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Requirements for software tools supporting project-based learning

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Requirements for software tools supporting project-based learning and CommSy as an exemplary solution

ABSTRACT

Project teams have become an important element in teaching informatics topics. Web-based groupware systems are increasingly used in such teaching settings to help building communicational competence and working with different kinds of material. This kind of educational teamwork and computational support compares well to project work observed in industrial settings. In our paper, we present the design principles for a web-based community system called 'CommSy' which has successfully been applied in a number of educational projects. We outline the didactic aims which lead to the particular design of the system as well as the special characteristics the system provides. Further, we provide some anecdotal evidence as to how the design principles helped the project teams and whether or not the teams felt the systems adhered to the principles discussed.

Keywords: Community system, groupware, virtual project teams, learning communities

INTRODUCTION

Dynamically formed, multidisciplinary teams which work together only for a specific project play a major role in new organizational forms like virtual organizations or virtual companies. The work in these "nomadic hordes" [8] can be characterized that it takes place part-time co-located and part-time "virtual", i.e. potentially asynchronous and geographically separated. In order to work in such project teams, various are skills required. The necessary social skills comprise the ability to deal with dynamic settings. It becomes more and more important, for example, to get oneself acquainted with other project members, grasp their perspectives and problems, or take up work done by others, all in a short period of time. It is also indispensable to make effective and efficient use of software tools that support such project teams. In this paper, we discuss the steps for promoting the build-up for the necessary skills.

In order to discuss how the necessary skills for working in a virtual project team are acquired, we explicitly focus on an educational setting. Like professional skills, the necessary social and technical skills must be trained, and in our opinion the training should take place at university level at the latest. In accordance with state-of-the-art learning theories we argue that learning only happens when learners work together on issues of practical relevance to them. Therefore, we organize courses where students work in teams on complex problems for a longer period of time. Plus, we promote that our students use software tool to build up social and technical skills for their future jobs in potentially virtual project teams. We call this didactic concept project-based learning.

In this paper, we will first describe how project-based learning is organized at the University of Hamburg, Department for Informatics, and how this fits in with learning theories and didactics. We illustrate this with examples from several courses on information systems, software-engineering and human-computer interaction – topics we offered over the last few years. We then introduce CommSy, an innovative web-based software to support project teams. We show how it evolved out of the need to support student project teams and then discuss how specific features of our community system fit in well with our didactic concept.

PROJECT-BASED LEARNING IN TEAMS AND THE USE OF SUPPORTING SOFTWARE TOOLS

Current topics publicly discussed and ongoing research deal with communication and knowledge management problems – we are approaching the knowledge society. New technologies are being introduced in all areas of life and especially in work situations with an increasing pace. Students should have the opportunity to gain experience in new communication and knowledge management technologies and corresponding work organizations and ways of living in their studies. Thus, enabling them to better understand the interaction of these new media and their field of application should be a central issue in the informatics curricula.

In this section we describe project-based learning and the use of supporting software tools as the didactic approach in the department for Informatics, University of Hamburg, to educate students for coping with the requirements of the approaching knowledge society. Project-based learning allows students to gain first-hand, authentic experiences which cannot be offered in lectures or traditional seminars. In projects, students can learn how to engage in real-world problems, and they are required to cooperate with their fellow students.

Didactic Aims

Project-based learning is to fosters learning processes on different levels. At team level students should learn how to take an active part in cooperation with others and to organize their work by using different methods. A team structure is to be established and team communication to be learned. The students have to take responsibility for their actions and they adopt certain roles within the team. On the subject-level, all learning should take place with a focus on the respective problem. Students learn by solving problems identified in cooperation with others rather than practicing by themselves. Therefore, the learning process has its own significance for the students. Furthermore, they do not only learn from books suggested by their teacher, but from a “flood” of information sources. They thus learn how to select adequate sources.

Two aspects are central to project-based learning:

1. Communication plays a major role, because successful communication is the basis for all social interaction. That is coordinating team-work, negotiating positions and responsibilities within the team, sharing own perspectives on the given problem with other team members, and so on [11].

2. The management of a tremendous amount of various working material is important, because a proper selection of information sources is the basis for any informed decision made within the project.

