Design and Execution of Dynamic Collaborative Learning Experiences

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ABSTRACT

The Computer Supported Collaborative Learning (CSCL) is a research domain whose methodological instances are vaguely recognized and even more rarely modeled. The purpose of this paper is to present a new approach for the construction of dynamic collaborative learning experiences and their devolution inside an Intelligent Tutoring System. The presented approach is based on the concept of "pedagogical templates," instructional artifact based on the CSCL scripting used to design learning experiences by applying principles of participatory learning and social media. In order to experiment this approach, a tool purposed to design and execute dynamic collaborative learning experiences has been developed and experimented in formal e-learning settings.

Keywords: *Adaptive Learning, Computer Supported Collaborative Learning (CSCL) Scripts, Learning Design, Learning Experiences, Learning Methods, Pedagogical Templates*

INTRODUCTION

The research field on Technology Enhanced Education (TEE) suggests that the collaborative dimension of a learning experience is one of the most important elements to take into account in order to ensure a high level sustainability of e-learning (Wilson et al., 2006). The Computer Supported Collaborative Learning (CSCL) today is a well recognized concept in literature and is evolving in parallel with the development of models and methods that support the design of efficient networking activities and processes

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in different learning contexts and groups (Dillenbourg & Fischer, 2007).

Particularly, in a formal learning context, an efficient collaboration process must have a well structured model to adhere to, with predefined rules and objectives connected with specific learning activities. It is widely acknowledged that in the CSCL the spontaneous collaboration through standard collaborative software does not necessarily lead learners to play functional and complementing roles that can foster group discussion, knowledge sharing and argumentation (Wilson et al., 2006).

Nevertheless, structuring the collaborative learning process in an appropriate way is relevant, since free collaboration does not necessarily produce learning. Moreover, the unguided collaboration among team members can lead to detrimental learning. As stated in Laurillard (2008), "never before there has been such a clear link between the needs and requirements of education, and the capability of technology to meet them." This is also true with respect to the difficulty implied in modeling collaborative learning processes and in defining and structuring groups or flows of collaborative activities.

In order to overcome this difficulty, the scientific community has recently developed and sustained the validity of new theoretical approaches related to the CSCL scripts (Griffiths et al., 2005). The CSCL (or collaboration) scripts are didactic scenarios that specify a sequence of collaborative phases through complex instructions. Different authors define CSCL scripts as "instructional sequences" that organize learning activities into phases. Each phase is defined by specific items: the activity (or activities) that learners have to perform, the group composition, the assignment of roles (to learners within the group), the interaction modes and the phase timing. These scripts are fundamental to guide collaboration.

The CSCL environments have to include more applications to support collaborative activities and to make the preparation of the CSCL script easier.

WHEN teachers engage students in collaborative learning, they give global instructions such as "do this task by group of 3." These instructions are completed with implicit expectations with respect to the way students should work together. The teacher's way of grading collaborative work strengthens this implicit contract. A collaboration script is a more detailed and more explicit didactic contract between the teacher and the group of students regarding to their collaboration mode. Most scripts are a linear sequence of phases. Each phase specifies the task that the students have to perform, the composition of the group, the way that the task is distributed within and among groups, the interaction mode and the timing of the phase (Dillenbourg, 2004).

The CSCL scripts are expected to facilitate learning by guiding peers collaboration and engaging all participants in activities that trigger the activation of their cognitive and metacognitive processes. The scripts need to be designed by an authoring tool able to formalize the learning activities in collaborative workflows. This tool has to respect several educational design requirements which we have identified in the CSCL literature: namely, group composition, role and resource distribution, coordination and flexibility. Each requirement implies a different challenge.

In this paper we present a novel approach to design and deliver dynamic collaborative learning processes and a tool able to apply such approach. The design process will not start from scratch but basing on the use and integration of pedagogical templates based on CSCL scripts. Pedagogical templates or patterns are used in order to capture and communicate recurrent learning design problems and opportunities (Goodyear, 2005). Each pattern describes a problem that occurs repeatedly and the solution core to that problem (Alexander, 1977).

The templates can be applied to instructional design at two levels: for learning materials and multimedia production, i.e., to define patterns for learning management systems (Avgeriou et al., 2003) and for instructional activities of different scale, i.e., to organize an entire course or to define specific learning activities (Bergin, 2003). In this paper we consider the second definition.

