CoLPE: Communities of Learning Practice Environment

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Abstract. This paper reports on the experience of using an innovative technology-enhanced learning tool to support a real community of formal learning practice. First, we introduce the underlying groupware platform, called CoPE, that provides the essential functional support for democratic groupware. Then, we describe the main guidelines for the requirements and design of this application. As part of the design, we propose specific action types that promote meaningful contributions to be used to analyse learners' interactions in terms of performance and the particular skills exhibited during interaction. The aim is to extract relevant knowledge in order to provide learners and tutors with efficient awareness, feedback, and monitoring as regards learners' performance and collaboration. Finally, we employ this tool in a real on-line learning environment to support a collaborative activity based on an asynchronous discussion. The experience and the evaluation results of using this application are reported, showing promising opportunities to support the formal and also informal discussion processes occurring in current communities of learning practice.

1. Introduction

Over the last several years, collaborative e-Learning needs have been evolving with more and more demanding pedagogical and technological requirements [1]. Modern pedagogical approaches targeting formal education include advanced learning techniques based on some form of collaborative consensus-building mechanism, such as learning by discussion and problem-based learning [2]. To this end, a great deal of software packages in the form of Learning Management Systems (LMS) has recently appeared in the marketplace to support those communities of learning practice formed during the formal learning process, which typically involve all students in a classroom. These tools enable the management of educational content and also integrate tools that support many of the groupware needs, such as e-mail, discussion forums, chat, virtual classrooms, and so on [3].

On the other hand, informal collaborative learning typically involves a small number of students who meet each other informally after classes in small study groups to carry out specific learning activities assigned during the formal learning process. These groups of people also form communities of learning practice where an important part of both individual and group learning process takes place and whose members are often separated geographically and have the need to meet asynchronously.

In all cases, collectives of students who are separated by geography and/or time form communities of learning practice where an important part of both individual and group learning process takes place asynchronously. However, the lack of suitable and available groupware applications makes it difficult for these groups of learners to collaborate and achieve their specific learning goals. In addition, current collaborative learning applications and sophisticated learning management systems do not conveniently address the support to learning groups who are chiefly formed by non-technical people and who lack of the necessary resources to acquire such systems, especially in informal learning.

In particular, in on-line collaborative learning environments, the discussion process forms an important social task where participants can think about the activity being performed, collaborate with each other through the exchange of ideas arising, propose new resolution mechanisms, and justify and refine their own contributions and thus acquire new knowledge [4]. The lack of technological support for democratic decision-making mechanisms is however a main handicap to both achieve a consensus in a discussion process by means of voting and substitute the central authority of knowledge in small study groups. Furthermore, current collaborative applications provide poor support for the representation and analysis of group activity interaction as an essential feature to sustain a collaborative learning discussion, in terms of coaching, monitoring, and evaluation [5], [6].

A large amount of information is generated from the actions performed by the participants during the discussion process, which includes complex issues of the collaborative work and learning process (e.g., group well-being as well as self, peer and group activity evaluation). This information is then used in extracting and providing effective knowledge on interaction behavior to adequately regulate the learning process as well as to enhance learning group participation by means of providing appropriate awareness and feedback.

Unfortunately, despite the great support of LMS systems to important areas such as communication, collaboration and assessment, little support is provided in general to awareness and feedback, which is fundamental in this context. Two LMS platforms especially have showed up in the marketplace and are being extensively adopted by educational organizations. Moodle[1] together with the Sakai Project[2] are the major open source movements increasing their share in the educational space. Moodle is designed using sound pedagogical principles such as constructivism, to help educators create effective online learning communities, while Sakai is a huge community source software development effort to design, build and deploy new collaborative learning environments for higher education. This allows educational institutions to highly customize Sakai to suit their pedagogical needs, and technological requirements. However, at the present time, the adaptation of both Moodle and Sakai systems to different needs of important modules is missing, such as the logging component for extracting selected information and relevant knowledge about what is going on during the collaboration.

In this paper, we take these entire approaches one step further by introducing a new collaborative learning tool called CoLPE, which was developed to support and enhance the discussion process encountered in many on-line courses and also in those informal study groups in the form of on-line discussions. This system implements many of the approaches described so far and the first results drawn from real collaborative learning show very promising benefits for students in a real context of learning and in education in general.

The paper is organized as follows. We present in Section 2 an existing groupware system called CoPE developed by our research group that provides informal support to collaborative work. In section 3 we present the main requirements that guided the development of CoLPE by extending CoPE to the learning domain and incorporating essential functionalities regarding the management of information and knowledge about group activity. The experience and the evaluation results of using this application in a real learning context are reported in Section 4. Finally, Section 5 concludes by summarizing the main aspects of the contributions presented in this paper.

