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Learning environments on the World Wide Web: experiences from Astronomy On-Line

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In this article the Astronomy On-Line (AOL) learning experiment on World Wide Web (WWW) is described. As a part of AOL, educational research was carried out. The purpose of this study was to measure how students experience the new medium in their learning and how students utilize the communication facilities (group e-mail, real-time discussion) available through the WWW site. This study also describes the computational facilities available among AOL participants all around Europe.

KEYWORDS: Distance learning; case studies; collaborative learning; communications; open learning.

INTRODUCTION

Astronomy On-Line (AOL) (http://www.eso.org/astronomyonline) was the world's biggest astronomy event on the WWW organized by the European Association for Astronomy Education (EAAE) and the European Southern Observatory (ESO) (1996). Its aim was to bring together students from all over Europe to explore astronomical questions using modern learning tools. The AOL started in October 1996 and ended on 22 November 1996. In total, 720 groups consisting of over 5000 students from 39 countries participated in AOL. There were students from all age groups ranging from under 12-year-old primary school students to university students. As part of AOL an educational study was set up to evaluate the learning process in AOL.

AOL activities

The main activity in AOL was a set of collaborative projects dealing with astronomical observations. The projects were described in AOL WWW pages. Usually, the project consisted of a short theoretical background, the observation procedure, advice on the measurements to be performed and references to extensive material. The collaborative projects were revealed in three ‘phases’. The first phase was used to experiment with the WWW. The second phase involved most of the projects and was the stage at which collaboration between student groups was begun. Finally the third phase, actually the last week of AOL, was the ‘hot’ phase involving a lot of intensive work and real-time collaboration in the Internet.

The first collaborative project was to observe the lunar eclipse on 27 September 1996. Based on the results the longitude of the place under observation could be determined. The second project was to observe the partial solar eclipse on 12 October. Based on the observations it was possible to measure the moon’s distance by means of a solar eclipse: this was probably the first time that such a measurement had been made by amateurs and students.

The third collaborative project was to study the Sun’s aurorae. Groups in Central and Southern Europe observed the Sun, looked for sunspots and made a daily sketch of the solar surface seen on a projected telescope image. At the same time, groups in Northern Europe made observations of variations in the Earth’s magnetic field and of the beautiful aurorae that were often visible there. The observations were e-mailed from south to north and vice versa. Together, the observations made it possible for students to study actively the relationship between the Sun and the Earth. For example, the changes on the Sun could later be registered at the Earth as a variation in the Earth’s magnetic field, when fast particles of the solar wind have travelled the distance between the two planets. This way the southern groups could forecast the next aurorae in Northern Europe.

Other AOL activities included treasure hunts using WWW navigational techniques, talks with professionals using real-time discussion software, the use of astronomical databases and software, group communications using e-mail and bulletin boards.

Network-based learning environment

The elements used in AOL constitute an ideal *network-based learning environment*. In this section we try to describe network-based learning environments from the theoretical point of view. Generally, a learning environment is a collection of topics (Siviter and Brown, 1992). A topic is a collection of educational activities, such as reading a piece of text, looking at a picture, playing with a computer-based interactive device or searching information from the library. The general definition of the learning environment is based on the concept of learning by doing (Pantzar, 1995).

A more technical way of describing the network-based learning environment is to characterize the elements that are needed in the network-based learning environment. In order to learn by doing educational activities it is necessary that the network-based learning environment consists of learning materials, such as hypertext, problem solving tools (cognitive tools), communication and collaboration tools and external information resources. The network-based learning environment is outlined in Fig 1.