Didactic Means

The University of Hamburg is a two term university with approx. 42000 enrolled students in about 100 different courses of study. A term is a half year period: three months of teaching are followed by three months of studying and exam preparation. In this general setting, project-based learning has a long tradition in the Department for Informatics at the University of Hamburg. During the teaching period, students participating in a project normally meet once a week (running up to 12 –14 times per term) for four to six hours to work on their task. But due to the interdisciplinary mixture of students in informatics classes, the high number of part-time students and the geographically dispersed site of the University in the city of Hamburg raise the demand for flexible forms of communication within and out of class. Setting up project teams working on different but related topics requires an even more

complex coordination and a richer communication process. Coordination thus becomes an explicit issue in our educational project.

Our didactics for project-based learning is based on the concept of “learning by doing”, first systematically developed by the philosopher John Dewey [9] and has been adopted by many educationalists ever since. The state-of-the- art learning theories based on ideas by Piaget and Vygotsky (cf. [16, 17, 18]) have shown, that learning and doing are strongly intermingled and in such promoted the idea of project-based learning. Our concept allows students to take an active and responsible part within an authentic project. In addition, students are urged to reflect on their tasks and roles in social interaction.

The following principles form the basis of our didactic concept:

- *cooperatively constructing complex tasks*: Students and teachers construct their tasks cooperatively within a broad area given by the subject of the course. For the project being educative, it is very important that the tasks are chosen carefully. A task shall should be of a lasting interest for students and teachers, not only a short-term enthusiasm. It should be both, enjoyable and of practical relevance (cf. [14]). Finally, it must be demanding and provoking the desire for more information, it must “lead the mind out into new fields.” [11, p. 292]

- *organizing the working and learning process in groups:* The students work on the chosen tasks for the whole term. They organize their work process themselves, and they have to thoroughly document (how they work out) their findings. Usually project teams are formed in groups of three to six students, to work on different aspects of the subject. Organizing and documenting the work process in a group of students fosters planning and evaluating action from different points of view (cf. [12]).

- *presenting (intermediary) results in plenary session:* In plenary sessions, basics are taught, opinions of invited filed experts are heard, preliminary findings are presented and work processes are reflected. At the end of the term, the project group presents its findings (as a product) to a bigger audience of interested faculty members and students. A product in this context can be anything like a paper- or software-prototype, a research report written by the students, etc. Presenting (intermediary) results fosters a process of reciprocal teaching and learning among the students (cf. [6]).

- *introducing software tools as new learning media:* In order to support the organization of the working process the use of supporting software tools is secured. Common information shared by technical means are dates, news and publications as well as some references. Furthermore, the provision of a technical means for organizing the project work promotes transparency for the others. Each project team and member has the chance to easily follow up on the work of the others (cf. [1]). Introducing new media is an effective way of redesigning teaching and stressing the relevance of practice. Its use in teaching gives a good example of the problems many professions face at the transition to the knowledge society: the use and understanding of state-of-the-art communication and knowledge management technology as well as the ability to cope with the recurring change of that technology. Especially in informatics, we educate the future specialists who will play an active role in developing new information technology solutions for people in other fields. Thus, we try to offer settings to them to better understand the interaction of these new media and their fields of application.

- *coaching the learning process:* Within the described setting of project-based learning, the teachers take on the role of "coaches". Their job is to set the conditions and to give impulses to the project work. They, for example, support the construction of a suitable task, they help project teams organize their work by reviewing their work processes, or they supervise critical situations by giving hints on how solutions can be found.

Our experiences

By applying the described didactic concept of project-based learning, students learn the two above introduced major abilities in addition to the field competence of the actual subject: communicative competence and the active work with different types of working material. Communicative competence means the ability to use a varied spectrum of different media to communicate and coordinate work within a project team. Students learn to choose the right medium for a specific communicational need, to select the medium which fits a given situation best, and how to express their intent within the selected medium. It is vital for students to get the chance to learn how to use electronic communication media during their studies, because electronic communication is central for the day to day work of project teams in practice and because electronic communication is in many ways different compared to traditional communication means.

Active work with working materials is both, scientific and professional work. Different working material is used by the students during their project work: they start off with a reservoir of preselected (by teachers) books, papers, videos, excerpts from newspapers etc. to help them orientate in the problem area. While working, they add own references to this reservoir. Additionally, students produce new working material – minutes of meetings and other documentation of their working process, presentations, software-prototypes, technical reports and (much) more. By working with a substantial pool of material, students learn to appreciate the usefulness of different information sources for their work process. By introducing electronic media they need to adopt these materials to the new medium and can tap new material, gaining additional competence.

