A Framework for Designing Collaborative Tasks in a Web-Environment

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Abstract. We present a framework that considers both the collaboration activities as well as the tools involved combining the artifact and process oriented approaches of knowledge engineering. Following the framework stages, we designed an Asynchronous Learning Network with a collaborative environment that enables structured collaboration between group members. Hundred and fifty (150) university students divided into teams of ten members each performed two collaborative tasks within a university course. As a preliminary evaluation we classified the messages sent by students within the discussion forum. Feedback on uploads increased significantly in the second assignment indicating that students besides performing their own task also took part in other group's tasks creating a cooperative group that produced a collaborative outcome. We discuss the suitability of the framework for the design of Collaborative Environments for knowledge sharing and raise a few topics for further research.

1 Background

The field of Computer-Supported Collaborative Learning (CSCL) focuses on how computers support learning processes performed by a group of people working on a given task. The needs and demands for collaborating with peers & colleagues that are located distance apart are increasing. Hence, it is an important goal for any educational institution to improve the students' performance in collaborative situations.

In the latest years we have witness the growing amount of implemented CSCL environments. However, only a few are based on defined frameworks that support the development of CSCL. Most groupware frameworks or toolkits attempt to cover a variety of domains, thereupon not being able to provide the most suitable solution for a specific domain. The domain of education in particular, requires specific mechanisms to address issues such as theory of learning, culture, evaluation and those related specifically to teaching-learning collaborative processes [1]. Littleton and Hakkinen [2] state that lately the interest in the field of collaborative learning has shifted away from considering just the outcomes and products of collaborative work, towards analyzing interactions as a mean of gaining insight into the processes of collaborative learning. The aim of such analysis is to identify what constitutes a productive collaborative activity.

The term *collaboration* implies that people engage together on a given task. *Collaborative learning* may be defined as situations in which particular forms of interaction among people are expected to occur, which would trigger learning

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mechanisms, but there is no guarantee that the expected interaction will actually occur [3]. Collaborative learning involves cognitive and social-interaction processes. In fact, collaborative learning is not one single mechanism: peers do not learn because they are two, but because they perform some activities (reading, building or predicting) that trigger specific learning mechanisms (induction, deduction, compilation and others). Collaborative learning includes the activities/mechanisms preformed individually, since individual cognition is not suppressed in peer interaction. In addition, the interaction among subjects generates extra activities (explanation, disagreement, mutual regulation, etc.) that trigger extra cognitive mechanisms (knowledge elicitation, internalization, reducing cognitive load and others) [4].

The advantages of collaborative learning in higher education encourage teachers and researchers to implement collaborative learning in virtual environments. Regardless the adopted approach many studies attempted to measure the effects of web collaborative learning. Lehtinen et al. [5] state that there is ample evidence to suggest that Web-based collaborative learning has significant advantages in comparison with the face-to-face (FTF) traditional approach as well as with the individual Web-based learning approach. He quotes a long list of experiments from the last decade that seem to corroborate the assumption that Web-based collaborative learning raises academic performance. Other advantages include: a dramatic increase in (high education) student participation rate Nachmias et al. [6]; enhanced student satisfaction from the educational process, combined with higher motivation and involvement; better combination of self-reflection and interaction among students [7] and developing group spirit and a sense of belonging to a community among individual learners – one that is missing in individual on-line learning methods [8].

There are numerous existing learning approaches. Hiltz & Benbunan-Fich [9] distinguish between the different types. The passive approach to learning assumes that students learn by receiving and assimilating knowledge individually, independently from others [10, 11]. On the contrary to the passive approach, the active approach presents learning as a social process, which takes place through communication with others. In between the passive and active learning is the interactive approach described by [11] and Alavi [12] who claim that the student acquires knowledge by formulating ideas into words and these ideas are built upon through reaction and response to others. Collaborative learning is defined as a learning process that emphasizes cooperative efforts among faculty and students. It stresses active participation and interaction by both, students and instructors [11, 13]. The collaborative learning approach is considered an interactive approach. It can be treated as a method that encourages students at various performance levels to work together toward a common goal [14]. Harasim [15] indicates that collaborative learning is fundamentally different from the traditional direct-transfer or one-way knowledge transmission model in which the instructor is the only source of knowledge or skills. In collaborative learning, instruction is learner-centered rather than teacher-centered and knowledge is viewed as a social effort, facilitated by peer interaction, evaluation and cooperation. Therefore, the role of the teacher changes from the transferring of knowledge to students to being a facilitator in the construction of the student's own knowledge[9].