The paper is structured as follows: First, a state of the art on collaborative learning experiences design is presented; then we describe, briefly, the IWT learning platform which we have used as basis to apply the defined approaches; the section afterwards describes the proposed approach and the developed prototype; then we report some early experimentation results, while the last section presents some conclusions and future works planned.

RELATED WORK

Recently, some developments in terms of languages and tools for collaborative experience design have taken place. They have been integrated within learning processes and tools naturally involving students, learners, teachers, instructional designers and didactical managers.

The main issue here is that complex learning experiences and, mainly, collaborative ones, where information exchange among people is more important than information transfer from one (i.e., a teacher) to many others (i.e., the learners), need coordination mechanisms that current methods and design specifications are not able to provide.

Nowadays, the collaborative tools may be clustered in the following main categories:

- Application sharing, i.e., a synchronous tool where users may show the functionalities of a software environment to other people and allow them to use it directly;
- Audio conferencing, i.e., a synchronous tool where users may communicate by speaking and listening as in a phone call;
- cHat and instant messaging, i.e., synchronous tools where users may interact by writing on a keyboard and sending short messages to other people;
- Forum and online discussions, i.e., asynchronous tools where users may post subjects, problems, issues on a given topic and may receive answers and comments so to establish a discussion;
- e-Mail, i.e., the typical asynchronous way of communicating by sending messages (and attaching files);
- News reader, i.e., an asynchronous tool that allows users to collect and read all the news they are interested in;
- Video conferencing, i.e., a synchronous tool where users may interact each other by means of an audio and video communication;
- Voting and surveying, i.e., an asynchronous tool able to collect votes and opinions very quickly and to create statistics on them;
- Web tour, i.e., a synchronous tool that allows the users to surf the internet and share what they are watching or looking for with other users;
- Whiteboard, i.e., a synchronous tool that allows a user (a teacher) to share pictures, images, photos and texts with other users (the learners).

To build a collaborative process, such tools should be arranged and orchestrated in some way during a learning experience. To do this, the IMS Consortium has defined the Learning Design (IMS-LD, http://www.imsproject.org/learning-design/), an educational modeling language that enables the description of any learning process (including CSLC scripts) in a formal way. The IMS-LD is strongly influenced by the theatre play-act-scene metaphor, where actors proceed sequentially through the acts, while proceeding in parallel within acts or activity structures. One of the most interesting features in the IMS-LD is the possibility to synchronize the actors in multi-actor process-based scenarios.

There are several IMS-LD editors available. As stated in Griffiths et al. (2005) they can be classified in two dimensions: higher vs. lower level tools, with respect to the level of expertise in IMS-LD the user may require (i.e., how much the tool interface is influenced by

IMS-LD and how many specification details it hides), and general purpose vs. specific purpose tools, with respect to the pedagogical scope.

The teachers using a defined pedagogical approach (e.g., collaborative learning) would not need all the IMS-LD functions and capabilities. Authoring tools more tightly focused on such an approach might present only needed functionality, significantly reducing the complexity of authoring. Even if some authors criticize the IMS-LD owing to its complexity, the main criticism is the lack of expressivity to clearly specify collaborative activities.

Tools as RELOAD (http://www.reload.ac.uk) and CopperAuthor (http://copperauthor.sourceforge.net/) are examples of general purpose editors. If they were employed to model collaborative learning processes, they would have some limitations related to the need for defining groups or classes. Collaborative Learning Flow Patterns templates have been defined to overcome these limitations. Basing on these patterns, the Collage project (Hernández-Leo et al., 2006) has developed an editor able to use patterns to design collaborative activities and related flows. Nevertheless, this approach shows some deficiencies and the collaborative tools that can be defined in such a way, are limited.

Thus, some newer research findings have proposed an extension to IMS-LD (and to Collage too) that enables to specify several characteristics of use for tools that mediate the collaboration (Hernández -Leo et al., 2005). In such a direction there is the Common Cartridge specification (IMS-CC, http://www.imsglobal.org/cc/) offering a framework to host a new version of the IMS-LD allowing many more possibilities in terms of learning activities. IMS-LD 2.0 (Durand & Downes, 2009) rethinks the learning design in the TEE context while keeping the most essential features of IMS-LD.

