending on the experiments and also the user roles. Up to now, different interfaces have been designed, from a basic hand controller to an advanced replica of Autostar II hand controller, going through astronomical object catalogs. A control interface of the Montegancedo observatory is shown in Fig. 4.

From December 2008, the first solar experiment is running. The goal of this experiment is to observe the Sun in H-alpha and distinguish sunspots and solar protuberances, apart from learning to control an astrophotography camera and change its parameters in order to take excellent photos. The telescope and the dome track the Sun, so users only watch an interface with four four real-time cameras broadcasting the video. Two of those cameras are used to watch the status of the telescope and dome. The other two are connected to the finder and telescope to observe the celestial objects. The parameters of these cameras can be modified from the interface, e.g., exposure time, gain, brightness, gamma and region of interest, and let user learn basic knowledge about Astronomy.

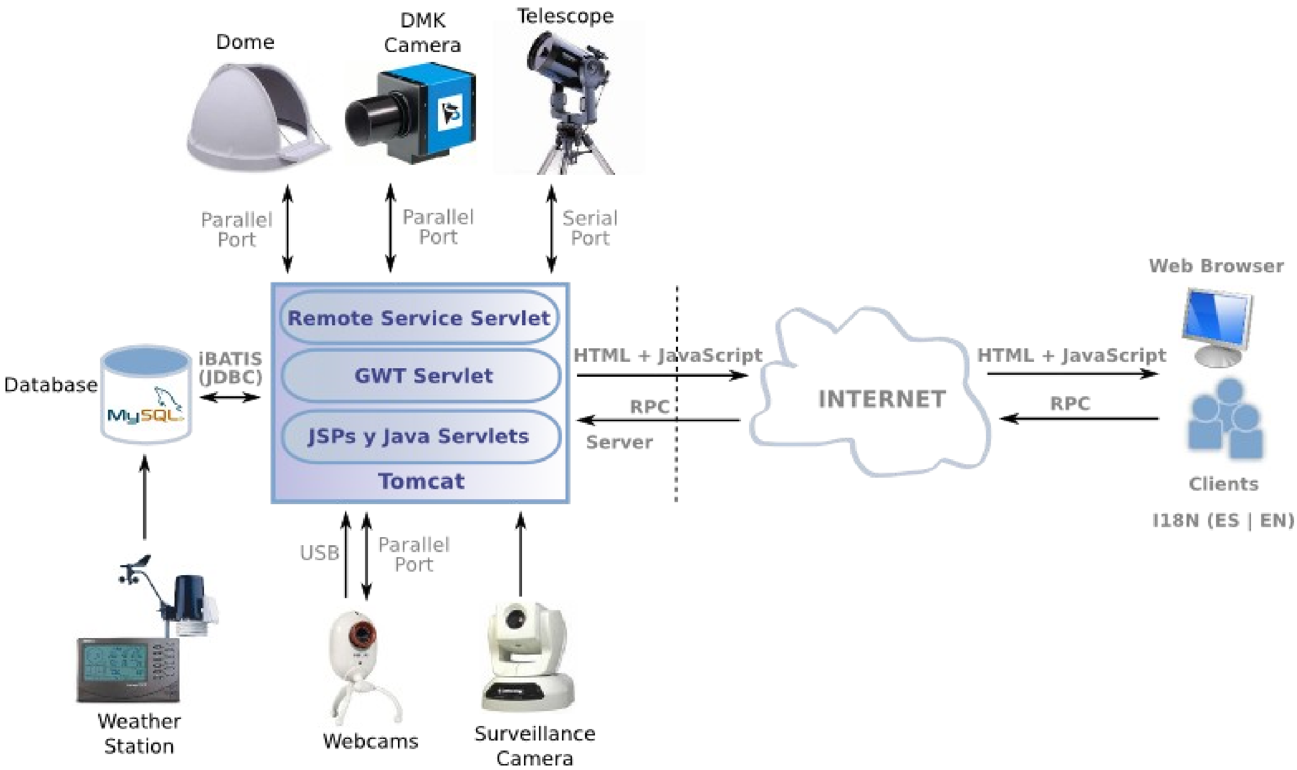

Figure 3. Montegancedo observatory's architecture

Another particular aspect is that to carry out each experiment there is a scheduling published on the website. In the case of the first experiment, each user has two intervals of ten minutes a day to control exclusively the observatory, as explained below. However, although an user has not the reservation or even is not registered, can observe what is happening during a session, since real-time cameras are broadcasting continuously through the web application. The drawback in this case is that the retransmission frequency is less than for the owner of the observing session, e.g., from twenty to one seconds.