Together with our colleagues, we applied the here described didactic concept to many projects on different topics during the last years (see table 1). In some of them students from other disciplines (economics, geography, journalism, pedagogic, psychology) attended. All projects received a positive feedback (from the students) and were successful. Feedback gathered in plenary-sessions and semi-structured interviews indicates that software-support strongly contributed to the success.

Year	Project Title	Faculty	Subject	Tool
1997	Enterprise Integrated Information Systems	Rolf, Wolff	information systems	Lotus Notes
1998	Software Support for Cooperation [19]	Bleek, Klischewski, Wetzel	cscw	Lotus Notes
1998	Software Development in Organizations [5]	Bleek, Floyd, Mack	software engineering	webspace
1998	Object oriented Software Development [3]	Bleek, Züllighoven	software engineering	webspace
1999	Workflow Management Systems	Klischewski, Wetzel	cscw	webspace

1999	Intranets and Knowledge Networks [4, 13]	Rolf, Wolff	information systems	CommSy
1999	Object oriented Software Development	Wolf, Züllighoven	software engineering	webspace
2000	Distributed Knowledge in Software Development	Bleek, Floyd, Wulf	software engineering	CommSy
2000	Interface Design	Oberquelle, Janneck	hci	Swiki
2000	Intranets and Virtual Communities	Rolf, Jackewitz	information systems	CommSy
2000	Object oriented Software Development	Lippert, Züllighoven	software engineering	CommSy
2000	Serviceflow management	Klischewski, Wetzel	cscw	CommSy
2000	12 independent Projects at the International Women's University, Project Area Information [2]	Floyd, et al.	information as a socialresource, interdisciplinary	CommSy

Table 1: List of relevant projects conducted at University of Hamburg with title, responsible faculty and subject addressed

In the educational projects listed above, we also experimented with a number of supporting software tools. Table 1 shows the project list with the chosen software. Some projects used webspaces with HTML pages to put documents online. In our experience, this level of technical support even in combination with mailing-lists and newsgroups does not enable an adequate support for project-based learning. In other projects we tried to alleviate technology use by using software systems like Lotus Notes (LearningSpace), Swiki, Teamwave Workplace, Hyperwave or BSCW. In our experience, these software systems offer a killing amount of functions and thus do not meet our usability requirements. Due to their technical complexity, these software systems threaten to superimpose the learning process with technical issues. To better support our didactic concept with a software tool, we will first explicitly state our requirements toward such a software system and then describe the web-based system CommSy as an exemplary solution.

COMMSY – A WEB-BASED SYSTEM TO SUPPORT PROJECT-BASED LEARNING

We have outlined the principles of project-based learning as our didactic concept. We also pointed out that the use of supporting software tools is an important element in this. Experience with software tools in educational settings show that they must match in order to be beneficial for the learning process. Therefore, we thoroughly derive requirements for a supporting software tool from our didactic concept. Then we discuss the web-based system CommSy as an exemplary solution.

Requirements for software systems supporting project-based learning

The following requirements for software-systems supporting project-based learning can be directly deduced from the underlying didactic concept. They reflect technical, usability and organizational issues:

- *basic technologies:* Since the software system applied in educational projects and its further development can both become a subject matter itself the students' access to the basic technologies utilized should be straightforward. These should, on the one hand, be

easily manageable to facilitate their introduction, at the same time they must be at their disposal anytime, in particular outside regular seminar times.

- *functional scope:* The software support should offer a functional scope motivated by and derived from the project work. It is crucial that the software permits an active and flexible handling of a variety of working materials. Additionally, the software should offer different forms of support for cooperative teaching and learning processes targeted at and for the benefit of all communicating parties involved.

- *easy individual usage:* An easy access must be ensured in order to avoid user problems receiving a higher ranking than the actual project work with the software system as a communication media. Participants should be able to take on an active role in the project without having to overcome technical barriers. Following internet standards is the most suitable because the client software is available in every operating system from the outset. This has the following advantages: No perhaps elaborate installations need to be made, and in consideration of interdisciplinary projects, web technologies facilitate the access to the software because internet use is simple, to a certain point standardized and experience with it widely spread. The software should do without the extravagant use of graphics and icons since learning and remembering the icons' meaning may create a further obstruction in application of the use of the system. A standardized set up and a consistent dialogue structure further facilitate the software application.