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[1] Moodle is found at http://moodle.org (Web site as of May 2008).
[2] Sakai Project is found at http://www.sakaiproject.org (Web site as of May 2008).

2. CoPE: Democratic support for collaborative work

CoPE [7], [8] is a web-based collaborative system aiming at providing formal and informal cooperative work over the Internet to non-technical people or those who lack of the necessary resources to acquire such systems. As such, CoPE provides most of the functionality expected from an asynchronous Computer-Supported Collaborative Work (CSCW) [9] application, such as information management and communication facilities.

CoPE is designed to enable a specific type of collaboration; a subset of CSCW that has not been adequately addressed so far. Specifically, this involves sets of individuals who share a need or desire to engage in collaborative production. The object of this production is something that can be codified in documents. CoPE is targeted to individuals who do not already have a formal workflow for this collaboration or who are seeking to improve upon inefficient workflows. CoPE also envisions enabling collaboration among individuals who are part of organizations with formal collaboration mechanisms, but whose mechanisms are limited to intra-organization collaboration. Finally, CoPE is designed to enable collaboration, not management, and thus envisions "democratic" collaboration.

There are many examples of sets of individuals around the world who have a need or desire to collaborate but lack the resources, knowledge, or institutions to do so. Consider, for example, public school teachers, social workers, and community action groups (where the group and its peer groups are the "individual"). Often these individuals are separated by geography and/or time and can be too distant from one another to organize face-to-face meetings. They also could be unable to meet due to scheduling constraints or differing work hours. Such individuals may already be part of existing organizations but the "peers" with whom they wish to collaborate are in different organizations. CoPE is especially targeted to these individuals and organizations who lack substantial technical expertise or the resources to acquire such expertise.

CoPE was developed for the needs of a certain type of user forming the CoPE User Community. The system interface design makes assumptions based on the characteristics of such users. We call this type of user the "General User." The following assumptions motivate this definition:

- users do not have specialized (information/computing) technical skills,
- users possess a basic skill set for computer and internet usage,
- users posses the ability to learn a new (information/computing) skill set of this same basic technical level,
- users are willing to learn a new (information/computing) skill set of this same basic technical level,
- users do not already share a sophisticated and/or long-used method for electronic collaboration.

There are several features and mechanisms of the implemented CoPE system that support collaborative work and in particular group discussions:

- hierarchical threaded discussion of documents to serve as a core for group consideration of material of any kind, which can include arbitrary additional material where a coordinator typically posts a document for discussion and also intervenes in the ongoing dialog when appropriate.
- support for the production of joint projects by subgroups of participants by easily setting up subgroups so that the work of each group is kept private from the others, but is visible to the coordinator.
- allow the coordinator of a CoPE site to customize much of the form and content of the material without programming and a range of choices on discussion and voting methods are provided enabling coordinators without IT expertise to customize their discussion environments.

CoPE is built by modifying and taking advantage of Plone/Zope's [10] powerful content management capabilities, such as information management, document workflow, and so on. CoPE modifies Plone appropriately to achieve the desired functionality.

3. CoLPE Development

The extension of CoPE to learning is called Communities of Learning Practice Environment (CoLPE) [11], which relies heavily on CoPE, and in turn on Plone, for most of the mentioned functionality that combines CSCW and collaborative learning paradigms. In addition, specific behavior has to be aggregated to facilitate both the construction of knowledge among learners and the development of cognitive-acquisition skills, such as problem-solving abilities as well as the provision of an adequate multi-support framework so that tutors and peers can provide a suitable scaffolding when needed; these are key aspects that distinguish CSCL from CSCW. CoLPE pursues these objectives by means of seeing discussion as a medium through which the building and distribution of skills and knowledge is effected.

In this section, we present the collaborative learning requirements that motivated the CoLPE development and the main guidelines that guided its design. The ultimate aim is to provide full support to both formal and informal learning groups by means of the collaborative discussion process.

General requirements and pedagogical background

CoLPE's requirements include support for the essential types of generic contributions found in any discussion process, namely specification, elaboration and consensus [4]. Specification occurs during the initial stage of the process carried out by the tutor or group coordinator who contributes by defining the group activity and its objectives (i.e. statement of the problem) and the way to structure the group activity in sub-activities. Elaboration refers to the contributions of participants (mostly students) in which a proposal, idea or plan to reach a solution is presented. The other participants can elaborate on this proposal through different types of participation such as questions, comments, explanations and agree/disagree statements. Finally, when a correct proposal of solution is achieved, the consensus mechanisms take part in its approval (this includes different consensus models such as voting); when a solution is accepted the discussion terminates.