An alternative approach is MISA (Paquett et al., 2008), an instructional engineering method graphically describing the instructional design processes and their products. MISA supports 35 main tasks or processes and around 150 subtasks. The method has been totally represented within the MOT+ editor.

There are also other design tools inspired by IMS-LD. DialogPlus Toolkit (http://www.dialogplus.soton.ac.uk/) is an example of an enhanced editor for a form-based scenario definition. This editor supports a variety of instructional design models, so it definitely fits a modern activity-based instructional design perspective, e.g., as an alternative to more traditional lesson planners and in the spirit of more powerful tools like MOT+, but being easier to learn. DialogPlus could be also used to model collaborative learning activities, although this new informal way which it applies is still far to be completed.

Research activities in the CSCL started working on modeling scripts and developing notational systems (Kobbe et al., 2007). The CSCL scripts are the most important design elements in CSCL and aim to support learning activities by structuring otherwise deficient interactions. A script describes the way the learners have to collaborate: task distribution or roles, turn taking rules, work phases, deliverables, etc. This contract may be conveyed through initial instructions or encompassed in the learning environment.

The CSCL scripts are specific suggestions, usually defined at a micro-design level, about how students should behave during their collaboration activities. While such techniques are generally proposed by tutors, the scripts are implemented through prompts provided, often automatically, to students, in order to guide them step by step through the different stages of the activity and/or to improve the quality of their subjects.

In Dillenbourg and Hong (2008) the authors have proposed the concept of macro-script which, generalizing the scripts described, leads to a less rigid work structure. Micro-scripts refer instead to processes that should be internalized by the learners. They usually describe the fine-grained actions that each participant should accomplish within activities.

Several works (Weinberger et al., 2005) present two examples of micro-scripts that guide the argumentation processes. Their goal leads the students to learn how to argument in order to construct the knowledge together. In contrast, the macro-scripts aim at organizing situations that encourage productive targeted interactions and lead to learning outcomes (e.g., the script arranges fruitful discussions by grouping students with different results in previous activities) defining flows of coarse-grained activities (Hernández-Leo et al., 2005).

Both macro and micro scripting can be regarded as two complementary ways of supporting the students during their collaborative work: the former is more general and suggests a procedure which can be modified at any moment by the person in charge of the activities (teacher, tutor or students themselves), the latter specifies more in detail the steps and behaviors the students should adopt through (semi) automatic prompts and therefore is more rigid.

The implemented scripts are neither resistant to technological changes nor easily tailorable to support another learning situation. To solve these problems, a promising approach is to formalize the scripts so that they are automatically interpreted by a script engine. Several studies (Hernández -Leo et al., 2005; Miao et al., 2005) deal with the computational representation of a CSLC script. These studies have led to projects like CPM (Laforcade et al., 2003), a UML profile and system somewhere in between CSCL and learning design and Cool Modes (http://www.collide.info/index.php/Cool_Modes), a system that includes several visual design tools for learners and teachers.

Currently, only two systems are being produced: the first one is LAMS (http://www.lamsinternational.com/), but it is still unable to overcome the quoted IMS-LD limitations; the second one is CeLS (Ronen et al., 2006), a Web environment to create and run structured collaborative activities and to embed them into existing instructional settings. CeLS is able to create and reuse activity structures: its formats reflect various collaborative instructional strategies, e.g., creating and analyzing a common database, reaching an agreement, peer-product evaluation, contest, creating a group product, etc. Unfortunately it is limited to asynchronous activities only.

To overcome these limitations, we present here a new approach for collaborative learning experiences design and execution. In particular we use a pedagogical template editor to design collaborative processes that can be interpreted and executed by an Intelligent Tutoring System. This integration allows to add dynamicity to the designed processes and to automatically adapt them to the learner's needs and preferences

THE STARTING POINT

In this section we introduce a learning platform named IWT (Intelligent Web Teacher) that we have adopted as a base to apply approaches and to integrate technologies hereafter defined. IWT (Albano et al., 2007) allows generating personalized adaptive learning experiences and relies on three main methodological interacting modules: the educational knowledge model, the learner model and the planning procedures (Capuano et al., 2009).