- *transparency in cooperative usage:* The software support should promote the users' initiative in such a manner that it becomes transparent to other users of the system. It can do this, i.e., by not permitting anonymous contributions. In this, the assignment to a particular person can be made, and confusion arising from anonymous or automatically generated, unrelated contributions will be avoided. Personal initiative should be enhanced through an easy, free and unlimited use. And building up a team structure should not be restricted by the design of the software system.

- *integration into a media-mix:* We consider an overall tool which covers all communication needs in university teaching as neither feasible nor desirable. In regard to acquiring the competence to use technical support for communicative needs it seems much more important to strive for the capability to handle a technology mix. Knowing which media is appropriate for which communication need and knowing how to express this need in the selected media accounts for one of the elements of the much cited term communicative competence.

CommSy – an example for a software system supporting project-based learning

CommSy stands for community system and is a web-based system to support the communication and coordination in working groups. CommSy has been developed and tested in various educational settings in the Department for Informatics, University of Hamburg since May 1999. We describe CommSy here as exemplifying a software system meeting our requirements for supporting project based learning.

Basic technology

A major requirement identified was that the chosen system must be accessible with a simple ready-at-hand commonly available web-browser. To ensure that everybody involved was in a position to access the system it needed to be adjusted to already established standards. Therefore, only simple HTML was used so that anybody with a browser (no matter what version or operating system) was able to retrieve pages and send input. The pages of the

community system are sufficient for W3C standards. At least the most common browsers like Microsoft Internet Explorer and Netscape Navigator/ Communicator were tested, others were reported to work properly in this setting (e.g. Opera, Lynx, iCab, and customized browsers provided by ISPs). In addition we also reduced demands for high speed internet connections in designing a system without major graphics or fancy layout features. Therefore home access was possible at any time.

On request, the pages of the CommSy were constructed to be as flexible and up-to-date with the presented information as possible. To do this a web-server (e.g. Apache) is combined with the script language PHP. Data is gathered in the relational database MySQL which is publicly available. All the basic technologies are such that the development of CommSy can be handled as a student project. Students can get a CD with the necessary software at the department and install the same configuration on their home PCs. All software components used are under free public licenses. On the server side this configuration is flexible enough to make sure that the operating system plays no important role in the availability of the system. Either any Windows or any Unix is instantly supported. Processor and memory requirements are not exceeding widely available standards. Thus, a positive effect thus is that both system usage and system development can be done for both purposes, research and teaching.

Functional Scope

Following the described didactic concept, we teach two major capabilities in projects: communicative competence and the active work with different types of working material. CommSy supports both: different forms of communicating and dealing with various types of working material.

News and dates can be announced in the respective sections *news* and *dates*. In these sections, every participant can post events or news that may be of interest for the whole project or a project team. Authors can assign entries relevant for a project team by simply making reference to existing teams within the system. Up to date information is displayed on the entry page of the system called home (see figure 1). By selecting a specific section, an overview of all former entries in this section is displayed and can be used as an archive. One can then choose a single entry and have the detailed view presented.

Besides posting announcements, CommSy offers multilateral communication by establishing the facility for all participants to annotate existing entries in any section. This can be done for different purposes, for example, to present a book review, provide an agenda for a meeting, bring in more details for a news entry or provide an additional hyperlink for any entry. For more controversially threaded communication there is room in the *discussions* section. This is a variation of usenet newsgroups, except that in CommSy every member may open a new forum instantly.

An indirect support for communication is supplied by the sections *people* and *groups*. In the section people every participant has a small “homepage” to present her/himself with her/his name, a picture and her/his contact information, if wanted, for the others to look at. This contact information helps establishing communication outside CommSy as well! In the section groups every participant may establish new project teams and join existing ones. Thus, the interests of every participant will be communicated indirectly and the structure of the project is depicted.