A fundamental requirement to sustain collaborative learning applications is the representation and analysis of group activity interaction to facilitate coaching and evaluation [2] as well as awareness and feedback about what is happening during the collaboration. To this end, in extending CoPE to e-Learning a primary requirement is management and provision of information and knowledge about group activity. The ultimate goal is to enhance and improve group activity by constantly keeping users aware of what is going on in the system (e.g. others' contributions, new documents created, etc.), In addition, monitoring participants' performance allows tutors to identify problems that participants may encounter during the assignments. These findings can then be used to provide both real-time and asynchronous support to students (i.e., help students who are not able to accomplish the tasks on their own).

Finally, in a discussion process, participants perform a role according to their profile (e.g., coordinator, member, guest, etc.), have personal preferences (e.g., language) and set up environment features (e.g., sound or visual effects, text or voice warnings, etc.) according to their personal characteristics. Participant needs are not static and they evolve as the discussion moves forward.

The design of the application

CoLPE design aims at providing specific support to the essential types of generic contributions in a discussion process identified in the requirements, namely *specification, elaboration and consensus.* In CoLPE, these different types of generic contributions are managed by the three essential aspects existing in any collaborative learning application (i.e., coordination, collaboration and communication) [9]. *Coordination* involves the organization of groups to accomplish important objectives to perform a discussion, such as workspace organization, group structure and planning. *Collaboration* lets group members share any kind of resources while communication represents the basis of the whole discussion process since it enables coordination and collaboration to be achieved by providing them with low-level *communication* support. Based on these three areas of cooperation, the main guidelines in designing the generic types of contribution is as follows:

- The *specification* phase is mainly based on coordination which involves the organization of groups such as workspace organization and group structure and planning, so as to accomplish group objectives.
- *Elaboration* is the main phase in the discussion, which relies on both collaboration and communication allowing students to share any kind of resources (e.g., participation spaces, documents, etc.) as well as exchange ideas by posting messages to a discussion space. To this end, this phase is mainly structured in CoLPE by means of folders, which hold the discussion threads and other subfolders forming the whole discussion as a learning assignment or activity. A discussion thread in turn holds a document or text page, which will head the rest of the comments of the same thread. A subfolder may contain others in order to organize the workspace more effectively or for the purpose of storing additional resources (see Fig. 1. Please note this figure and the following contain Spanish and Catalan text due to they are extracted from a real learning experience carried out in Barcelona, Spain. See Section 4 for more information).

Figure 1. Discussion thread formed by the head of the thread and the follow-up comments. Red flags provide feedback at thread level informing where the news is

During the elaboration phase, a key issue in CoLPE is that before a participant sends a new contribution to a discussion thread, this contribution is categorized using a predefined list of labels or categories, such as request for information, opinion, clarification, elaboration, etc.; inform in terms of extension, suggestion, explanation, justification, illustration, etc.; problem, which may be found as statement, solution, etc; greetings, motivation, among others (see Fig. 2 and also Table 2 for a complete list of labels). The purpose of these categories is to classify the intention of the contribution. Not all categories are always made available since depending on where the discussion is found just a subset of them are made available. These categories represent the information source to eventually present complex feedback to users in terms of participation impact and user profile (see further in this section for details).

Depending on the pedagogical model and objectives pursuit in the discussion, a discussion thread may start by submitting a proposal, a solution of a problem, etc., which is to be later on discussed by the participants by means of sending contributions to the thread. Eventually, based on the cognition level achieved during the discussion, participants may vote on the initial proposal submitted so as to approve/disapprove it. On approval the proposal may be archived while on disapproval it may be also revised and resubmitted to be discussed again. Therefore, a discussion thread follows a workflow with several states, from draft to approval or rejection (see [7] for more information). The functionality is available to the tutors who can manually change the state of the thread.

Figure 2. A list of tags to qualify a contribution

- The *consensus* phase in the discussion process is also based on collaboration by which a voting system is shared by the group members to choose the best proposal arisen during the discussion. To this end, several voting modes are available in CoLPE to meet different consensus needs (see Fig. 3).

