



Design of Collaborative Learning Environments: bridging the gap between CSCL theories and Open Source Platforms

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Abstract

Starting with the assumption that collaborative learning and working will occupy a strategic role in undergraduate, post-graduate and life-long education as well as in collaborative, flexible and distant working, in this paper we present a reflection on how to reduce the gap between constructivist and CSCL/W theories and practices, and open source initiatives for e-learning in universities. The main goal, beyond the production of technologies, is to put forward research directions and to stimulate instructional designers to closely work with open source researchers and developers. In this paper we present a synthetic selection of collaborative features that are usually included in CSCL/W environments but are missing in e-learning platforms. Thereafter, we propose the design and implementation of some of the more relevant features in a very well known open source e-learning platform (Moodle). Finally, we discuss the potentialities and critical aspects of Moodle as a possible solution to the need for the dissemination of collaborative learning experiences in Higher Education contexts.

1. Introduction

In the past few years e-learning, mostly because of the rise of the «learning object movement» with a number of related specifications and standards, has come ever more close to a single pedagogical model, based on single learner interactions with content via a web-based system. However, in the Higher Education context we observe a growing trend to support constructivist experiences by adopting systems and tools that allow groups of learners to interactively construct knowledge. In universities in general, and in post-graduate courses and life-long learning initiatives in particular, the need to enact situations of collaborative learning is becoming more and more frequent. When the dimension of the group grows — in term of participant number/s — there is a more evident need for «ruling» supports (netiquette, socioquette) as well as for technological functions that support the group in collaborative interactions.

For instance a group coordinator, who is usually chosen from among the participants themselves and may avail her/himself of the support of a tutor, has to stimulate group engagement in problem-based or project-based activities, with various levels of collaborative actions: simple resource sharing, more structured cooperation, negotiation or collaboration in the strict sense of the term, etc.

If on the one hand we foresee that collaborative learning and the social construction of knowledge will undoubtedly play a strategic role especially in post-graduate and life-long education, on the other hand, we witness a certain delay in the provision of adequate collaborative functionality by the most diffused e-learning commercial and open source platforms.

When analysing e-learning platforms, even those which claim to be designed according to a «collaborative-oriented approach», we find that, typically, they offer simple communication tools such as a web forum, a chat, a mail-list, which have *per se* a very limited connection with collaborative learning activities, provide only weak support for collaborative learning or working, and do not supply any real «collaboration management» function at all.

However, as a consequence of the growing interest aroused by the collaborative paradigm, specific (constructivist) methodologies and technologies (CSCL/W, Computer Supported Collaborative Learning/Working) have been developed. Actually the domain of CSCL/W — with some integration of AI (Artificial Intelligence) — led, in the last decade, to the development of a number of interesting tools and environments even if these applications, sometimes prototypes, have often remained in isolated contexts, with very limited features of easy update or upgrade and, more importantly, are unavailable under open software or free software conditions.

The arising question which motivates this work concerns, therefore, how to exploit the CSCL methodological and technological know-how in the open source

learning environment domain, to support extensive applications such as its use in the university campus, teacher training, adult learning and life-long learning in general. In other words, we intend to contribute to «bridging the gap» that exists among the current open source e-learning platform solutions and the research field concerned with technologies for collaborative knowledge construction.

To achieve the goal of making a concrete effort for «bridging the gap» between the CSCL and the open source worlds, the paper is articulated as follows:

1. choice of relevant collaboration features to be integrated in an e-learning platform;
2. selection of an open source e-learning platform suitable to be upgraded with the collaboration functions defined in the previous step;
3. presentation of some issues emerging from the implementation of the functions defined in step 1 into the environment selected in step 2;
4. discussion of further developments of the platform in the context of higher education.

2. Choice of relevant collaboration features

Is it really possible to enable collaborative learning using Internet technologies? Or does this still remain a very complex activity, mainly delegated to the work of good tutors and coordinators? Are there technological tools which really enable collaborative learning over the net?

The research field known under the name of CSCL/W has sought answers to these questions, offering a variety of hypotheses and solutions sometimes grounded on technological supports: CSCL deals with collaborative environments focused on learning, while CSCW tackles workplace collaboration. Several analyses, studies and projects concern CSCL environments and deal specifically with enabling technical solutions for both commercial and open source platforms. We can here cite the Euro CSCL program,¹ the ITCOLE project,² the ECOLE project³ and some relevant research papers by Kurhila (2003), Cesareni (2004), and Seitamaa-Hakkarainen (2004).