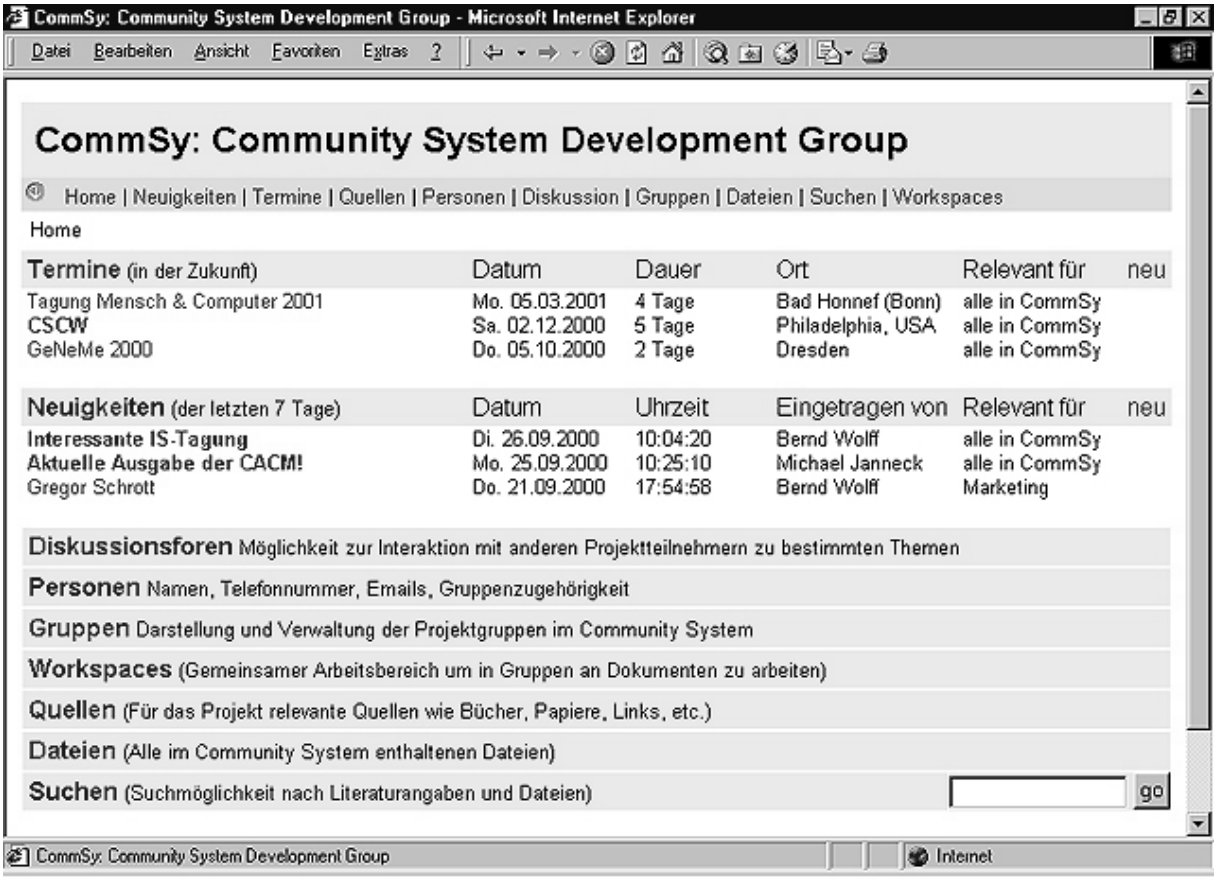

Figure1: The entry page of the system (called ‘Home’) as everybody can see it. Here in German.

Working Material

There are three means provided in CommSy for dealing with various kinds of working material. Within the system, every participant may attach *files* to almost every entry (news, dates, groups, annotations, discussions, sources). With this file-feature CommSy supports the management of working materials, including text documents as well as other multimedia files. This up- and download feature is used mainly for exchanging preliminary working material.

In the section *sources* all participants can enter information on books or papers, CDs, videos, hyperlinks, etc. which they consider relevant for their common work. Given this possibility, the student-project as a whole and each project team gathers a shared list of relevant references. Of course, all participants can add working material to a source entry by attaching a file [2].

CommSy does not only support submitting “foreign” documents like those mentioned above, the participants of a student-project have the possibility to create own HTML-documents in CommSy. For this purpose, there is a section called *workspaces* where groups can joinly write HTML-documents asynchronously and present the resulting pages.

A *search* mechanism is provided to quickly access all entries stored in CommSy. At present, a simple full text search is offered because so far there has not been a request for a more sophisticated search tool.

The distinction between communication and management of working material is more an analytical approach for didactic purposes. Each designed section combines communication support as well as handling working material. For instance, a thread in a discussion group is

first of all a means of communication. A completed discussion thread can for example be regarded as working material for a decision-making process.