Figure 3. Several voting modes are available

In order to equip CoLPE with appropriate knowledge management of the users' interaction data analysis, we took advantage of a generic, reusable service-oriented, component-based platform called Collaborative Learning Purpose Library (CLPL) [12], [13], [14]. This platform enables a complete and effective reutilization of its generic components for the construction of specific collaborative learning applications. The CLPL is made up of five components in all, handling user management, security, administration, knowledge management and functionality (see [13] for a description of each component). The aim is both to map the essential elements involved in any collaborative learning application and provide specific support for interaction data analysis as explained in Section 1.

To this end, this library is mainly performed by the two components, namely *CSCL Knowledge Management* and *CSCL Functionality*, which form the core of the CLPL in the construction of collaborative learning applications. They are briefly described here:

- The *CSCL Knowledge Management* component is made up of two subsystems, namely *CSCL Activity Management* and *CSCL Knowledge Processing* so as to support the first two stages of the information and knowledge management. The first subsystem manages the system log files made up of all the events occurring in a certain workspace over a given period of time. This event information is then classified according to a complete and tight hierarchy of events based on three general types of collaborative activity, namely task performance, group functioning and scaffolding [6]. The second subsystem performs the statistical analysis event information as well as the management and maintenance of the knowledge extracted by that analysis.
- The *CSCL Functionality* component implements the last stage of the information and knowledge management process, that is the presentation of the knowledge generated to users in terms of immediate awareness (see Fig. 1) and constant feedback (see Fig. 4) of what is going on in the system. In order to provide the essential awareness information to support collaboration, communication and coordination effectively, this subsystem defines three generic entities respectively, namely *resource state*, *user status* and *group memory*. Each of these abstractions acts as a vehicle so that awareness information can be classified and presented to users in the correct form depending on the type of activity involved. Finally, feedback information is achieved by defining certain generic entities such as *history*, *pool* and *diagram* and functions such as *sorting*. Based on these abstractions it is possible to dynamically gather and store a great amount of history data and statistical results from group activity. For the purposes of presentation format, this component defines a *flag* as a single abstraction supporting the presentation of awareness information to users through the user interface as well as a *chart* for the presentation of

complex information in the appropriate diagrammatic format (e.g., pie chart, histograms, plain text, etc.).

Finally, personal features of the discussion group participants (their role, collaboration preferences and so on) were taken into account and a user and group model were designed so as to allow participants to add new services as their needs evolve as the discussion moves forward. All these user features were included by the *CSCL User Management* component through the user profile management subsystem, providing solid support for building and maintaining the user and group model.

Figure 4. Partial feedback at folder level presented to all participants. The *most by* and *yours* indicators allow students to compare their own quantitative performance to the rest of the contributors

Therefore, CoLPE supports a complete discussion process through the realization of three generic contribution types and an open user and group model. Furthermore, this application constitutes a valuable resource to improve essential features of a discussion process such as awareness of participant contributions and enhance the abilities of users by increasing their knowledge of each other in terms of motivation, interaction behaviour and so on.

4. Evaluation and Results

In order to evaluate our prototype of CoLPE and analyze its effects in the learning experience, and in particular the discussion process, we used the real on-line learning context of the Open University of Catalonia[3]. 43 graduate students enrolled in the course Methodology and Management of Computer Science Projects were involved in this experience.

[3] The UOC is located in Barcelona, Spain, and offers full distance higher education in different languages through the Internet since 1995. The virtual campus supports currently about 47,000 students, and 2,000

Experiment procedure

The experience consisted of a discussion assignment, with the aim of discussing how a project manager can deal with the problem of changing the requirements of software projects which are already in advanced phases of their development because of demanding and urgent needs of the clients. The assignment title was: “Change management: necessity or virtue?”.

The procedure was the following: students were free to open zero, one or several discussion threads (i.e., head of threads) where they proposed strategies, ideas, etc., to appropriately deal with the topic of the discussion. During the discussion, any student could contribute in both his own and any other discussion thread as many times as needed, as well as start extra threads to provide new arguments or approaches with regards to the issue addressed. The only requirement was to make at least one post to either a head of thread or a comment.

Results and analysis

The results of this experiment are provided by means of statistical analysis. A structured and qualitative report was also conducted at the end of the discussion addressed to all participants who were asked to both assess the prototype and compare it to the standard well-known discussion tool they had already used in previous courses at the UOC.

A statistical analysis of the results of the discussion is shown in Table 1. Note that the discussion took place at the end of the course and even though the number of potential participants was 43 (i.e., students enrolled in the course), roughly 40%[4] of them had already made the decision to give up before the assignment started and as a result they did not pay attention nor contribute to the discussion. So, the number of active participants who participated in the discussion actively or passively was 26.