Collaborative learning can be characterized by the level of collaboration as its being exercised during the learning process. The continuum ranges between students sitting together, on one pole, and autonomous collaboration groups, on the other. In this study we have defined cooperative groups that implement different tasks, linked to each other that generate a one collective outcome, made of different parts.

The synchronous environment is mainly used for lecturing or training tasks. Harasim et al. [16] reviews a variety of on-line CL models based on the group interactions enabled such as seminars, students workgroups and learning circles, peer learning groups and networked classroom. All the models include a certain involvement of a controller/tutor and all are based on peer interaction. Since synchronous environment imposes the time constraint of being together at the same time on the net, it is usually complemented by an asynchronous environment. The Asynchronous Learning Network (ALN) is a teaching and learning environment located within a Computer-Mediated Communication (CMC) system designed for anytime/anyplace use through computer networks.

Any web collaboration environment enables interactions between learners and tutor through (mostly asynchronous) web based tools. Defining the web collaborative learning environment through the tools included is known as the *tool based approach*. Among the prevalent web-based collaborative learning tools, Clark [7] describes the following: e-mail, forum, private conference, gated conference (also described as a question and answer protocol), video and internet conferencing (chat).

Another approach classifies collaborative learning environments into document-centric or session-centric. Systems based on the document-centered approach focus on the management of documents and objects respectively. These documents and objects are classified (e.g. task, address, date etc.) and access rights (i.e. write and read permission) are assigned. Electronic mails can be considered a special case of document management. These systems usually offer the users a number of different views on the data collection dependent on the object's attributes. Some of these systems support special co-ordination tasks such as defining dates for group meetings or task delegation among group members. Besides context-neutral tools (such as Lotus Notes or Microsoft Exchange, that must be adapted according to customers requirements) there are systems developed especially for the purpose of learning (so-called web-based training systems for computer-based distance learning). Tools that are based on meeting-focused concepts (session centric approach) concentrate on the support of synchronous communication at different locations [17]. Services normally allow textual, graphical and audio information exchange. Typical functionalities are text chat, audio and video communication, multi-user graphic programs, and application sharing.

We have presented in this section prevalent approaches to web–based collaborative learning and research support for its advantages. However, we cannot deduce from the research, which is the most effective approach to the design of web collaborative learning environments. This is due to the fact that all these studies are embedded in very specific contexts, rely on different research methodologies and the collaborative approaches implemented strive towards different aims. The question is not just how to implement collaborated activities via the web medium in the educational domain, but rather when one comes to implement a collaborative activity what are the tools that should be used to evaluate the success of the collaborative process. Furthermore, how do we measure success and effectiveness?

A collaborative e-learning framework should enable a systematic approach for the development of web based collaborative learning environments including the technological, educational and social processes involved. The present study is a first step towards defining a general framework that will enable to characterize a collaborative learning process within an electronic environment.

2 Defining a General Framework for Collaborative E-Learning

Cambridge Advanced Learner's Dictionary defines *framework* as a supporting structure around which something can be built or a system of rules, ideas or beliefs that is used to plan or decide something. TEPCEL is an acronym for Technological, Educational and Process oriented Collaborative E-Learning Framework. It is composed of five stages: (1) objectives definition, (2) collaborative features settings, (3) collaborative assignment definition, (4) collaborative tools definition and (5) evaluation (see Figure 1). Each stage is characterized by a set of attributes that enable the design and later evaluation of the collaborative learning environment. The first four stages refer to the design process while the fifth is the evaluation process. Since the evaluation is performed during the implementation process (formative evaluation) as well as after the implementation has finished (summative evaluation) there is no point in defining a separate implementation stage.

The TEPCEL framework enables to design synchronous as well as asynchronous collaborative learning environments. It combines several approaches including the tools, outcome and process, document centric, and session centric approaches into one integrated framework. This kind of integrated approach is crucial since many studies have shown the importance of each approach in collaborative learning. Choosing just one approach may lead to limited results.

For each stage, TEPCEL provides a set of attributes with possible values. For each attribute (O) denotes that one value should be selected and (O+) denotes that at least one attribute should be selected. There is no intent to provide a finite set of attributes and values. Both may be updated to enable TEPCEL to be an evolving framework for the design and evaluation of collaborative e-learning activities. Stages 1-5 provide a detailed description of the attributes per each stage of the TEPCEL framework (Figure 1).