C. *Observing Time Allocation*

In this subsection it is explained how observing time in this remote observatory is allocated innovatively.

First of all, user who wants to manage exclusively the observatory (telescope, dome and cameras) previously has to make a reservation in that interval. The web application publishes the reservations by means of a calendar, listing all the busy reservations made in a concrete day. A registered user has an interface in order to reserve the free intervals which are not reserved by other users. As said above, now in the solar experiment, the reservation policy only lets users reserve in the current day, from 00:00 AM. Website administrators are responsible of setting the timetable to carry out each experiment, the duration of each session, and the number of sessions a day per user. By default, the allocation policy is called FIFO (First Input First Output), that is, an user can reserve any free interval as they log in. However, these policies can be modified by the administrator according to behavior and feedback shown by the community.

Furthermore, there is implemented other policy based on a reputation system based on users' karma, that is, observing time per user is proportional to its karma. So, more karma, more observing time. This is a original way in order to compete for the available observing time using typical reputation technicals for Web 2.0. Basically, it is a manner of promoting and awarding to those most and best participative and collaborative users, and penalizing to damaging users for the community.

III. Web 2.0 Collaborative Services

One of the most important features of this system is the set of typical collaborative services for Web 2.0 incorporated in order to users participate creating and sharing knowledge, like collaborative edition through wikis, discussion threads or tagging through folksonomies. The synchronous communication by means of instant messaging also is fundamental to users exchange opinions, hobbies and knowledge. The social meritocracy is other of the most evident features of the Web 2.0. This methodology lets determine the karma of each user and other items within a remote laboratory based on the participation and acceptance of the rest of community. The fact of setting a user hierarchy is essential to encourage the motivation for competing for the use of online resources. And, in this sense, offering voting mechanisms is useful to organize the content of the collaborative systems. Next some of these services are described.

A. *Photo Gallery*

The photo gallery stores every astronomical photographs which are uploaded by the authors, both photos taken with own material and photos taken with the Montegancedo observatory.