Statistics	CoLPE
Number of students enrolled	43
Number of students actually participating	26
Number of heads of thread	17
Number of comments in threads	93
Total posts	110
Mean number (posts /thread)	M=6,4 SD=4,5
Mean number (posts /student[5])	M=4,2 SD=3,8

Table 1. Basic statistics about participation.

From the results of Table 1, the SD statistic for the posts/thread mean appears to be high, which shows the heterogeneity of the discussion involving threads of very different length and also that actual discussion was generated and as a result the contributions became highly structured and specific. In addition, the posts/student mean rates high (the requirement was 1 post per student) and shows a general interest in the

lecturers and tutors who are involved in some of the 600 on-line courses available from 23 official degrees and other PhD and post-graduate programs. The UOC is found at http://www.uoc.edu

[4] Currently, the drop-out average at the Open University of Catalonia is about 50%.

[5] Students who participated in the discussion.

discussion.

On the other hand, the SD statistics for posts/student is also high meaning that some students participated a lot (more than 10 posts) while a few tried to fulfill the assignment's requirement and provided single, monolithic point of view. It could be argued that at the end of the course students lack time, though more experimentation have to be undertaken to confirm these results.

Exchange actions	Contribution categories	# Tagged contributions
support	Greeting	3
	Motivation	0
request	REQUEST-Information	1
	REQUEST -Elaboration	0
	REQUEST -Clarification	3
	REQUEST -Justification	0
	REQUEST -Opinion	20
	REQUEST -Illustration	0
	INFORM-Extend	17
inform	INFORM-Lead	0
	INFORM-Suggest	8
	INFORM-Elaboration	0
	INFORM-Explain/Clarification	17
	INFORM-Justify	1
	INFORM-State	0
	INFORM-Agree	21
	INFORM-Disagree	6
	PROBLEM-Statement	16
set-up-an-issue	PROBLEM-Solution	1
provide-solution	PROBLEM-Extend solution	0

Table 2. Distribution of the tagged contributions

Table 2 shows the most frequent categories used to tag the contributions. Although the choice of the category appears to be mostly correct, they could indeed be more precise. The permanent availability of all possible categories did not help participants to choose carefully. In future iterations, only those categories which are appropriate (i.e., make sense) at a certain point of the discussion will be shown, thus facilitating the choice a great deal.

Selected questions	Average of structured responses (0 – 5)	Excerpt of students' comments
Assess the CoLPE application	4	"Despite technical problems with the server I found CoLPE very useful due to the distribution of posts into threads and also be aware of where the news was" "I liked the categorization as it helped me understand others' contributions and reply being more confident on my contribution" "The notification of news was useful"
Evaluate how CoLPE fostered your active participation	2	
Did CoLPE help you acquire knowledge on the debate's issue?	2	

Compare CoLPE to the UOC campus' standard forum tool	3	"CoLPE is more suitable to support this type of discussion than the UOC's forum" "Certain functions are missing in CoLPE: subscription to your thread, advanced search function, …"

Table 3. Excerpt of the questionnaire filled out by the students

Table 3 shows the results of a structured and qualitative report conducted at the end of the discussion addressed to the CoLPE users who were also asked to compare it to the standard well-known tool they had already used in previous courses at the UOC. This report shows the technical problems we faced due to the server where CoLPE was installed (Linux SuSE 2.4.21-99 machine, Intel Pentium 4 CPU 2.00 GHz, 256MB RAM) performed poorly and it was unable to conveniently handle both the demanding hardware requirements of Zope and the participants' concurrency.

Conclusions and Future Work

This paper describes a promising approach for enhancing communities of learning practice by means of an innovative tool that contributes to the improvement of the discussion process occurring in both formal and informal collaborative learning settings. To this end, we report the experience of using this prototype in a real context of on-line learning, though the results are not conclusive due to its exploratory nature. However, the analysis of the results promise significant benefits for students in the context of project-based learning, and in education in general.

More powerful hardware will be used in the next experiments so as to overcome the poor server performance issue. Moreover, a decentralized distributed infrastructure is intended to be added to the CoLPE prototype in order to meet other important non-functional requirements that may influence the learning process a great deal [14], such as scalability, fault-tolerance, and interoperability. For instance, the gain in fault-tolerance might help enhance the effectiveness of complex collaborative learning processes (e.g., by avoiding a central point of failure). We plan to explore these interesting possibilities in the next iterations of the CoLPE design.

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