ASTRONOMY EDUCATION FOR THE PUBLIC VIA EMERGING INTERNET TECHNOLOGIES

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Abstract

Astronomy is a scientific field that, through both the allure of the sky and popular culture, enjoys significant penetration into the public and especially the young. This fact along with the interdisciplinary character of the field, makes astronomy an ideal avenue for teaching basic scientific principles in a context that is both relevant to the subject and interesting to the learners. Advances in the understanding of learning processes suggest that the conventional lecture-based paradigm may be suboptimal to address such requirements. Thus current approaches focus on adult education and situational learning and are active, self-directed and experiential, with a readjustment from process to product. The emerging view is of learning as an active, constructive, social, and self-reflective process with the aim to develop problem-processing skills, self-directed learning skills and group competence. Thus in contemporary physical science and astronomy education, educational programs increasingly include problem-based learning and other small group instructional models, collaborative organizations to support student-faculty interactions, and technology-enhanced educational tools. Information technology and the internet are widely used to support educational processes. Although such technologies have succeeded an immense impact in information dissemination, they relatively lag in supporting active and collaborative learning. This paper proposes new ways of engaging Web 2.0 technologies to support self-directed, experiential astronomy education for the public, enhancing the instructor's presence and team collaboration.

Keywords
web 2.0, problem based learning, e-learning, astronomy.

1. INTRODUCTION

In the last century we experienced an enormous expansion in scientific knowledge and an increasing dissemination of such a knowledge outside the specialized scientific community towards the general public. In order to accommodate this increased knowledge and the need for widespread dissemination, contemporary education is embracing tools and approaches from two different fields. On one hand, alternative educational approaches have long been introduced in science education. These include integrative curricula delivered via active, self-directed, student-centered, experiential learning. One the other hand, information technologies are also being employed to harness information explosion and support teaching in various ways. Ultimately, these two different fields could join their contribution, with information technology effectively supporting active learning.

Effective technology-supported learning is created when there is a successful alignment of the approach to learning with the use of technology. Having this in mind, let us concentrate on the specific characteristics and requirements of active learning. This educational approach concentrates both on knowledge achievement, as well as on the reinforcement of social skills, such as the ability to act and interact in the real world, to collaborate and solve problems. Thus, in order to support active learning, it only seems natural to employ the social computing paradigm of Internet 2.0.

In specific, the paper presents the educational activities at a regional Amateur Astronomy Club that aim to disseminate the basics of astronomy and related physics to the public and especially the young. Communicating astronomy to the public presents certain additional significant challenges: (a) highly specialized scientific knowledge is disseminated to an audience of a disperse scientific background, often without extended and/or uniform scientific education and skills; (b) the audience is of a wide age range, preferences and goals regarding their pursuit of astronomy knowledge; and (c) the audience has a diverse daily time-schedule while scattered over a region considerably larger than a university campus. Most importantly, considering the amateur, sideline nature of public astronomy education, the whole educational procedure ought to be more of a leisure activity rather than formal learning.

The proposed approach involves the use of wikis and blogs to entirely re-create the process of problem-based learning approach on the internet. A number of astronomy problems at various levels of difficulty and specialization are deployed on the internet. Problem deployment and presentation is collaboratively performed via the internet by a number of instructors using wiki technology. Participating students and instructors can resolve and discuss the problem via a dedicated blog, while they can record their educational experiences in their personal blogs, thus providing a way for a temporal recording of attitude, experience and skills progress. Problem solution is then performed collaboratively via a wiki. Preliminary results of a user (student and instructor) satisfaction analysis are also presented.

2. BACKGROUND

Traditional education requires students to sit through hours of lectures and discussion takes place in large groups, sometimes with the whole class present. Advances in our understanding of learning processes now suggest that such techniques may be suboptimal, and that learning should evolve from learning by acquisition to learning by participation.

New approaches build on concepts of active learning, defined as the process of having students engage in some activity that makes them reflect upon ideas and how they are using these ideas. Such new educational approaches require students to regularly assess their skills and knowledge at handling real world problems. Some student centered, active learning approaches include problem-based or case-based learning, inquiry and discovery based learning, role and game playing based learning, as well as collaborative and interactive learning of all kinds. Such approaches rely on situational learning and are active, self-directed, student-centered, and experiential [1].