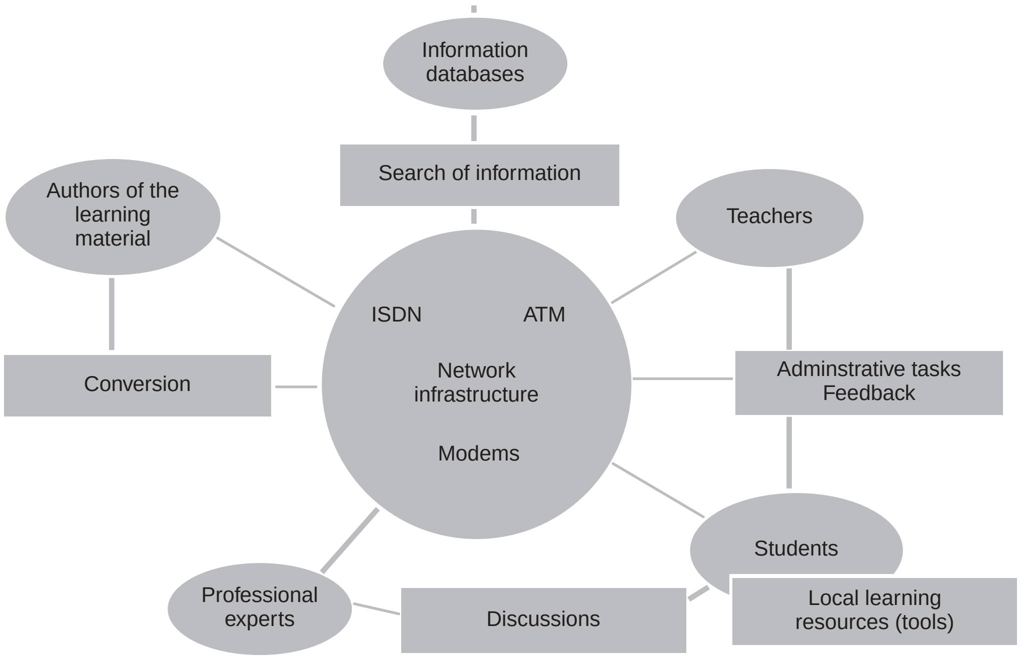

Figure 1. A network-based learning environment.

Learning

An example of a cognitive tool can be a spreadsheet application that is used to solve a computational problem. By constructing a spreadsheet model the student is able to solve the problem. The construction and testing of the model is certainly a cognitive process.

Collaboration tools are tools that can be used by several students from different computers at the same time. Often a collaboration tool includes a shared workspace that can be a graphics area or a wordprocessing document. The workspace can then be viewed and edited by several users at the same time. Examples of collaboration tools are shared whiteboard or shared calendar applications. Communication tools enable communication between the students and the teacher. The communication can be off-line (e-mail) or on-line (audio- and videoconferencing applications). Also, the communication can be one-to-one, one-to-many or many-to-many. An evaluation of several conferencing applications is presented in Juell *et al.* (1996).

The type of network connections in the user and server sides can considerably limit the type of activities that can be delivered to the remote student. For example, the use of video material may be impossible with slow modem connections but acceptable in integrated services digital network (ISDN) connections.

There have not yet been many implementations of learning environments that can be described as network based. For example, a survey of learning environments in mathematics (Multisilta, 1996) shows that many learning environments do not yet utilize communication technologies. The network-based learning environments differ from local learning environments in that in network-based learning environments the information is loaded at least partly from the network and not from the local hard disk or CD-ROM. This fact must be remembered when designing and implementing network-based learning environments. In particular, the three key factors for using networked information are:

(1) Availability: information may be available and still be impossible to use (slow connection prevents the use of large materials).
(2) Reliability: how to be sure about the correctness of the information.
(3) Usability: how to find relevant information (searching, filtering) and how to find information that can be understood with the user's background.

Research objectives

As a part of AOL, an educational study was set up to evaluate the learning process in AOL. The main research objectives were:

- How did students experience the new medium in their learning?
- What was the level of international collaboration and the usage of communication tools in the collaboration?
- What was the role of astronomical observations in the learning process?
- What was the role of experts (talks to professionals) in the learning process?
- What was the availability of local resources (computers, networks, time)?
- How much did the students' previous knowledge influence their learning outcome?
- What were the motivational factors to learn astronomy in AOL?