The *educational knowledge model* is composed of three abstraction levels. The lowest level is the Learning Resource. Learning Resources are learning objects or services requiring to be indexed in order to let the engine know what each one of them is about and how they can be used during the learning process. This is done by a second abstraction representation level (Metadata).

A Metadata is a collection of Learning Resource attributes describing some features such as type (e.g., text, simulation, slide, questionnaire, lesson, exercise, etc.), required educational level (e.g., primary school, high school, university, other training contexts, etc.), language, interactivity level (e.g., low, medium, high), interactivity type (e.g., active, expositive, mixed, etc.) and parameters related to time, technical requirements etc.

Finally, a third abstraction level (called Ontology) is used to represent, from a semantic point of view the educational Domain Concepts and their relations. A Domain Concept is a concept belonging to a Dictionary of an educational domain and can be possibly explained by one or more Learning Resources. The Domain

Concepts are not content, by the meaning of content they are related to.

Typical relations among the ontology concepts are: *Has Part*, *Is Required By*, *Suggested Order*. The first one indicates a hierarchical relationship: a concept may be divided into other simpler concepts. The second one indicates a constraint: to understand a concept it is required to have previously understood another concept. The last one is an ordering suggestion between two concepts (Gaeta et al., 2009).

IWT uses a *learner model* to collect information about the learner's Cognitive State and Learning Preferences. The Cognitive State includes all the acquired competences about Domain Concepts. The Learning Preferences refer to the way each learner prefers learning content on a domain. The *planning procedures* are capable to build a course satisfying all the learner's requirements taking into account their Cognitive State and Learning Preferences.

Each course is characterized by a set of Learning Goals that are concepts chosen by the teacher (or by the instructional designer) on the educational domain ontology. Basing on the ontology, IWT calculates the best sequence of concepts needed to reach the selected Learning Goals and removes concepts that the target learner already knows (i.e., concepts already included in their Cognitive State). This sequence is called Learning Path and, in the delivery phase, is translated into a Learning Presentation by covering each one of its concepts with the best available Learning Resource with respect to Learning Preferences.

Thus, IWT supports a learner centered approach by building the best course for each learner from a set of Learning Goals. Different learners with the same Learning Goals will have different courses generated by the system. IWT also integrates many classical features of a Learning Management Systems also including a wide set of Web 2.0 and collaborative services as described.

- **e-Portfolio:** It stores personal information, learning style, cognitive state, tracks of learning activities in which a learner is involved or has been involved in.
- **Blogs:** They allow the learners to share ideas on close or open topics. Educators can fix or make explicit the expressed knowledge.
- **Podcasts:** It is a simple way of capturing and spreading video/audio learning content. Podcasts can be used to record and disseminate the teacher's lectures. They can be also used as output of the learners' tasks.
- **Wikis:** They are used to build structured knowledge (like texts and ontologies) by cooperating with other people. The produced artifacts could be evaluated by a teacher to assess the learners' tasks.
- **Social Networking and Bookmarking:** They are used by the users to informally keep in contact each other; to set up a study group; to find people who have the same skills, preferences, learning styles, interests, etc.
- **Knowledge Forums:** They are used to post questions and to answer, tag and rate them through informal-intentional mechanisms.
- **Shared Areas:** They are used by people to share content, download others' content, tag it, post rating comments and feedbacks;
- **RSS Feeds:** By means of them, people may publish and collect quickly and easily information on their status, activities, interests, etc.

As learning objects, also quoted services are semantically annotated through feasible Metadata to allow IWT to select and combine them in the creation of learning experiences. They are also used to model collaborative flows as explained in the next sections.

THE PROPOSED APPROACH

The Theoretical Model

The development and management of collaborative activities as part of a formal learning process requires a conceptual model that, on the one hand, aims at describing the architectural strategies and methods and, on the other hand, helps define the communication processes, the description of groups, and the selection of tools and services for the interaction.

The approach we propose is based on the definition of a Collaborative Didactic Model able to describe collaborative learning experiences as workflows involving users, content and IWT collaborative services. The first thing to do is to define Learning Goals from the available Ontology concepts. Then, it is necessary to define, at an upper level, the specific collaborative strategies to apply. A collaborative strategy corresponds to a CSCL macro-script and is seen as a given configuration of learning parameters like learning type, orientation, types of course content, educational goal, learning focus and interactions.