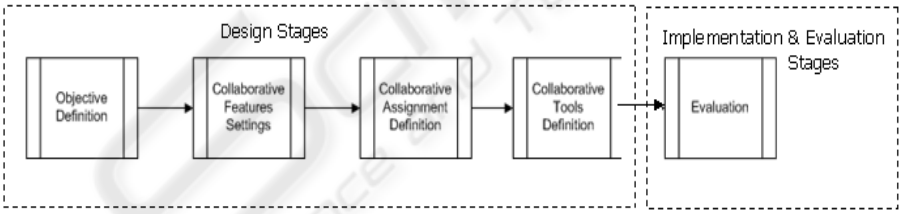

Fig. 1. TEPCEL FRAMEWORK Outline

Stage 1 - Objective Definition

This stage defines the goals for collaboration. The following attributes should be defined.

1-a. ***The cause for the CL process*** – (O) Voluntary or mandatory (decided by some authority).

1-b. Expected Collaborative Outcome – (O) Different outcomes; Each participant completes his part; One collective outcome made up of the different parts; The same outcome - the product of mutual effort.

Stage 2 - Collaborative Features Settings

The second stage defines the collaborative features for both the personal attributes and the assignment settings. Personal attributes will be gathered using assessment tools that will be defined as part of the framework.

2-a. ***The size of the CL group*** – (O+) The number of group's members, number of subgroups and its members.
2-b. ***The duration of the CL process*** – (O) Number of days, weeks or months.
2-c. ***Document/Session-centric*** – (O+) Focus on the management of documents and objects (asynchronous) and/or meeting-focused concepts that concentrate on the support of synchronous communication at different locations.
2-d. ***The nature of learners in CL process*** – (O+) Learners characteristics such as type of learners (full/part time, profession, status in the organization).
2-e. ***The aspects of the learners –*** (O+) Personal traits relevant to the CL process (behavioral (i.e.: likes to learn alone/in groups), emotional (confident), cognitive (learning style), informational (level of computer knowledge).

Stage 3 - Collaborative Assignment Definition

The third stage defines the collaborative assignment content, educational approach and format.

3-a. ***The subject of the CL process*** – (O+) The main subject matter learnt, practice acquired or issues or problems discussed***.***
3-b. ***Educational approaches –*** (O) Networked Classroom as Course Enhancements, Online Course Delivery, Distance Education and Open Learning.
3-c. ***Group Type*** **-** (O) Sitting Groups, Work groups, Cooperative groups, Autonomous collaboration groups
3-d. ***The motivation sources of the learners in the group –*** (O+) External motivation such as final grade, pass mark, prize; Internal motivation such as research work selected by the students, competition (with no prize or mark assigned but some kind of recognition such as publication at website or mention in class).
3-e. ***The nature of the outcomes(s) of the learning process*** – (O+) Conceptual understanding or knowledge on the discussed topics, some shared capacity or consensus (such as a solution to a problem or a list of recommendations), a written document or an object (program, prototype or product).

Stage 4 - Collaborative Tools Definition

The fourth stage defines the set of collaborative tools to be used within the environment.

4-a. ***Available tools and technologies –*** (O+) The following is a proposed list of available tools and technologies that enable web collaborative processes. A non-exhaustive list of the proposed technological tools for the collaborative environment may include: conference call (phone), email, message board, discussion forums, news groups, ICQ, FAQ pages, instant messaging, shared virtual scheduling systems, text chat, audio chat over the Internet, video conferencing, application sharing, web based training software, FTP, download function and upload function [17].

Stage 5 - Evaluation

5-a. ***Timing of evaluation*** **-** (O+) During the process (formative evaluation), at the end of the process (summative evaluation).
5-b. ***The intensity of the CL process*** – (O+) Number of meetings, their frequency and their length for synchronous collaboration; Number and type of messages for asynchronous collaboration.
5-c. ***Evaluation criteria*** **-** (O+) Student participation rate; student satisfaction from the educational process; student satisfaction from the social collaborative

process; Student's feeling of belonging to a community; academic performance; group spirit; student's perceived learning efficacy (for example by adapting the instruction procedure to the learner's individual learning style).

5-d. ***Evaluation type*** - (O+) Quantitative or Qualitative.

5-e. ***Subjects of evaluation –*** (O+) The individual learners; the group of learners,

5-f. ***Who determines the type of evaluation? –*** (O) Decided by the tutor/evaluator, Decided by the tutor/evaluator after consultation with the learners, Decided by the learners themselves.

5-g. ***Who decides on the evaluation criteria? –*** (O) Criteria are given/dictated by external circumstances; the tutor dictates criteria; the tutor dictates criteria based on dialogue and consultations with the learners; the learners themselves decide criteria.