Learning is perceived as a qualitative change of one’s conception of phenomena and ideas and, consequently, knowledge must be actively processed by the student. A fundamental idea is that learning is organized in small student groups, i.e. tutorial groups, and not around lecture meetings. In the tutorial group students actively work with reality-based situations to formulate problems and learning needs that will guide their further studies. The teacher’s role is that of facilitating learning rather than transferring knowledge. In the tutorial group, the students discuss and defend their choices and standpoints. Using library resources, text books, databases, laboratory work, field studies, lectures and other forms of faculty resources, they are urged to find answers to and perspectives on their problems and learning needs. The aim is also to develop problem-processing skills, self-directed learning skills and group competence [2]. Learning is now regarded to address to types of knowledge, explicit knowledge (conveyed by books, lectures and scientific documents) and tacit knowledge (directly related to experience and practice, as shared by interaction and collaboration) [3].

The evolving shift from teaching to learning in education is also strongly related to an increasing involvement of new information and communication technology (what is often collectively referred to as “new technologies”). In recent years, advances in information and communication technology, and especially the internet, have acted as catalysts for significant developments in all sectors of our society. There is currently an international trend to involve computers and the Internet in educational curricula as well as in continuing life-long learning. This practice is reinforced by active support and funding from bodies such as the European Union and local governments. Specifically, the European Council in its Lisbon meeting in March 2000 set forth the European policy for an information and knowledge-based society, stressing the need to encompass the emerging technological revolution and change in the exchange of knowledge affecting all institutions and various aspects of the society [4].
Education can be considered in terms of three levels of increasing complexity and importance [5]: information (i.e. simple facts), knowledge (i.e. information with a purpose), and understanding (i.e. conscious knowledge, achievement of explanation and grasp of reasonableness). Technology has been employed in diverse ways to support different levels of the educational process. Supporting the dissemination of information is the easiest and most straightforward achievement of information and communication technologies. They have extensively and successfully been used to give quick, easy

and cheap access to information sources, such as books, textbooks, atlases, scientific databases, research journals etc. Structuring and organizing information with a particular educational purpose refers to knowledge. On the other hand, understanding implies experience as well as inquiring. Managing and supporting these levels of the educational process is a rather complex issue. Of major importance is the potential of hypertext technology to provide interconnected pieces information, and link questions with explanations within the wider scope of a particular educational task.

However, in order to promote knowledge and understanding in education, information technology, and especially the internet, should embrace and support active learning approaches. Initially, the Internet and the Web were a static structure with passive viewers. Currently they are changing towards a second generation of dynamic services and communication tools that emphasize on peer-to-peer collaboration, contributing, sharing, usually known under the collective term Web 2.0, coined by O'Reilly in 2005 [6]. Web 2.0 is not an upgrade, but a whole range of new technologies, tools and services that support and promotion group and community activities. In Web 2.0 the user is seen as a contributor, rather than a recipient. Content is created by participation and collaboration as an emergent product of human interactions. Most commonly used representative Web 2.0 applications include wikis and blogs. Wikis are websites that can be edited by anyone who has access to them, while blogs are online multimedia personal logs that can be commented on by other users.

3. SUPPORTING PBL IN PUBLIC ASTRONOMY EDUCATION VIA WEB 2.0

Although Web 2.0 emphasizes on participation, in its early days it is still used in the majority of cases to hold and provide content (albeit created dynamically and via peer participation and collaboration) and then systematically deliver it to students. In this paper, we propose the use of wikis and blogs not to create, store and provide information, but as active tools to support problem based learning in medicine. In our approach, students and instructors use the web as a virtual place to collaborate and explore and create new knowledge. Specific objectives of this work include:

(a) support collaboration of remote astronomy experts (amateurs and professionals) in order to devise, develop and deploy didactic problems for problem based learning in astronomy;

(b) deploy problem-based sessions in virtual teams, where both students and instructors may be located in remote places;

(c) support strong instructor's presence in a PBL episode;

(d) provide tools for student inquiry and collaboration; and

(e) provide mechanisms for continuous monitoring and evaluation, that would address direct knowledge, as well as tacit competencies targeted via PBL.

Considering the amateur/public educational set-up, there is also the additional requirement for integration with generic environments that support teaching, i.e. open source learning management systems and related educational standards [7].