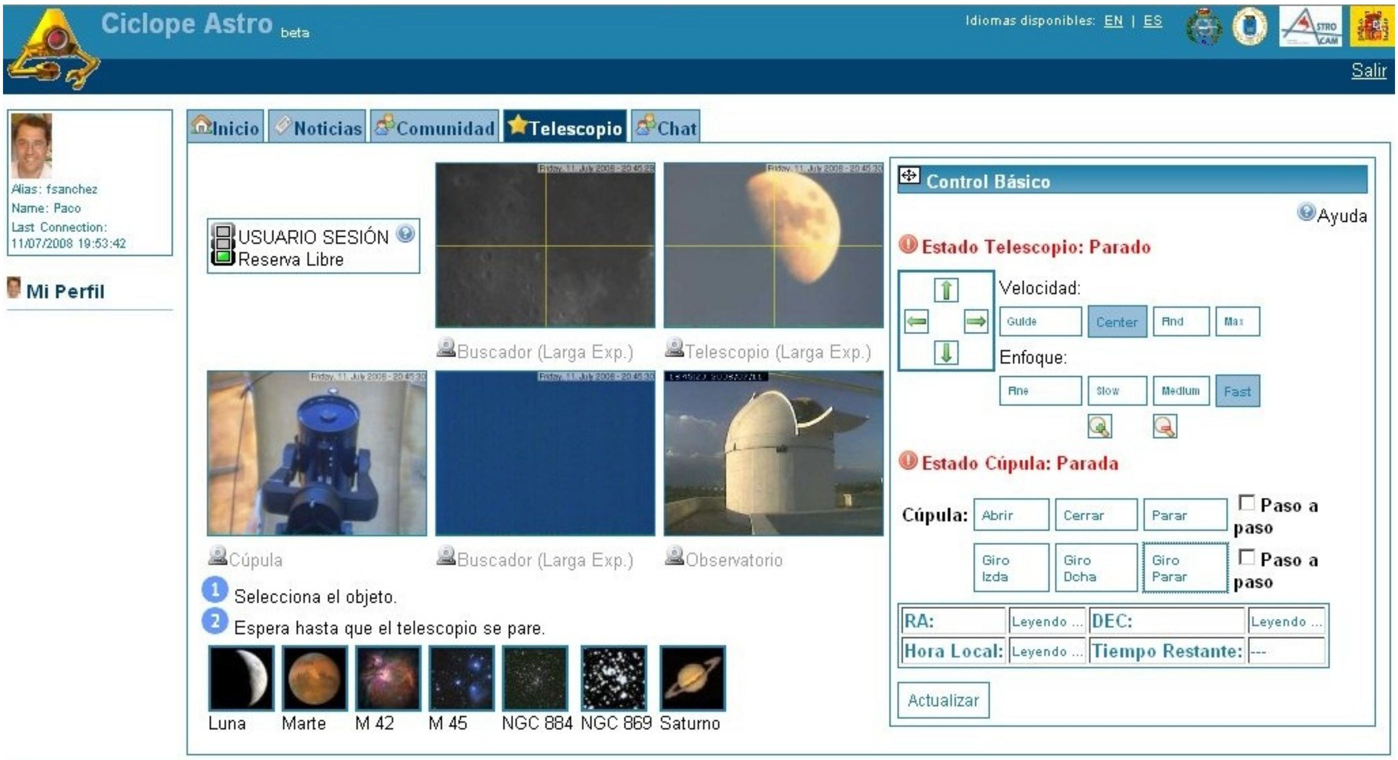

Figure 4. Control interface of the Montegancedo observatory: Observing the Moon

When an user uploads a photo, also has to fill a form indicating the title and the tags and, optionally, the rest of the fields regarding image processing, observing material, location, date and a free description about the photo. Each photo also has a karma associated and a global position which represents the importance and evaluation for the community.

B. *Meritocracy: Karma Reputation System*

Regarding to the meritocracy, karma is a parameter which measures the collaboration in Webs 2.0, a quantitative measurement of the user's effort within the community. The aim of the karma is to give more weight to the votes of those users who send the most and best contributions and best ability to determine the most valuable contents. As a result, content selection and hierarchy processes are accelerated.

All users obtain same karma value when they register in, but their karmas go up or down according a mathematical algorithm called PageRank, which is used by Google to order webs [9]. Essentially, users' karmas are calculated depending on quantity and quality of their contributions, votes sent and received, the attendance to live broadcasts (eclipse, occultation, etc.), that is, all set of own contributions.

Users are penalized if they carry out damaging actions for community, such as reserving observatory but not using, sending problematic photographs, etc.

C. *Suggestions*

Suggestions or proposals service lets users raise questions to the community. As far as community is concerned, they send suggestions and vote them. Users, anonymous or registered, vote proposals and, after deadline, close the process and award the winner proposal.

This service was used the first time to choose observatory name. In this case, name was chosen by means of democratic system where every vote has equal weight. The exhaustive survey process is described in Raquel Cedazo's doctoral thesis [10], besides the results obtained in comparison with a meritocratic system, where users have different voting weight.

D. *Wiki*

Its aim is that users edit collaboratively articles about Montegancedo observatory and Astronomy in general. Through this wiki, it is expected that users write astronomical articles which be useful to any Internet user, not only to observatory users. On the other hand, this wiki also is used for publishing terms and conditions regarding the use of observatory, press notes, related links, user guides for devices and functionalities, and results and statistics relating to experiments.

E. *Instant Messaging*

The observatory includes a synchronous communication as a virtual way communication among users. This instant messaging service is known as *chat*. It only can be used by registered users when logging in the application. It allows to open private conversation windows between two or up to five online users. Among main features, the chat allows to see any online user, set a own status message (busy, away, work, etc.), see online users' status messages and, finally, maintain a contact list. The chat divides connected users in two groups, those that are or are not on the contact list, so it is easier to locate favorite contacts.

IV. Experience In Higher Education

Montegancedo observatory was used in the 2008-2009 academic year for first time within the higher education context. Authors received a fund for an educational innovation project within the framework of the process of the establishment of the European Space of Higher Education and the improvement of the quality teaching. This project was entitled "Execution of collaborative remote practical assignments through Montegancedo robotic astronomical observatory. Applied to subjects: Geodetic Astronomy, Computer Vision, and Design for Web Applications ".

This project supposed to use Montegancedo observatory as a remote laboratory to carry out the practical assignments of three subjects of the three following Technical University of Madrid's centres: Computer Science, Industrial Engineering, and Topography. The target was to motivate students to put into practice the theoretical knowledge during lectures.

The three practical assignments were carried out by students after timetable through the Internet, and were focused on the solar experiment previously described.