From an analysis performed on these resources, three specific environments emerge because of their implemented features and technical solutions:

- Knowledge Forum (formerly CSILE and WebCSILE);
- Synergeia;
- FLE3.

¹ <http://www.euro-cscl.org/>.

² <http://www.euro-cscl.org/site/itcole/>.

³ <http://www.ecolenet.nl/best7tools.htm>.

*Knowledge Forum*⁴ (Scardamalia, 2003), formerly known under the names *CSILE* (*Computer Supported Intentional Learning Environment*) and *WebCSILE*, has a very rich history. It is based on the first and most quoted research project in this domain, and it was designed by Marlene Scardamalia and Carl Bereiter in 1986 at the Ontario Institute for Studies in Education. Since then, a number of versions of the platform have been developed. It is now a commercial product sold under the name of *Knowledge Forum*. This environment incorporates only asynchronous tools such as forums and document repositories.

Synergeia (Stahl, 2004) is a system developed within the framework of the EU-funded ITCOLE (*Innovative Technologies for Collaborative Learning*) research project (2001-2003). It is designed to support collaborative learning and it includes an asynchronous environment for *documents* and *idea* sharing, respectively repositories and forums, and two synchronous tools: *Map Tool* for collaborative conceptual map creation, and a chat environment for exchanging instant messages. Although *Synergeia* is not an open source software, its use is free for educational institutions.

FLE3 (Leinonen et al., 2002) is an open source project, released under the GNU licence. *FLE3*, like *Synergeia*, has been developed within the ITCOLE project. Its features are similar to those available in *Synergeia* and are based on three tools: a repository (*WebTop* tool), a forum (*Knowledge Building* tool) and a shared space (*Jamming* tool) for the construction of digital artefacts (pictures, text, audio, video, etc.).

From the analysis of these environments, we see that they generally include a number of basic functionalities, including:

- shared repositories, to organise and archive collaboratively-developed material;
- knowledge construction environments (mostly discussion forums), where participants can share ideas on topics related to the educational objectives;
- the possibility to describe the type of contribution being made to the discussion forum through scaffolds, or *thinking types*, which can be seen as tools to sustain metacognitive processes; features of this kind are often present in a variety of platforms (e.g., *Knowledge Forum*, *Synergeia*) with the purpose of fostering metacognitive reflection on the contributions to the discussion. Participants can mark their messages with a label indicating their function within the structure of the discourse. Thinking types are usually chosen from a teacher-defined, closed set; examples might be of the type: *My Design Idea*, *New Information*, *Evaluating Idea*, *Organizing Process*, *Summary*, etc. The availability of *thinking types* can also allow for *a posteriori* thematic reconsideration of the exchanges, e.g. for evaluation purposes; besides, their usage can enhance the effectiveness

⁴ <http://www.knowledgeforum.com/>.

- of roles in group learning or work (e.g., *proposer*, *opponent*, *reviewer*, *rapporteur* etc.);
- tools for representing the knowledge construction process (e.g. as *conceptual maps* and other diagrams) or the interactions that occur among the participants (e.g. Social Network Analysis graphs.);
- shared calendars supporting group and individual working management.

A noticeable characteristic of these CSCL environments is that — according to constructivist learning theories — their main focus is on the development of knowledge representation and metacognition techniques, while less attention is devoted to the area of collaborative management. Collaboration management functions are even more rarely implemented in these environments, as these issues are almost exclusively addressed in research works that pursue the use of intelligent agents in CSCL (McManus and Aiken, 1995; Okamoto et al., 1995; Baker & Lund, 1996; Mühlenbrock & Hoppe, 1999; Barros & Verdejo, 2000; Jermann et al., 2001). Typically, these systems offer menu-driven, sentence-opener or dialogic interfaces and are chiefly concerned with the problem of how to build automatic intelligent coaches that foster interaction inside a learning group.

Based on our experience, the *web forum* is the most important tool to be used for collaboration; this tool — if properly designed and used — can easily become a *place* where the participants meet together, propose and discuss ideas and develop projects, in an asynchronous mode, each at his/her own personal pace. The forum should be a dynamic discussion environment in which collaboration is structured on many levels: topics, design phases, educational objectives, etc. On the basis of the analysis conducted to-date, we describe hereafter the main functions that are relevant for the implementation of a collaborative web forum. To this end, we have extended the model proposed, according to the synthesis presented by Jermann et al. (2001) to encompass also basic communication functions. The ideal collaboration-enhanced web forum should implement functions of four types.