5-h. ***Patterns of interactions amongst the learners*** - (O+) Division of labor, hierarchical or symmetric relationships, roles, interdependence, negotiation, autonomy of the individuals.

The framework attributes and tools described above enable to define and compare many different environments. They also enable to test the influence of different attributes in a specific environment over time. In the next section we present a case study implementing TEPCEL framework.

3 TEPCEL Framework – A Case Study

We have implemented a web collaboration asynchronous environment based on TEPCEL framework in an undergraduate course for Information Systems Engineering students. The course population consisted of 150 students divided up into 15 groups. Each group was further divided up into 5 dyads. The students had to complete a collaborative task, consisting of two assignments; each assignment was divided into 5 tasks. Each dyad of students selected one of the 5 tasks based on the principle: "first come first served".

The registration to the groups was conducted as follows: During the process of registering to the course website each student was required to select a teammate. Each new dyad was assigned automatically to the next group that was being formed. Every five dyads formed a new collaborative group. The students were unable to control their collaborative group belonging. As a result in some of the groups the members became acquainted only during the collaborative assignments.

Each group was provided with a private workspace with asynchronous capabilities that contained the following:

- A list of all group members
- A list of five tasks
- Collaborative Assignment description
- A threaded asynchronous discussion forum
- Upload capabilities for draft files and for final assignment submissions
- An automatic email mechanism that sent notifications to the group members each time a file upload operation was performed by one of the dyads requesting for feedback.

The group members used the forum to discuss topics that referred to the collaborative assignments and to add feedback on uploaded files. In both assignments, there was no content intervention by the course instructor. Each discussion forum was

a private workspace and was independently managed by each group, based on students' initiative. We have instantiated each one of the TEPCEL attributes in our case study. A full description of all the attributes is beyond the scope of this paper.

As mentioned, the collaborative activity was compound of two assignments. Each assignment was divided into five different tasks related to each other. The expected outcome per each assignment was one collective outcome, made up of 5 different parts. Each group had to plan the task, and divide the work among the participants. At the end of each assignment we have analyzed the collaborative interactions within the discussion forum and provided feedback to each group.

Assignment 1 - The objective of the first assignment was experiencing with the phases of a software project life cycle. This type of assignment enabled us to implement 5 different tasks related to each other and produce one collective outcome. Each group received a description of a requested system that was based on multi-modal technology. The implementation of each phase was assigned to one dyad as a task. The first dyad was responsible for performing the exploration phase during which they were required to perform a literature review by searching for relevant articles, existing enterprise systems, track faults within existing tools based on existing publications and provided a detailed report based on their findings. The second dyad gathered and analyzed the user requirements based on the literature review of the first dyad and performed a limited user requirements survey. The third dyad was in charge of the design and functionality of the prototype system. The forth dyad defined and performed the system usability evaluation based on Nielsen's usability parameters [18]. The last dyad prepared a comprehensive presentation that summarized all parts and presented it to the class in a face to face session. During the assignment, the students collaborated by using the proposed workspace. They have submitted documents to the website by using the upload capabilities and provided feedback and suggestions on their group-mates products by using the discussion forum tool.

Assignment 2 - The objective of the second assignment was to create an interactive lesson on the web. The assignment was divided into 5 related tasks. Each dyad was in charge on the implementation of one task. In addition, it was clearly emphasized by the course instructors that the group members are expected to collaborate. The first dyad was responsible for searching for relevant references and contents to be used when creating the interactive lesson content. Based on the literature review the second dyad was in charge of writing the contents and designing the lessons' WebPages. The third dyad developed a quiz to evaluate student's learning performance in that lesson and implemented the DB to store the students' lesson's data. The fourth dyad was in charge of the development, integration and implementation of the website. The last dyad planed and preformed functional and usability evaluation testing.

4 Evaluation

The evaluation aims to demonstrate the assessment of the case study performed according to TEPCEL framework. We measured the level of group collaboration within the ALN in the two assignments. We expected that the level of collaboration will increase in the second assignment as a result of acquired experience in the first collaborative assignment. We defined three dependent variables:

1. The quantity and quality of interactions. This dependent variable was assessed by the number of messages per type. All the messages in each private forum were recorded in a data base at the web server. We classified the discussion forum messages into one of the five following categories that were defined during the content analysis of the discussion forums: (1) Not Relevant - messages not related to the assignment, such as jokes or messages related to other courses. (2) Collaboration support/request for assistance (3) Encouragement (4) Updates on activity (5) Feedback on upload – messages that provided feedback on the form, presentation, or content of the files uploaded to the collaborative private workspace (6) Administration Messages – after each upload, *an event driven agent* sent an automatic email to the group members notifying them that a file was uploaded by a certain student, and requested for feedback. The classification of the messages was performed manually by doing log file analysis.
2. Number of uploads per group – The environment enabled the students to upload an unlimited number of working files to the private collaborative workspace. At the due date each dyad uploaded their final submission file to be graded by the course staff.
The number of uploads per group was computed automatically by the system.