Table 1 summarizes feasible values for the defined learning parameters. Once the parameters are clear, a collaborative strategy can be represented at a bottom level, through a workflow of didactic activities to be executed corresponding to a CSCL micro-script. This workflow is the Collaborative Didactic Model, allowing to:

- Design structured experiences, according to the principles known by the scientific community to be of high-impact effect on the learning class activity;
- Associate content as well as collaborative and Web 2.0 services to each activity to enhance the model and to define, in the form of didactic package, the final cognitive product of the group activity;
- Reuse such a product in different didactic contexts as a collaborative learning component.

After having defined the Collaborative Didactic Model, setting all the activities and related resources and services, it is possible for the teacher to associate specific learners and to run the class activity. The model can be directly executed or saved as a pedagogical template that can be revised and reused in other learning contexts. The use of pedagogical templates is a technique broadly accepted among practitioners when they need to structure learning activities (Dillenbourg, 2002). They can be seen as a way of collecting “best practices” in instructional design.

In our case, these best practices refer to suitable ways of arranging participants in a collaborative learning situation, sequencing types of collaborative learning activities in order to promote the achievement of a set of desired educational objectives. Among other advantages, they provide a way of communicating collaborative learning expertise to other (novice) practitioners: instead of trying to create their own collaborative designs from scratch, practitioners can reuse the templates as instructional guides for structuring their own collaborative experiences.

Table 1. Learning parameters

Learning Parameters	Feasible Values
Learning type	Content and Support; Wrap Around; Integrated; Individual Exploration; Networking Learning / Informal e-Learning
Orientation	Content and Personalization; Interaction and Collaboration; Cooperation and Project Work
Type of course contents	Facts; Concepts; Procedures
Educational goal	Information Storing; Relations Understanding; Application of Simple Skills; Application of General Skills; Interdisciplinary
Learning Focus	Cognitive Domain; Topic; Problem; Interdisciplinary
Interactions	Individual / Group; Human / Systemic

The Software Prototype

In this section we present some software tools we developed to design collaborative learning scenarios oriented to Web 2.0 and to execute them inside IWT. In particular, the tool operates as a guided lesson for teachers to help them design and allocate the group experiences with assigned didactic objectives.

The editing environment is composed of two main areas: a control panel with a list of activities to put into the collaborative process (each one with a set of parameters to be settled) and a workspace, where activities can be dropped and composed.

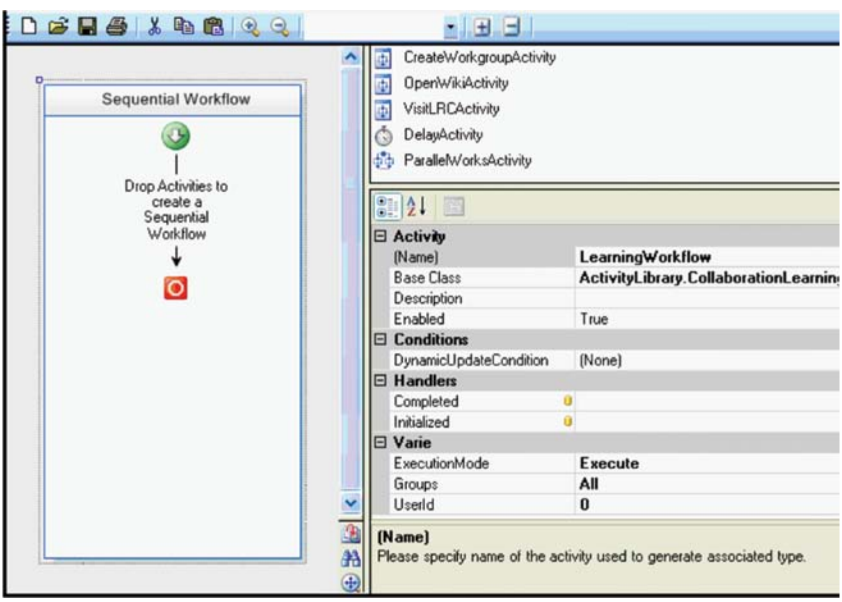
The Figure 1 shows the prototype user's interface. From the control panel it is possible to choose what the users are likely to do when they take part in collaborative learning activities. In particular the teacher (or the instructional designer) may define different kinds of activities:

- Collaborative activity i.e., a chat, a conferencing or a wiki activity involving a group of learners;
- Other learning activities to allow the access to any kind of Learning Resource Component (object or service) available in the delivery phase;
- Creation of workgroups i.e., grouping users that access the execution flow;
- Branch and join i.e., to allow the creation of parallel flows to be enriched by learning activities as well.