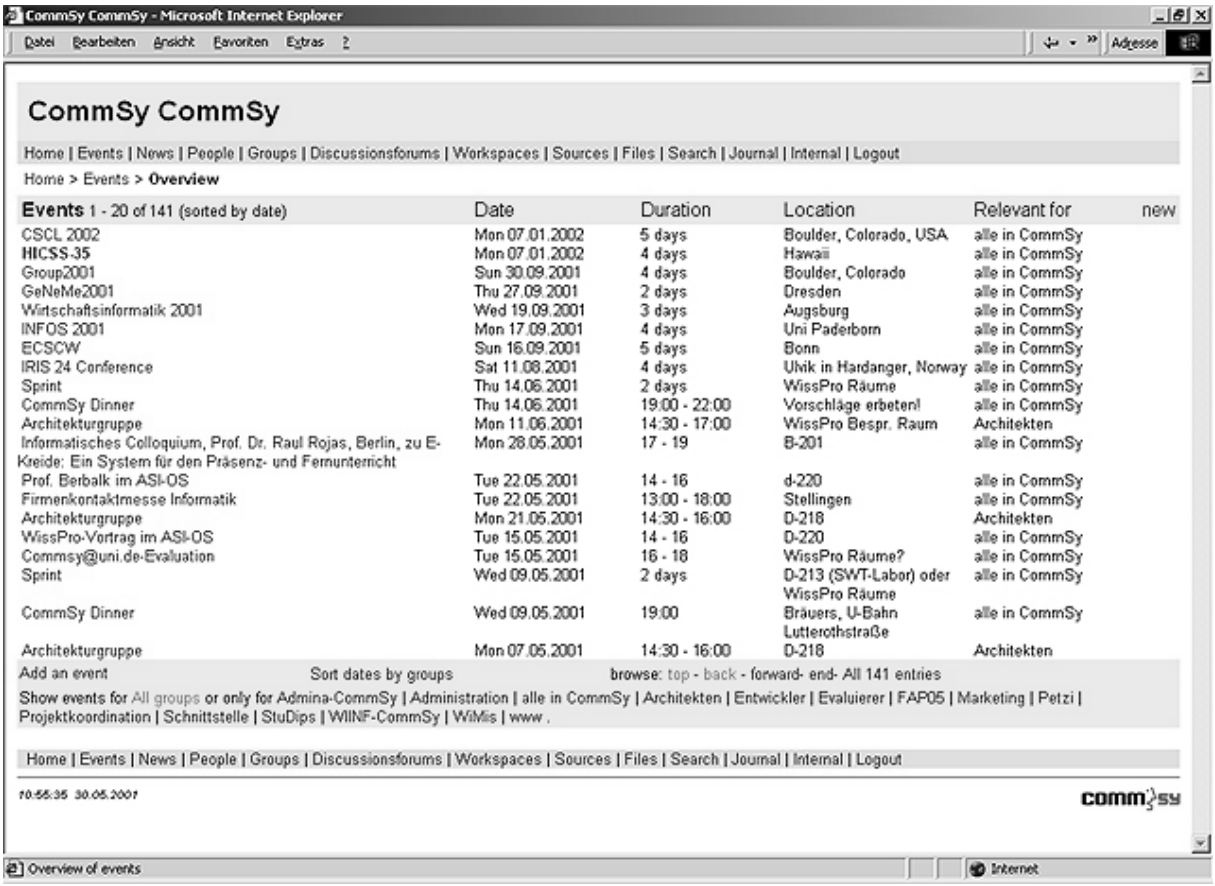

Figure 2: An overview page of the module Dates showing all entered dates sorted by date. Now in English.

Easy Individual Usage

Enabling individuals to use CommSy in an easy way is a prerequisite for any project member to actively engage in the project work without having to overcome technical barriers. We achieve an easy individual usage of CommSy by:

• *clear functionality:* CommSy holds an adequate range of functions. Users are not confronted with an excess amount of functionalities like in other groupware (e.g. Lotus Notes, Hyperwave, BSCW). For example, the section Dates is restricted to a small group-calendar rather than a powerful, personal date-assistant.