Our approach combines collaborative tools such as wikis, blogs and forums in order to provide problem based learning solely on the web. In these PBL sessions, instruction is performed by an interdisciplinary team of astronomy experts (amateurs and professionals) from different towns in the greater region of Thrace as well as from other places in the country, while the group of learners can be situated anywhere. Instructors collaboratively develop a problem in a wiki. Discussion is initiated via a problem's blog or forum, where students and instructors collaborate to analyse the problem, identify conquered knowledge and plan actions for problem solving. Then students search (via the web and not only) and collaborate to solve the case via the wiki. Student activities, progress and more importantly gained experience and competences are recorded, shared and commended on via their personal blogs. The entire learning episode and all its steps (with the final problem/answer deployment) are recorded, commended on and monitored via the wiki (final and intermediate versions) and the participants' blogs.

One current implementation is based on the wiki, blog and forum modules as available in the Moodle 1.8.4 open source learning and course management environment (http://www.moodle.org/). Moodle emphasizes on social constructionist approach to education, and on mechanisms for rich interaction within online courses. It is multilingual, exhibits several thousands of registered sites, and embraces among else a variety of Web 2.0 technologies.

The PBL session is presented as an individual course in the Moodle LMS, consisting primarily of discussion forums and a wiki. The didactic problem in this case is deployed in a number of consecutive steps. The student participants are expected to read through the first step, and discuss it via the problem's forum. Then, they should set out to find the answers to the questions asked, as well as answer all other questions that have been raised during the forum discussion. They have to record important steps of their search in their personal blogs, as provided within the environment. Finally, they have to provide answers collaboratively in the wiki. They are also urged to discuss each wiki entry via the special entry discussion page within the wiki. During this process, different instructors participate in the forum and wiki discussions. Instructors initially collaborate via the wiki in order to develop the didactic problem.

Once the session is initialized, the students are encouraged to spend some time to get accustomed with the environment and the procedure. This familiarization phase always spawns interesting side discussions on technical issues around web 2.0 technologies as well as on educational notions and approaches, which are conducted via a second forum devoted to technical and procedural issues. Then, the first step of the problem is deployed and initial discussion is conducted via the forum. The students are encouraged to list unknown words and notions in the wiki (under a "Problem Deployment" area) and perform personal or collaborative inquiries in order to resolve them. Final conclusion for each wiki entry is reached via a discussion for the specific wiki entry. Instructors participate in all discussions with comments and cues.

An important feature of this approach is that it enables various expert instructors (remotely located) to comment on and participate in the discussions providing highly specialized knowledge in their individual field of expertise. Another interesting issue is that tacit knowledge can be recorded, archived and mined, via the blog entries of the participants. Using the provided blog, instructors can record interesting and important steps in addressing questions, thus implicitly recording their expertise in scientific problem solving. On the other hand, students can record their own process of tackling the problem, searching literature, resolving ambiguities etc. These blog entries can then be viewed collectively as PBL session entries to reveal the progression of problem solving procedure or as individual participant blog entries that may help evaluate personal progress and especially reveal skills mastered by each participant and the process of evolution in skill mastering.

4. AN EXAMPLE PBL EPISODE DEPLOYMENT AND EVALUATION

A specific example of PBL deployment presented here was used for demonstration and evaluation of the proposed PBL implementation via Web 2.0. The PBL session was on "A Modern Outlook of the Sky" and was deployed in http://iris.med.duth.gr/elearning/. The learning objective, around which the PBL electronic course was organized, was an introduction of the participants to a modern outlook of the sky and was intended for an audience from the general public, with diverse backgrounds and itnerests. More specifically it was an introduction to a modern view of the solar system, to the physical mechanisms underlying stellar evolution and familiarization of the participants with the order of magnitude of stellar distances and the relevant measurement units. After the course, it was expected that the participants would know the basic morphology of our solar system, beyond the planets, they would have a basic grasp of the stages of stellar evolution and of the physical mechanisms that lead to that evolution. Additionally it was expected they would be able to correctly correlate the astronomical distances and time frames to the familiar everyday ones.

To that end the participants were organized as a group and assigned the imaginary role of a "Press correspondence team" of an amateur astronomy club that would be called upon to comment in the local press about several articles that would have relevance to the field of astronomy. The context of the problem specifically as was communicated to the participants (in the one single introductory meeting of the team) was the following:

«As members of an amateur astronomy club in a rural area that lacks an appropriate Physics or engineering department it has been delegated to you to be the unofficial "Press correspondence team". That is to provide the local press with an unofficial but well informed statement regarding various astronomy related news and stories coming into the spotlight at various times.