1. *Basic communication functions*: all the functions of a traditional discussion forum should be present, while some of those that are deemed essential for collaborative learning practices ought to be particularly ergonomic and effective.
2. *Mirroring functions*: students and tutors are made aware of other participants' actions and intentions by using a variety of representation systems, message type taxonomies etc.
3. *Monitoring functions*: especially surveys and rating polls that allow the group to represent its internal climate⁵ and *thinking types*; the possibility of easily monitoring the communication process has favourable effects on metacognition at

⁵ These functions include *e-feedback* and *barometer* as proposed in (Smith & Coenders 2002).

both individual and group level, fostering the reflection on collaboration. In this sense we use the term *reflection board* (see in the following) to identify the interface component that hosts digest information related to these elements.

4. *Coaching function*: a set of tools that support the tutor in such activities as suggesting, soliciting, reminding deadlines etc., on the basis of tutor-defined rules.

Besides the enhancements to the web forum, we envisage the need for two additional spaces that could significantly exploit the learning potential of a collaborative environment:

- the *Reflection Board*, geared to fostering group metacognitive reflection: here the group can find essential information on the learning processes, such as links to the most frequently read messages, the relevant events which have occurred, the overall compliance to the communication rules that the community defined etc.;
- the *Planner*, that allows for the management and monitoring of interaction; here the tutors define rules that automatically trigger actions when specific events occur. The condition of a rule can be expressed in terms of the expiration of a deadline, of the number of messages of a particular thinking type, of the submission date of a message, etc. The actions fired by the rule include sending a message to one or more participants and posting a signal in the *Reflection Board*. In expressing a rule participants can be identified both with their individual identifier or as *roles*: for instance, *if a student⁶ has sent at least a message of type hypothesis ...*;
- on these grounds, Table 1 (three leftmost columns) analytically lists the most relevant features that a web forum should offer.

3. The choice of an open source platform

At present, many specialized and complete e-learning products are available, as either commercial or open source products. The price of commercial products can vary a lot: from less than a hundred dollars to several thousands. Due to the wide range of choices, selecting an e-learning environment is often a very articulated task.

Instead of adopting a vendor-dependent e-learning platform we believe that contributing to the design of an open source one offers a better development possibility, because it exploits a broader diffusion potential and constitutes an important academic opportunity to refine CSCL theories, methods and tools. Besides, we leaned towards open source products because, apart from cost issues, commercial products are often tied to specific educational objectives; they are poorly reusable,

⁶ Roles are existentially qualified: *if there exists a student who has sent at least a message...*

adaptable or customizable, thus penalizing their potentially beneficial use in various educational or working contexts.⁷

Among the many available open source platforms the one we chose for the purpose of this work is Moodle.⁸ Several reasons ground this choice.

- It is a fully open source software (download, usage, modification and redistribution of the code and all of its dependencies such as script language and database modules are regulated by the GNU General Public License).
- It is a platform-independent environment, flexible, easy to use, available in multiple languages and open to customisation.
- Its design is explicitly grounded in social «constructivist pedagogy» as is pointed out by the design team. Moreover, its architecture and user interface are focused on «activities» rather than on «content», so a large number of activity modules is available, allowing for a wide range of pedagogical settings.
- It features a nice user-friendly interface both for students, teachers and administrators.
- From a technical point of view, it is designed with a very strong modular structure, a fundamental feature for those willing to integrate additional functions or upgrade existing functions.
- The community of Moodle developers and users is very lively and is actually offering a very good support through a dedicated web site and a number of specialized web forums. Also, a lot of high quality technical documentation is available. The source code has been judged of very good quality by several professional programmers we consulted.

It must be stated that, for these reasons, Moodle is often the preferred environment for many e-learning initiatives all over the world. The far right-hand column in Table 1 indicates which of the listed functions are already present in the current Moodle version,⁹ and which have to be developed as external add-ins.

4. «Enhanced collaboration» module developing plan

On the basis of the considerations reported in previous sections, we designed and developed an *Enhanced collaboration* Moodle module that enhances the features of the existing *Forum* module by adding the new collaboration functions listed in Table 1.¹⁰ As our work complies with the Moodle architecture and rules,

⁷ Examples in this sense are *Synergeia* (<http://bscl.fit.fraunhofer.de/>), *Knowledge Forum* (<http://www.knowledgeforum.com/>) and *Groove v3* (<http://www.groove.net/home/>), which are not open source products.

⁸ <http://moodle.org/>.

⁹ The table was referred to Moodle version 1.4.2.

¹⁰ We aim to implement all features not already present in Moodle, as stated in Table 1, except for those related to conceptual maps.