• *simple structure:* Across the different sections CommSy is structured into three levels. The first level is the home(page) of a CommSy with all sections visible and accessible (see figure 1). The second level is represented by the overview page of each single section (see figure 2), which lists either all entries (news, dates, people, groups) or shows an additional option to sort the entries in a section (in the discussion section the different discussion forums are listed, in the section sources shelves are shown, where you can put sources on). On the third level an entry is shown in detail (see figure 3). The different sections all have a similar dialogue structure. Once it is understood it serves for all the others.

• *simple layout*: Generated pages only use a small subset of the HTML possibilities. CommSy uses text rather than icons to simplify it's easing learnability. In addition, CommSy is fast

even to connected with a slow internet access to avoid unnecessary access obstructions for the client.

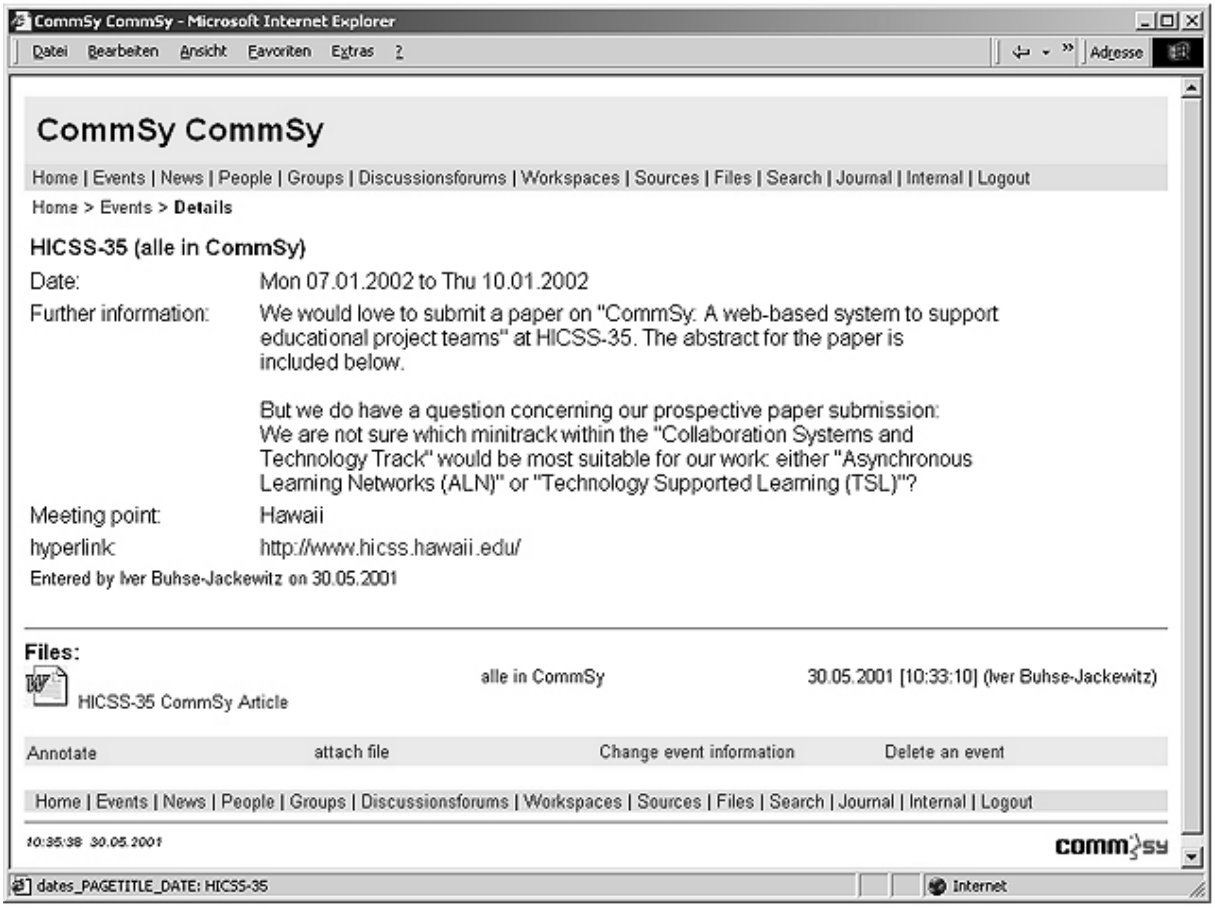

Figure 3: A detail page showing one date with description, a hyperlink and an online document attached.