We expected that students will collaborate more in the second collaborative assignment. We performed Student's paired t-Test, with a one-tailed distribution comparing the two assignments. It is clear that messages types between the two assignments differ in one dimension only: feedback on uploads. The number of messages dealing with comments on uploads (message type 5) increased significantly in the second assignment ($p= 0.023$). In addition we may see a close to significant decrease in requests for assistance ($p= 0.060$). This result may indicate that when students collaborate better, they give more feedback on uploads and request less assistance. This result should be studied further.

5 Discussion

The main goal of this study was to define an integrated framework for the design and evaluation of collaborative e-learning environments. We described a case study that implemented a web collaborative environment according to TEPCEL framework. The evaluation aimed to demonstrate the assessment of the case study performed according to TEPCEL framework.

The evaluation was intended to verify that collaboration took place within the collaborative environment designed according to TEPCEL framework. This preliminary evaluation intended to test face validity of the framework, meaning that the framework indeed helps in the design of collaborative learning environments. Further evaluations should compare a collaborative environment designed with TEPCEL with a control environment (collaborative environment designed according to another model) and test the collaboration enabled by both collaborative virtual environments.

The results of the preliminary evaluation on a case study of two collaborative assignments indicate that TEPCEL helped in designing the collaborative e-learning environment for knowledge share. Furthermore, we found significant increase in the interactions about the material uploaded by students in the second assignment. Unfortunately, the order of the assignments could not be counter-balanced, it was defined according to the course schedule. There could be other reasons for the

difference between the assignments in terms of feedback on uploads: a different task, a different time period, the students just may be more experienced with the environment.

Our assumption was that messages classified as “feedback provided on upload” indicate the level of collaboration as students not only perform their own task but either they take part in other group’s tasks and therefore create a cooperative group that produce a collaborative outcome.

The assignments included a variety of Harasim et al. [16] on-line CL models: Learning Partnership and Dyads (which are recommended as an introductory step for students in acquiring online CL skills), Students Workgroups (a task with a distinct pre-defined division of labor, roles, timeline and decision making process within the group), Team presentation and Teaching by the Learners (an important motivational factor for collaboration) and Peer Learning Groups (which enabled the students to complement each other’s weaker points by asking for assistance and advice on various tasks, mainly used in the first assignment).

The collaborative environment was designed according to the TEPCEL framework parameters. TEPCEL is indifferent to the electronic available tools. It will track the interactions done within the diverse tools. However, collaboration is not only depended on the tools and the activity models. In order to design successful collaborative tasks we should relate to the social interactions which take place during the assignment's development. Another approach stresses the importance of personal attributes on the success of the collaboration within ALN environment [19]. TEPCEL relates to the personal attributes as one of the parameters being defined or tested (as pre-defined or evaluated). In our study, students expressed their need for a tutor or leader, a person who is in charge of the assignment timeline. We have noticed that during the second assignment numerous groups have nominated a group chair and defined timeline for each task by themselves. One of the groups that received a low grade on the first assignment due to low collaboration of its members decided on corrective action during the second assignment.

Another interesting factor is the improvement of the collaborative work from which we can conclude that group collaboration requires training. It takes time for students to get familiar with the collaboration concept. Collaboration is not just a tool or an activity but either a process. The collaboration takes place within a technological environment. Therefore, a careful design of the diverse attributes implemented in the environment should take place. Also, a careful planning of the task should be done in order to favor the collaboration between team members. TEPCEL is able to deal with the different factors that influence collaboration through the definition or the testing of the relevant parameters: groupings (groups and subgroups), initiative (for the activity and the evaluation), roles, volume of interactions and its contents, outcomes, various personal attributes and more. We found that TEPCEL enabled us to easily characterize and analyze the collaborative process that took place during the collaborative assignment. The linkages between the messages in the discussion forum serve a role in the nature of the dialogue.

Future work will deal with the development of more measurements in order to analyze the quality of collaboration that takes place within the web-based environment.

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