Figure 5. Traditional methods to calculate the azimuth in practical assignments for Geodetic Astronomy subject (Topography)

The use of this system was specially benefit for Geodetic Astronomy subject, since practical assignments observing the Sun were canceled years ago because students were not safe running the risk of damaging their eyes by looking directly at the Sun, as shown Fig. 5. In this sense, Montegancedo observatory supposed to be a new opportunity to reincorporate it (118 students enrolled in 2008-2009 course), being out of danger and doing really comfortable for students, as shown Fig. 6.

This first year good experience [11] has caused that authors develop new experiments for 2009-2010 academic year. In this case, experiments are pretended to focus on calculating the azimuth, latitude, and longitude through observing stars at night.

V. Results

Data collected for analysis represents the collaboration of the users up to now. Statistical data are collected automatically into a database and analyzed subsequently. The experiment was successful in many aspects.

Dated 1st November 2009 and before one year running, there are satisfactory results: 609 registered users, almost 800 reservations, and a good participation and positive response: almost 150 photographs, 300 posts, 600 tags, more than 1000 votes, etc.

Furthermore, it is worth mentioning first results reflect that users access regularly, reserve the observatory, and take photographs. Even they use the other collaborative services, e.g., they upload and share their own astronomical photographs, edit wiki, send posts, votes, news, and suggestions, among others.

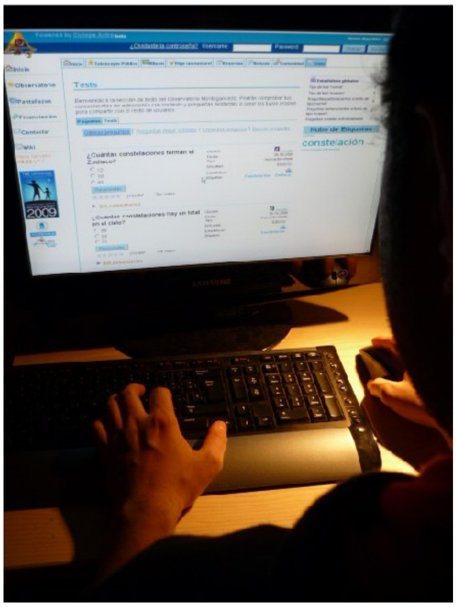

Figure 6. Montegancedo observatory' web controlled by a student from a computer

A. Social Network

Data analysis techniques are fundamental to understand how community works and its global behavior. The social network methods are particularly well suited for dealing with multiple levels of analysis and large communities [12] . Fig. 7 is an example of how visualization tools are useful to extract relevant information about the community [10]. So, it is possible to find out at first sight intrinsic aspects related to network structure or who are the most active users, the most influential ones, powerful, etc.

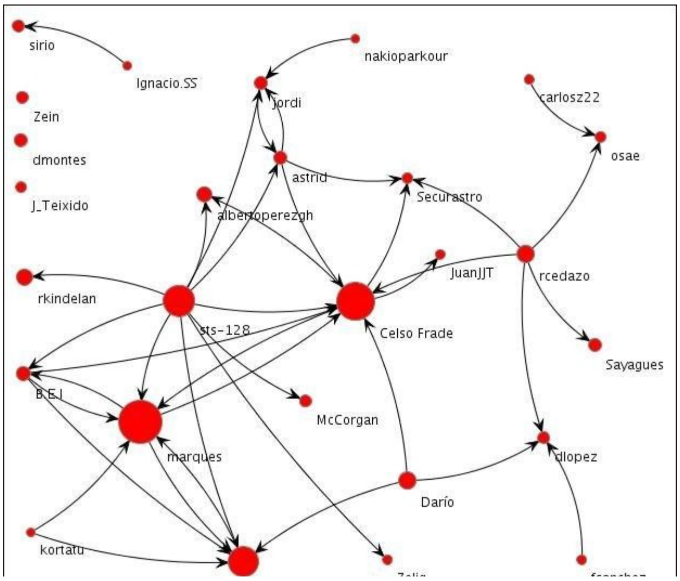

Figure 7. Graph which represents a observatory subnet and where it is possible to watch different sizes of the vertices to indicate the user karma. Links between vertices are votes

B. *Socio-demographic profile*

A users socio-demographic survey has been made in order to extract a pattern of the user profile. User data have been analyzed according to the age and gender, information required for the registration.