Table 1
DESIRED FEATURES AND AVAILABILITY IN MOODLE

			<i>Already present in Moodle</i>	
Basic communication and sharing functions: Forum	Communication support	Minimal set of functions to guarantee communication exchange (<i>add new thread, reply</i>)	✓	
		<i>Quoting</i> of a message (a part of it) when <i>replying</i>		
		Text formatting with WYSIWYG-type editor	✓	
		Add images and other multimedia objects in message text	✓	
		Add emoticons	✓	
	Document sharing	<i>Attach</i> file to message	✓	
		<i>Insert</i> links (URL)	✓	
	Information storage	All data related to messages must be stored in a standard database accessible for statistic purposes, tracking or other needs	✓	
	Mirroring functions	Presentation structure	<i>Hierarchical threads</i> with tree visualization (single discussion topic)	✓
			Simultaneous <i>tree visualisation of all discussion topics</i>	
<i>Collapse, expand</i> threads				
Multiple ordering options (by sender, subject, date, etc.)			✓	
Possibility to <i>select/unselect</i> messages and to visualize in a page only selected messages				
Social space representation		<i>Internal advanced search</i> functions (by author, date, subject keywords, body keywords, thinking type, etc.)		
		Automatic link to the personal page/card of the message sender	✓	
		History (who read the message and when, who downloaded the attachments, etc.)		
		Explicit representation of online current presence of other participants	✓	
		Private chat room	✓	
		Public chat room (scheduled or «open»)	✓	
Monitoring functions		Monitoring communication	Quantitative information obtained by tracking forum data and used for statistic analysis (e.g., Social Network Analysis)	
	Conceptual map representation (e.g., as in <i>Knowledge Forum</i>)			
	Polls and group self-representation (e.g., <i>barometer</i>)		✓	
	Shared writing environments (e.g., <i>journal</i>)		✓	
	<i>Path</i> : to represent course «milestones»			
	Meta-communication support	<i>Thinking types</i> ; the possibility to create new thinking types and associate them to each forum		
		Possibility to structure the environment in different forum and to configure each of them according to the different objectives to be pursued		
		Support to discourse structuring by means of the assignment of specific roles		
Coaching functions	Action planner	Rules and actions setting		
		Action notification in Reflection Board area or by e-mail		

it can be effortlessly installed on a platform running Moodle using the automatic setup and administration features. The *Enhanced collaboration* module can be distributed separately to the Moodle Community as an open source component under the GNU General Public License.

In particular we designed:

- enhanced DB tables to support the new features provided by our module, according to the Moodle DB schema;
- new CSS, languages support — at present we support English and Italian — and graphic interface elements;
- new software functions included in a Moodle compatible function library.

The *Enhanced Collaboration* module is described in the paragraphs below.

4.1 Enhanced collaboration module architectural schema

The module can be logically subdivided into three parts:

1. Forum plus;
2. Reflection board;
3. Planner.

4.1.1 Forum Plus

The *Forum Plus* component of the module provides basic and enhanced communication features. Besides the typical collaboration functions that are present in most forum platforms including Moodle *Forum*, we enriched the basic module with new mirroring elements to enhance the structure of the presentation, introduced a «social space representation» and provided also a sort of meta-communication support by adding a further forum messages characterization, the Thinking Type schema. Threads and messages posted by the users are characterized not only by *title*, *author* and *content* but also by *thinking type* labels (TTs) that are added as a property of the message. The TTs contribute to explicitly organize the phases of the learning process hosted in the forum. Number and types of TTs can be decided and easily authored by the teacher or tutor who manages the forum.

Each TT is described by a *title* (i.e. hypothesis, synthesis, conclusion, etc.), an *incipit* that appears at the beginning of the message when a TT is associated to it, and an icon that graphically identifies the TT inside the tree forum representation.

The tree representation of the Moodle *Forum* has been modified to include graphic icons representing:

- Thinking Type associated to messages;
- Read or Unread Messages (envelop icons);

- Message currently opened (arrow icon);
- Threads that can be collapsed or expanded.

We enhanced the presentation structure of the Moodle *Forum* module by adding advanced search features and multiple ordering options: messages can be searched and ordered by author, title, date and TT. We also added the possibility for a teacher to mark significant messages posted by students and visualize them in a separate report. The marked messages represent the most important contribution to the collaborative knowledge construction process carried out by the community of students.

4.1.2 Reflection Board

The *Reflection Board* is the component of the *Enhanced collaboration* module responsible for monitoring the knowledge construction process. Each activity on the forum is tracked by adding data to the Moodle log according to the standard Moodle logging mechanism. We added some options such as tracking attachment download, messages mark, and TT insert.