The output of the editing environment is a collaborative learning workflow named Didactic Activities Flow (DAF). It can be played inside IWT which we have extended with an execution environment, where the teachers are able to bind activities with groups, users and resources and, where the learners can take part in collaborative learning activities.

These two environments have been developed using the Microsoft Windows Workflow Foundation (Chappell, 2005). This environment has a Workflow Designing tool that allows developers to design processes including activities and transitions. The default set of activities can be extended by defining custom activities.

Figure 1. The prototype user interface



The designed workflows may be executed and managed by the Workflow Engine.

The Figure 2 shows prototypal components that manage both workflow composition and execution phases of learning resources and services. The composition happens through the DAF Designer Tool: a client desktop application based on Microsoft Workflow Designer. The author (i.e., a teacher or an instructional designer), may define the flow of learning activities taken from the Didactic Activities Library.

The defined learning flow is then compiled by the Microsoft Workflow Compiler and transformed into a DAF that can be executed by the Microsoft Workflow Engine. The execution happens in the DAF Execution Environment, a Web application interoperating with the Workflow Engine and with the IWT Users and Resource Management Service.

Through the extension with such prototype components, IWT is able to dynamically compose resources and services for a knowledge-based sequencing of learning activities and collaborative workflows. In such a sense an IWT course may become a dynamic component of a DAF and, also, a dynamic IWT course may contain a DAF as any other learning resource. Thanks to the integration of defined prototypes, IWT is so able to execute dynamic collaborative learning experiences.

EXPERIMENTAL RESULTS

The objective of the experimentation phase has been to test how dynamic collaborative learning experiences in formal learning contexts, as defined in the previous section, are able to support the collaborative learning process by means of adaptive feedback, motivational input and peering, sharing, etc. Although in recent years, design-based approaches have become popular as methods for the educational research, the validation process remains a gap, especially if it involves collaborative tools.

The developed functionalities have been tested by means of test plans and evaluation and the prototype tools and their methodologies have been experimented by following two concrete scenarios (Figure 3). In the first scenario, the learners were involved in a personalized self-instruction session made through IWT course sequencing features ending with a self-assessment test on the topics they had studied. After that, the course learners were randomly divided into two groups, each of them involved in the preparation of an essay on a topic inside a wiki environment. These scenarios were carried out with teachers and learners in Mathematics Courses at the Faculty of Engineering of the University of Salerno

A preliminary study was conducted on 40 students from a Computer Science Class at the University of Salerno. This class was characterized by a teaching program in which the learning of target concepts is linked to a capability of handling and abstracting multiple applications. This particular type of learning requires a learning experience where motivation, reflection, adaptability and corrective feedback (assessment) are key words characterizing the educational process. Our goal was to study the benefits of providing learners with an educational setting that allow them to manipulate and learn in a collaborative way.

Figure 2. Components for composition and execution of a DAF

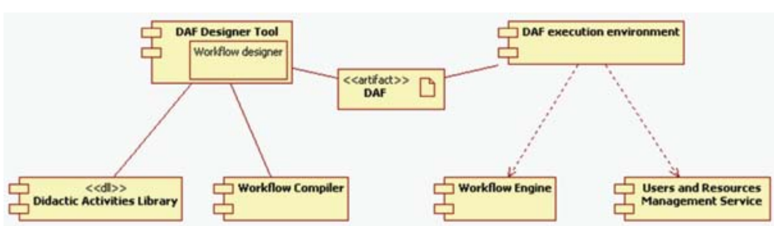
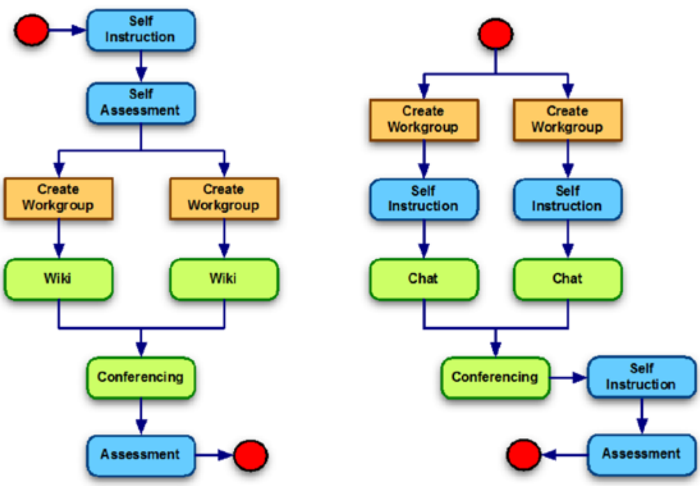