For that reason you will be called upon to comment on several fictional news stories regarding astronomical observations and phenomena. Some of these stories will be of sound scientific basis while others will not. Your job is to comment on both, after you have formed an informed opinion through widely available research means (internet, libraries etc.). The ideal response should be concise, relatively brief, but well documented and researched. You are not considered a scientific authority on the subject so any non-obvious scientific knowledge should be adequately referenced. No specialized education or resources will be required to be able to adequately address the issues covered by the articles».

After that, the team was exposed to a series of "articles" pertaining to the supposedly discovery of several astronomical finds along with commentary from other virtual amateur astronomy clubs. Their role was, after separating the solid scientific finds and facts given in the article from scientific institutions (NASA, ESA, Universities etc.), to research them and then suggest an explanation for these finds while commenting on the validity of the other clubs' opinion. In brief the articles were revolving around the arrival of interstellar matter from a far away supernova that exploded several hundred millennia ago. They were given in 3 stages. The first was about the discovery of the interstellar matter in our solar system where the participants were called upon to research the solar system in order to dismiss several erroneous statements in the article. The second was about a dispute between amateur astronomers about the nature of supernovae where they were called upon to research stellar evolution and resolve the dispute. The third was about the origin of the interstellar matter where they should research astronomical distances and time scales in order to comment on the origin of the supernovae that produced this matter. An example of the first screen of the problem currently being deployed is shown in Fig. 1. As mentioned earlier, there are two different forums, one aimed for the PBL discussion and one reserved for general discussion on technical and procedural issues. Furthermore, there are links towards 3 different wikis, each one reserved for a different problem stage.

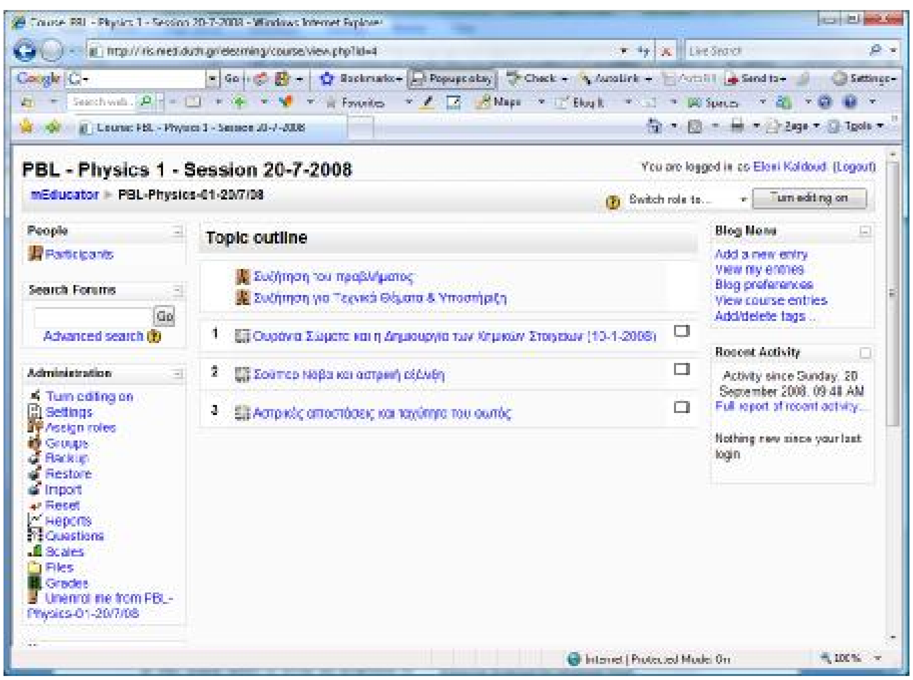

Fig. 1. Initial screen showing links to 2 different discussion forums (about the problem, and about technical issues) as well as to 3 different wikis, corresponding to the 3 different steps of the problem.