The *Reflection Board* shows on separate reports the following forum activity data:

- most frequently read messages;
- most frequently downloaded attachments;
- all messages read and by whom (history);
- rules activated by specific actions of the users on the forum (from the *Planner* module – see below);
- most significant step in knowledge construction process in a timeline representation (milestones): start up and end (from the *Calendar* module), most significant activated rules, most read messages, marked messages, etc.

4.1.3 Planner

The *Planner* is the component of the *Enhanced collaboration* module that provides coaching features. Through the *Planner*, teachers can define specific rules to activate warning, signalling and notification to the whole community. The rules are based on the following elements:

- number of messages posted by the user (i.e. a rule can be defined that activates a warning if a user never took part in a discussion);
- presence or absence of messages associated with a specific TT in a thread (i.e. if nobody uses a TT defined by the teacher for a thread a warning is activated);
- activity on the *Forum Plus* (i.e. downloaded attachments, posted messages etc.);
- milestone and significant date (i.e. a deadline is approaching).

When a rule is activated e-mail messages are sent to students, teacher or administrators. Moreover, each activated rule is listed in the *Reflection Board*: by clicking on each rule, the details are shown.

5. Discussion and Conclusion

In the domain of Higher Education and life-long learning the need to promote collaborative learning activities making use of systems and tools that support the group in the self-management of the activity is becoming more and more pressing.

Throughout this paper we addressed the following question: Are there technological tools that really enable collaborative learning over the net? Our belief is that even if the reflection on collaborative learning environments is still in its early stages, at a theoretical level some findings can already be applied so as to become of practical and current use in e-learning environments.

Some results achieved in CSCL are grounded on the concept that highlighting and taking into consideration the individual collaborative action (according to specific criteria and indicators) can support group reflection and metacognitive awareness. Other tools, more specifically oriented to favour collaboration management such as assigning roles, suggesting, guiding, providing feedback, etc. can play a crucial role in limiting the problems that emerge in online collaborative groups (dispersiveness, conflicts, etc.).

Considering the e-learning environment in which these functions should be implemented, we recognise that the open source approach offers a greater guarantee of flexibility and easier maintenance. Among the popular open source environments, Moodle proved to be the most promising choice for several reasons within which its highly modular structure. Apart from our aim of extending Moodle with additional modules, we also implemented Moodle¹¹ as the main e-learning platform for one Faculty (Education Sciences), in which we deliver several courses, most of them inspired by the collaborative learning pedagogical model.

Is it really possible to enable collaborative learning using Internet technologies? Or does it still remain a very complex activity, mainly delegated to the work of good tutors and coordinators? Our belief is that collaborative learning is indeed a very complex activity which still needs to be managed by well trained tutors and coordinators. Nevertheless, adequate technological solutions such as those presented here could add relevant meaning to the learning activities, thus allowing us to improve learning effectiveness. This issue is still to be tested by field experiments that we will carry out in the future development of this work.

However, both in the analysis and programming work, and on the basis of the early feedback collected from teachers and students, we noted the emergence of

¹¹ Without additional modules that are still at development stage.

some critical elements at the core level of Moodle; the most relevant of which are (in our context):

- the lack of an extended, flexible and customisable management of roles. Presently, Moodle offers limited, pre-defined roles (administrator, course creators, teachers and students). Having user-defined roles is essential for the full development of collaborative learning experiences;
- the management of groups is quite peculiar. Most of the cited CSCL systems intend groups as «containers», a way to sub-divide courses, not only by enrolling users into one group but also by considering groups as separate working spaces. Users can usually take part in more than one group,¹² while activities and resources can be restricted to certain groups. In Moodle, on the contrary, groups are intended only as an administrative partition of activities, that remain associated uniquely at course level.

Thus, our final remark is in relation to Moodle development perspectives and is directed at the whole Moodle community. Thanks to the enormous potential of the this environment, we encourage Moodle development in a direction that sustains the rising demand for rich and effective collaborative learning in the University context, especially for graduate courses and life-long learning.

Acknowledgements

This research has been carried out thanks to the Italian Research and Education Ministry (FIRB action, Investment Funds for Basic Research) which funded a three year project aimed at studying strategic directions for life-long learning and e-learning development.

Authors would like to thank the colleagues participating in this project, who supplied support and essential information for the achievements of this work: G. Bonaiuti, D. Capperucci, M. Delfino, C. Delogu, J. Earp, E. Magno, S. Manca, R. Nicolussi, D. Persico, G. Tortora, M. Ranieri, L. Vanni.

¹² E.g., tutors often need to be enrolled in more than one group.

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