Figure 3. Workflows of experimented collaborative learning scenarios



In parallel with the environment for collaborative learning experience, we organized a second context of experiment, where the students had access to didactic resources and traditional lessons. Students were divided into two balanced groups (each of them of 20 people) with an equal mix of high and low competency levels. The experimental group was called *cscl group*; the control group was called *none csclgroup*.

The goal of this experiment was to demonstrate the added–value of having a collaborative pedagogical template embedded in an active learning environment. Students were invited to participate in this new learning experience. Both groups were involved for 10 days in learning and asked to verify what they had learnt by answering to final and intermediate evaluation sessions. At the expiration of the ten days, data and feedbacks were analyzed. To get an idea of how the pedagogical requirements impact on the validity of resource design, we have measured the following parameters.

- **Learning and Reflection Level:** The quality and effectiveness of the educational collaborative design framework can be attributed to the capacity of reflection and abstraction of the learner in collaborative setting; the effective collaborative activity should encourage the learner to develop their mental conceptual structure or reformulate their learning strategy.
- **Motivational Level:** Is a concept intimately linked with learning. The learners' motivation is crucial in programming education activity where the learners are required to actively apply their knowledge. Therefore, it is important to analyze the collaborative actions that affect students' motivation to learn.

Concerning the *learning and reflection level*, the evaluation of the educational collaborative design framework effectiveness, with respect to the traditional didactic methodologies, is obtained by two assessment milestones: "interim" and "final" evaluations. The "interim" evaluation is obtained through a first measure of the learning level ("knowledge acquisition"). This level of knowledge is tested on both groups through a sequence of tests (10 multiple choice questions) and a completion of a conceptual map of the treated domains.

In the *cscl group* 15 out of 20 students passed the final test; 0 out of 15 students (who passed the final test) responded correctly to 90% of questions; 5 out of 20 students did not pass the final test. For these 5 students the prototype created automatically a remedial work, a series of new collaborative paths to fill in the gap. Once the students followed the indicated path, they were involved in a new assessment phase. All of them had successfully completed the learning experiences and passed 100% of questions.

In the *none csclgroup* 9 out of 20 students passed the final test; 6 out of 9 students (who passed the final test) responded correctly to 90% of questions; 11 out of 20 students did not pass the final test. We can therefore say that the educational collaborative template allows the students to discover new rules and ideas rather than to keep the materials that others have presented.

The different scenarios offer to students the possibilities to interact with their colleagues for exploring and manipulating objects and knowledge as well. To improve these results and to evaluate the learning phase, the students were involved in creating a conceptual map starting from the knowledge of a single concept assigned to them. The evaluation was made on the basis of the following criteria:

- Number of concepts expressed;
- Congruency of some concepts with respect to the knowledge domain;
- Number of relations expressed;
- Relevancy of these relations;
- Number of original relations found.

The target map designed by the teacher had 30 concepts related to each other using a predefined set of relations that expressed the special link between them. For the *cscl group* we have that 15 out of 20 students produced a map similar to the target one (in terms of pointed out criteria). For the *none csclgroup* we have that 2 out of 20 students produced a map similar to the target one (in terms of pointed out criteria).

Concerning the *motivational level*, the importance of affective and motivational factors in educational collaborative model has been extensively reported in the educational psychology literature. Recently, the researchers have investigated about the relationship between motivation and learning experiences. A positive motivation helps the learners achieve successful learning outcomes. This aspect has been verified through a motivational questionnaire submitted to the students three days before the assessment moment.