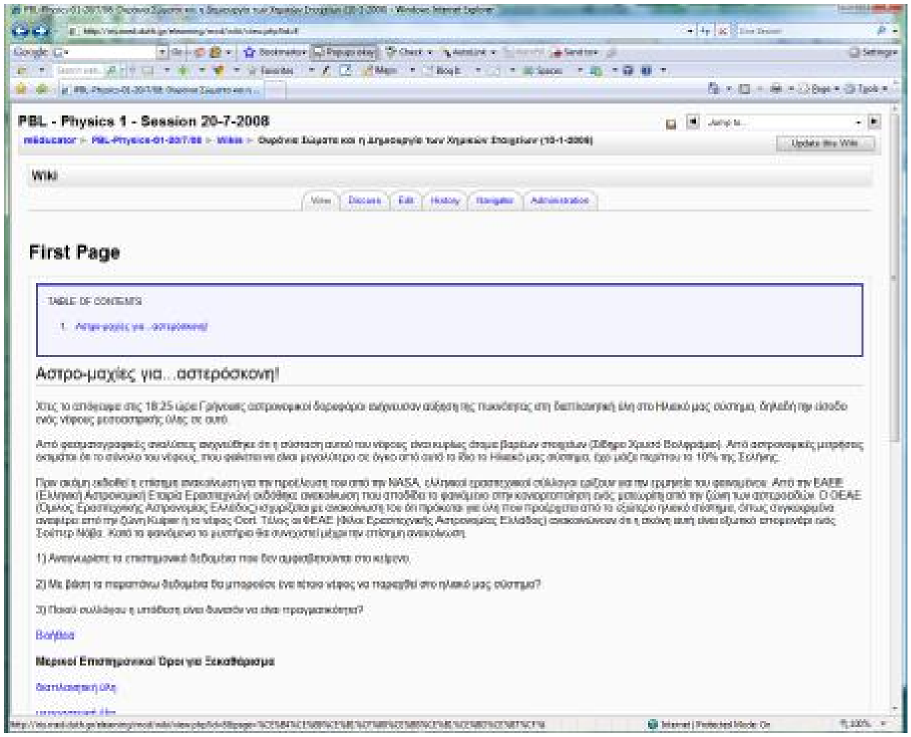

Fig. 2. A wiki entry stating the first stage of the problem deployment

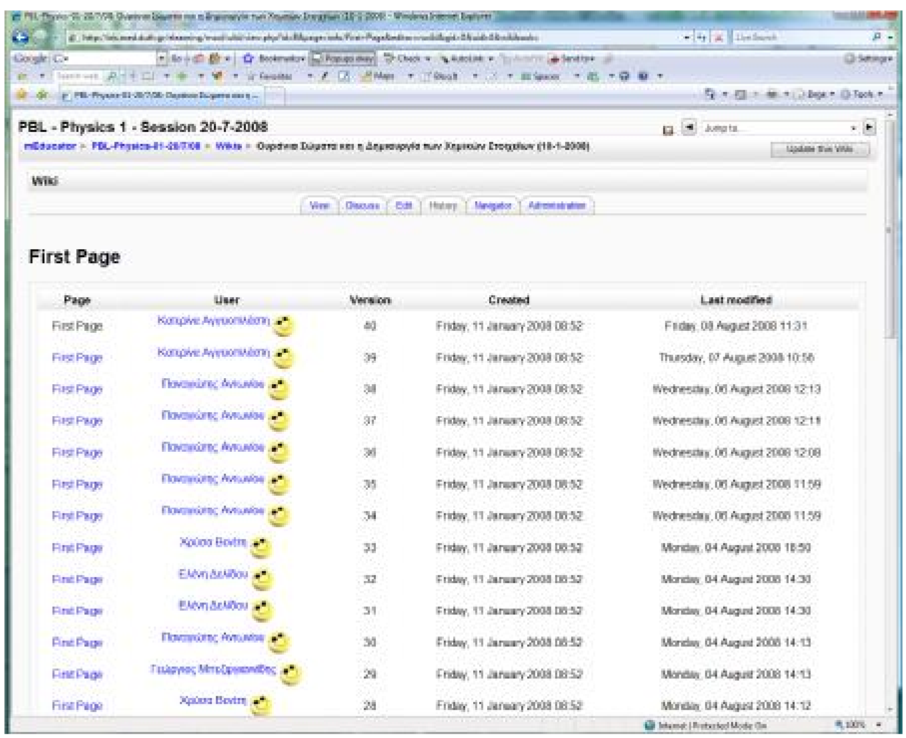

Fig. 3. A wiki screen showing the history of entries by various group participants.