Transparency in cooperative usage

CommSy gives special emphasis to user communities rather than individuals. We do this by::

• *no anonymous access:* CommSy is exclusive accessible for members of a certain group, who need to register before entering.

• *no anonymous entries:* Due to the authenticating procedure, each user's name is filed in the system, automatically saved with every entry this person creates and later presented together with the entry.

• *no concept of roles:* Ownership is the sole access right in CommSy. Only the owner of an entry may modify or delete it. With respect to this rule, every member of a CommSy is allowed to do everything and everybody sees everything. There is no distinction between students and teachers. Users can be sure that they get the same presentation as everyone else, thereby grounding communication on a common basis [7].

• *group identification:* Every CommSy can be customized to help building a group identity. This is done by offering color selection, choosing a name for that specific CommSy, and preselecting a set of available modules. All settings are equally visible to all members. Color has been observed to be an important criteria in finding group identity.

CommSy supports project-based learning in an asynchronous manner. CommSy does not serve all possible communicative purposes, but specific ones. In our experience, it therefore makes sense or is even necessary that there are additional technologies provided to support the project work. The usage of additional technologies also fosters the competence to deal with a set of technologies. In our educational project we explicitly stimulate the students to use additional communication media like email, phone or direct conversation and to reflect on the respective media selected.

DISCUSSION, CONCLUSION, FUTURE WORK

Introducing software support in educational projects is a significant intervention in learning processes. Developments in work life and in communication technology progress demand changes to make student-projects more realistic and allow for new experiences. We argue that the design of teaching must reflect these demands and the needs and necessities of the new work life. Software, on the other hand, needs to fit the culture and setting established in organizations. A software support introduced in teaching must address the needs identified concerning the didactic concept and at the same time give an impression of state-of-the-art technology. Software must on one hand be stable, reliable and easy to use and on the other hand show what may be demanded in real life application.

The here introduced web-based system CommSy supports different types of communication and different ways of dealing with working material. The types of communication supported are shaped by the ways and the variety that has been observed in the field of application. As a design principle, CommSy offers a means for developing different kinds of communication within the range of the tool: information like fixed dates, news, sources can be announced and discussions are specially supported. Individual sections are especially designed with respect to their needs. In addition to that the design principles are a recurring theme in each section. Users can rely on certain information and handling features to be present at all times. Examples are the annotation function or the file attachment feature, which can be used in any section. Working materials can thus also be dealt with in any section. This support reflects the necessity of going beyond the implemented types of communication material (e.g. dates, news and sources). By not being limited to those types users can expand their communication and adopt common files like PDF or Word documents. This is essential for integrating CommSy in existing environments. Communication and dealing with working materials are thus intertwined in CommSy. In this paper, we have shown our understanding of a software system that supports group work in project-based learning. The outlined principles and functional scope are keys to the success of the systems application. The requirements that have been identified for CommSy guide to several freedoms or possibilities relating to communication and management of working materials for the participants of a student-project. These possibilities imply that the participants must learn to make use of these freedoms. Participants are free to attach their files wherever they want, but they must learn to arouse interest in their respectively files and make other participants become aware of them. Working also means making a decision how often a participant wants to read all (new) entries: once a week, every second day or more than once a day. Finally, one must decide of the relevance of one’s own entries. E.g.: is a news important enough to be displayed on the first page of a CommSy? The variety CommSy offers corresponds to the aim of our didactic concept for student-projects. We want the students to gain technical and social competence for their future (work) life in the knowledge society.

We are intending to support project teams that do not only consist of students and teaching personnel but include staff from adjunct companies. Thus, offering the possibility to have even more realistic projects in university teaching and expanding the project teams from university to companies. First experiences made in real life projects offer optimistic outlooks.

Moreover, technology used in teaching has to pay attention to available resources like hardware as well as people and infrastructure. We have experienced a huge amount of infrastructure work that was not anticipated and not recognized by others. We will work on ways to describe this kind of work and its effects on the success of the introduction of software systems in educational settings. Plus, we work on technical support, like concepts for providing application service.

The software system and efforts to its technical transformation are only parts of a successful support for project teams. In our experience, system introduction and the need for continuous moderation are essential tasks during project time. Only the combination of social action and task oriented designed software do help establish an online community. In the future, we will work on respective concepts.

Finally, we will work on ways to evaluate the success of different system designs for an educational setting in order to empirically validate the theoretically deduced design criteria for CommSy described in this paper.

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