Regarding to active users, that is, those who have logged in at least once, gender statistics show that a high percentage of users are men (74.35%) in comparison to women (15.06%), as shown Fig. 8 and Tabla I. Meanwhile, the rest of the active users (10.59%) did not specify their gender since at the beginning these data were not compulsory.

With regard to age, Fig. 9 and Table II summarize that the predominant age corresponds from 20 to 44 years (73.64% over total).

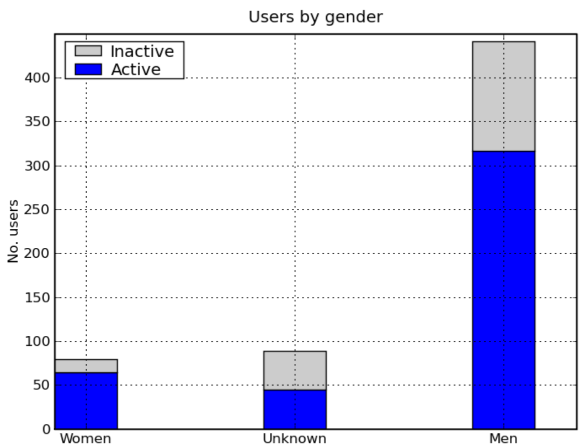

Figure 8. Statistics users: gender (5th November, 2009)

TABLE I. Users By Gender

Gender	Total	%Total	Active[a]	%Active
Female	79	12.97%	64	15.06%
Male	441	72.41%	316	74.35%
Unknown	89	14.62%	45	10.59%
Total	**609**		**425**	

a. Active users are who have logged in at least once

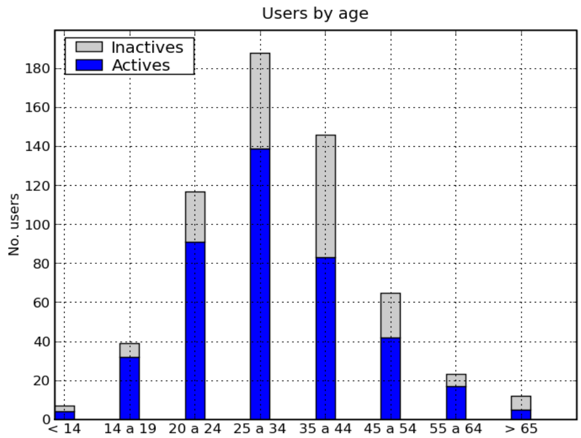

Figure 9. Statistics users: age (5th November, 2009)

TABLE II. Users By Age

Age	Total	%Total	Active[a]	%Active
< 14	7	1.15%	4	0.94%
14 to 19	39	6.41%	32	7.53%
20 to 24	117	19.21%	91	21.41%
25 to 34	188	30.87%	139	32.70%
35 to 44	146	23.97%	83	19.53%
45 to 54	65	10.67%	42	9.89%
55 to 64	23	3.78%	17	4.00%
> 65	12	1.97%	5	1.18%
Invalid[b]	12	1.97%	12	2.82%
Total	**609**		**425**	

a. Active users are who have logged in the system at least once
b. Invalid age refers to value less than 7

VI. Conclusions

As other authors have already proved, and as can also be observed from the Monteganecedo project, the high potential of Web 2.0 tools allows to set up a large learning community, offering remote experimentation scenarios. Furthermore, one of the main features of this system is enhancing collaboration and participation through current well-known services on the Internet.

According to statistics collected, the experiment was successful in many aspects: high number of registered users; moderate number of reservations of the observatory; good quality content uploaded and written by users; and other collaborative tasks like writing, posting, voting, and tagging.

This paper has presented the experience using Montegancedo observatory to carry out practical assignments at the Technical University of Madrid. It has shown that this system offers huge opportunities for higher educational context.

Apart from being a project which could be used as a good example for designing new citizen science and e-learning projects in any other discipline, it will be a solution to face up to more and more data and to the insufficient number of experts needed for the review process of the astronomical tasks.

VII. Future work

One of the most ambitious objective is to build a network of free access remote observatories around the world, both hemispheres, to result in more observing time and more interesting experiments. Collaborations with amateur and professional astronomers will still be essential to design the remote experiments and to acquire the suitable material.

Gathering a large community that analyze data arrived from telescopes on this network is a socio-technical challenge and could be decisive to interpret astronomical phenomenons. Organizing this community and motiving them to collaborate in this initiative is a long-term objective.

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