The participating group of the electronic course consisted of 8 persons of ages between 12-24 years while the distribution between males and females was equal. The PBL session took place in the span of 15 days. There was one introductory in-person meeting that lasted approximately 1 hour. In that meeting after the introduction of the participants and the facilitators, personal login information to the LMS platform was handed to each participant, a short primer on the use of the system was delivered and the context of the problem was explained to them.

The aim of this pilot PBL deployment was to evaluate the educational impact and the participants' satisfaction of a PBL course delivered utilizing web 2.0 technologies. To that end, each participant was interviewed prior and after the project using semi-structured interviews. These interviews were organized along 3 axes: the subject of the course, the technology utilized and the educational method. In the initial interview the aim was to discover the prior experiences, the expectations, and the fears of the participants regarding each axis of the educational process. In the post-project interview the aim was to explore the participants' impressions and to compare their perceptions of the educational method with the traditional classroom approach. It must be noted that, in order to not bias the participants in any of their answers when a specific answer about a subject was not freely given there was no follow up with specific answering options. Due to that fact in our results some participants appear not to provide any response at all to some issues. Furthermore it must be noted that only 6 of the original 8 participants provided post-project interviews due to reasons beyond our control such as relocation or travel during the time of the interviews.

As summarized in Table 1, most of the participants have never been exposed to a PBL scenario before. Only one participant was exposed to what only could be described as interactive problem solving in physics and mathematics but that was always in the context of the traditional classroom paradigm. When the PBL educational method was explained to them the participants univocally seemed to prefer either solely that or a mix of PBL and a traditional lecture approach. Most of them considered PBL a more accessible method of learning. When asked about the perceived advantages of the method most of them thought that they could absorb more knowledge from this, while some also mentioned the cooperation and teamwork as a strong point. It is interesting to note that these same persons that recognized the potential of teamwork in a PBL approach were those who considered that it would lead to problems in the learning process. Most of the participants, nevertheless, recognized as a potential hindrance the pressure of time with only one of them noting the problem of research resources' availability as a possible obstacle.

PARTICIPANT	**Prior Knowledge**					**Expected Difficulty**		**Expectations**			**Fears**			
	Familiar with PBL		**Perceived Preference**											
	Y	N	Conv. Course	PBL	both	Pbl easier	Pbl harder	Knowledge	Cooperation	Fun	Time Pressure	Cooperation	Resource Availability	None
1		X		X		X		X	X		X	X		
2		X			X	X		X						X
3		X			X	-	-	X	X		X	X		
4		X		X		X		-	-	-	X			
5		X		X		X		X			X			
6		X		X		X		X	X		X	X		
7		X		X		-	-	X						X
8	X			X			X	X	X				X	
tot	1	7	0	6	2	5	1	7	4	0	5	3	1	2

Table 1. Participants' attitude towards the educational method prior to PBL deployment.

As summarized in Table 2, after the project the perceptions of the participants regarding the method had significantly improved. Most of them perceived themselves as having gathered more knowledge, than a traditional lecture based approach with some mentioning the positive effect of cooperation and parallel research. While the participants still viewed PBL as a easier and more preferable, this time the exposure to the project removed their fear of time pressure. The most significant result here is the fact that 4 (out of 6 who answered) mentioned that in retrospect they could not find any inherent difficulty in the educational method. The only concern remaining for only 2 of the 6 participants was the difficulty of finding educational material.

PARTICIPANT	***PBL impressions***		***Preference***			***Difficulty***			***Pros***			***Cons***	
	Positive	*negative*	*Standard course*	*PBL*	*both*	*easier*	*harder*	*Same/medium*	*Knowledge*	*Cooperation*	*Fun*	*Difficult access to resources*	*None*
1	*X*			*X*		*X*			*X*	*X*			*X*
2	*X*				*X*	*X*			*X*				*X*
3	*X*				*X*	*X*			*X*				*X*
4	*X*			*X*				*X*	*X*	*X*	*X*		*X*
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-
7	*X*			*X*				*X*	*X*		*X*	*X*	
8	*X*			*X*		*X*			*X*			*X*	
Tot	*6*	*0*	*0*	*4*	*2*	*4*	*0*	*2*	*6*	*2*	*2*	*2*	*4*

Table 2. Participants' attitude towards the educational method after PBL deployment.