The research was done by implementing an on-line questionnaire on WWW (as a WWW form) and a corresponding cgi-script that automatically processed the answers in the questionnaire to the data matrix. The questionnaire was available to the students during the last days of AOL. The questionnaire contained 28 statements that students were asked to evaluate on a scale of 1–5 (i.e. from totally agree to totally disagree). In addition there were seven questions where students had to characterize: (a) in a five-point scale, themselves as a learner (active or passive, theoretical or practical, quick or slow, explorer or listener); (b) the WWW as a learning environment (active or passive, information database or a learning tool); and (c) navigation in the AOL WWW site (easy or difficult). There were also seven questions that described the computational facilities and the backgrounds of the students (age, reference group, sex). Finally there were questions where the students could answer verbally to explain their expectations from AOL, their most positive and negative experiences from AOL and the main problems they had during AOL.

In total 89 responses were received in time. This can be considered as a small number of responses compared with the total number of students participating in AOL. There are many possible explanations why we did not succeed in obtaining more responses. From the feedback available we can say that many students had problems with slow communication lines, strict timetables and language. Also, the questionnaire was only available for about a week during the hot phase. Students who participated in the AOL mainly during the hours of their astronomy class (for example once a week) may have missed the questionnaire.

RESULTS

In this section the collected data are summarized. The data are analysed using only descriptive statistics. For deeper analysis the amount of data collected may not be sufficient.

Characteristics of the responses

The answers were distributed geographically quite heterogeneously all over Europe. The most responses were recorded from Norway and Denmark which between them yielded 17% of all responses. The responses from Norway came almost entirely from a group taught by one of the designers of the questionnaire. In contrast, there were no responses from Finland.

Only 12% of all respondents were under 16 years old. This could be explained by the language problems. The English questionnaire was probably too difficult a language for the younger participants. There were also a couple of verbal responses that asked for German or French versions of the WWW pages.

Some 15% of the informants were members of astronomy clubs, 32% were secondary school students, 18% were college students and 10% were university students. The responses from teachers accounted for about 15% of all the responses. The minority of informants was composed of females, only 15%.

Connections and WWW site navigation

It seems that the most popular place where the AOL was mainly used was at home (30% of all responses). This can also be seen from the most popular connection type, i.e. the fast modems: 52% of all informants had a 9600 bit s^{-1} or higher modem: 10% of all respondents did not know the connection type at all. They probably used a computer in a public library or at a school other than their own. However, in the verbal responses many mentioned that the main problem with AOL was its slow connection line. On the one hand, AOL WWW pages have a lot of graphics that take a long time to load over modem lines. On the other hand, because of the graphics, navigation in the AOL WWW site was found to have been easy (65% of all responses).

Usability and reliability

The reliability of the information in AOL was not a problem because it was known that the activities and information pages were designed by professional astronomers and teachers. This is an important factor if we think of the utilization of the AOL material after the project has ended. Some groups informed that they had not enough time to do all the collaborative projects during AOL, so instead they printed the projects and intend to do them later by themselves. The AOL WWW pages also remained on-line after the project.

Some 65% of all respondents reported that they easily found activities that corresponded with their level of knowledge. This is because many projects consisted of observations for students in different knowledge levels.

Communications

Many respondents expected to get in contact with other students interested in astronomy. In general, communication was considered to be the most positive feature and also a weakness of AOL: there was the real-time discussion channel, but it opened too late (i.e. during the hot phase).

One of the problems in AOL was the cloudy skies. During AOL there were many projects that required observations to be made on certain nights at certain times (for example eclipses). It is a fact that the sky can be cloudy, but even that could not put an end to the observations: some sites broadcasted, for example, the eclipses in real-time to the Internet.

In AOL local resources were all seen as important factors for learning. It seems that the role of the local teacher was extremely important because the local teacher could integrate AOL with other work at school and to the school's curriculum.

The activities on AOL were generally not seen as too theoretical and the theory behind the activities was understood very well. In this study computers were seen as tools for learning (they made the studying easier and efficient) and they were not used too much in learning. What was more AOL encouraged many students to study the Internet further.

CONCLUSIONS

The Astronomy On-Line event connected 5000 students all over Europe. As such it can be described as the biggest astronomy event on the WWW. The educational study received 89 responses. From the feedback available we can say that many students had problems with slow communication lines, strict timetables and language. The feedback was generally positive and encouraging. It can be said that the possibility of communicating with other groups and with professional astronomers was possibly the best part of AOL. The role of the local teacher was important for the success of the individual group. An enthusiastic teacher can inspire the work of a group and as such be a motivational factor.

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