With regards to the e-learning platform, as summarized in Table 3, while all participants perceived themselves computer literate, their perceived familiarity with wikis and blogs was not as unanimous. Nevertheless probably due to the age range of the participants, when faced with a computer project, they were positive to the point of overconfidence. Almost everyone considered e-learning easier than the traditional learning process, expecting increased learning benefits and smoother cooperation. In that mood almost everyone perceived that no difficulties would appear in the in the learning process. This view was slightly modified after exposure to the e-learning platform (Table 4). While most of the participants found the introduction to the system helpful and utilized the internet for research, almost everyone admitted that there was a non trivial learning curve to the utilization of the system. When asked about suggestions, one participant mentioned that improvement to the UI of the e-learning platform would streamline the procedure.

Regarding the educational subject, i.e. astronomy, all of the participants had been prior exposed to some kind of astronomy education, but none perceived herself/himself as having more than casual knowledge of the field. Almost all of them hoped to improve their knowledge, with some having open queries that they hoped to answer. It is interesting to note that even in the context of a learning project there was one participant who expected fun from the interaction with the subject. The post-project evaluation of the participants' impression showed that participants had a positive impression considering the content of the problem. They felt that their knowledge of the subject has improved. In fact, one participant went so far as to change her opinion about her prior exposure to the subject and consider herself not even exposed to astronomy prior to the project. Two of the participants went even further and expressed that the research on the subject was a "fun" activity. There were of course hurdles in the process and almost all participants admitted to have problems either understanding the problem in general or in specific issues. Nevertheless with most of the participants having devoted either less or approximately one hour daily to the project the important note is that they felt they had significantly improved their knowledge of the field.

PARTICIPANT	**Prior Knowledge**				**Expected Difficulty**		**Expectations**			**Fears**			
	Familiar with IT		**Familiar with web 2.0**		E-learning Easier	E-learning Harder	Knowledge	Cooperation	Fun	Unfamiliar with Software	Cooperation with Strangers	Resource Availability	None
	Y	*N*	*Y*	*N*									
1	X			X	X		X			X	X		
2	X		X		X		X						X
3	X		X		-	-	X	X					X
4	X			X	X		-	-	-				X
5	X		X		X		X						X
6	X			X	X		X	X					X
7	X		X		X		X				X		
8	X			X	X		X		X	X	X	X	
tot	8	0	4	4	7	0	7	2	1	2	3	1	5

Table 3. Participants' attitude towards the web 2.0 e-learning platform prior to PBL deployment.

PARTICIPANT	**Internet Helpful**		**Clarity of Instructions**		**Pros**			**Cons**			**Suggestions**	
	Y	N	Y	N	Knowledge	Cooperation	none	Learning curve	Remote Cooperation	None	UI Improvements	None
1	X			X	X			X	X			X
2	-	-	X				X	X			X	
3	X		X		X			X		X		X
4	X		X		X			-			-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	X		X		X			X				X
8	X		X		X			X				X
tot	5	0	5	1	5	0	1	5	1	1	1	5

Table 4. Participants' attitude towards the web 2.0 e-learning platform after PBL deployment.

Concluding the results of this study, it is worth noting that all participants expressed their interest in participating again in a similar project. Furthermore most of them after the project was finished had developed a personal interest in one of the specific subjects of the field of astronomy. Be it Supernova, the scale of the cosmos, or the physics of stellar evolution, 4 participants (out of the 6 interviewed) had found a “favourite” subject that they would like to know more about in the future.

5. DISCUSSION

The new opportunities offered by the Internet and the expansion of information and communication technologies have enabled the explosion of web-based educational initiatives, like online education and e-learning in sciences and in public education. However, the success of online education depends more on the mechanisms that make educational content available to learners and techniques to support the learning process, rather than on the educational content itself. Moreover, effective online learning experiences require a successful alignment of the learning approach with the technology used.

Such an inherent alignment exists between the notion of active learning and the paradigm of Web 2.0 technologies, as they both rely on and emphasize on social skills (such as collaboration, interaction and peer activity) as opposed to mere content. In our approach we take advantage of this inherent alignment, and use the wiki and blog Web 2.0 technologies to create online distributed problem-based learning sessions for distributed public education in astronomy.

Work in progress elaborates on mechanisms to process and analyze the learning process as recorded in personal blogs of our approach so as to extract meaningful information about capturing expert's practical skills (e.g. on information searching and knowledge extraction) and monitoring learner's progress in learning.

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