The construction of the questionnaire has required an accurate study of the variables to be investigated and then is enabled to any assumptions and correlations. A set of parameters, that we can take into account in order to set a motivational scale for measuring the level of motivation in educational experiences were identified by looking at the ARCS model (Keller, 2010) as a theoretical reference, and extracting a set of questions representing the motivational indicators.

The ARCS model presents four categories of motivation (attention, relevance, confidence, and satisfaction), each of which has several subcategories of concepts and strategies. Gaining and retaining the learner's *attention* is a condition for an efficient learning method; *relevance* (of the learning content) is a necessary element to keep up attention and engagement; *confidence* determines the level of effort invested in learning experience by the student; *satisfaction* refers to the reward gained from the learning experience.

The students are motivated to learn when they feel that the instruction methodology is interesting and relevant to their concerns, and when they are confident in the learning process and satisfied with learning. On these parameters a self-evaluation questionnaire of motivational quality was structured. The questionnaire followed the mentioned four macro-dimension. Each dimension had three sub-level categories, and therefore, there were in total twelve sub-level categories. Each item was presented using a five-point Likert scale and the student would respond by checking for each item: *very satisfied – satisfied – neither – dissatisfied – very dissatisfied*. Sample questions are presented in Figure 4.

Each dimension was examined from a quantitative point of view through a set of items with fixed answers. The quantitative aspects were also supported by the active observation

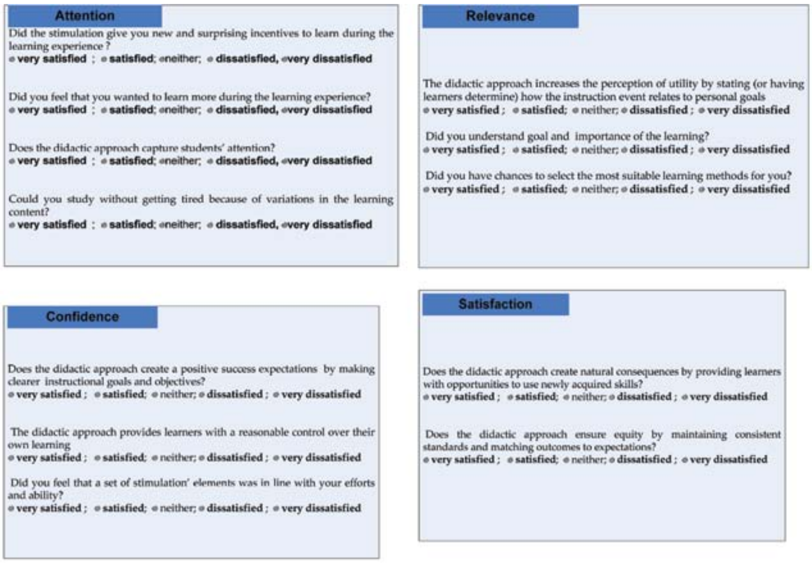


Figure 4. Sample of questions for affective and motivational factors evaluation

of three specific members (a teacher and two tutors). The questionnaire was sent by mail to the groups participants for a month; their answers were then gathered and put together in clusters in a nominative form. Following a close analysis of the averages and correlations among the items was confirmed and compared to what can be considered or not a qualifying factor of the motivational level in support of learning.

Specifically, we investigated the differences between the two groups in terms of motivation and, in a second time, this correlation with the assessment of learning outcomes. For the *cscl group* we have:

- The maximum value for the motivational dimensions *attention* and *satisfaction* (in particular, the participation in collaborative activities is directly proportionate to the perceived satisfaction with respect to the implication associated to the method);
- The teaching method matching the expectations (the high value associated to these dimensions is correlated to the results obtained in the *interim* assessment);
- A high level of *relevance* (5 students that did a remedial work, had given the maximum score on Likert scale);
- A high level of *confidence* (a greater involvement of the user and on increased perception of success guarantees in building the knowledge and skills is promoted).

For the *none csclgroup* we have:

- A lower value on *attention* and *satisfaction* (poor results in the evaluation of the knowledge acquisition, missing capability of the didactic experience to attract the attention and to keep a high level of satisfaction);
- The teaching method does not match the expectations (low value associated to low results obtained in the *interim* assessment);
- A missing perception of *relevance* (poor results in terms of learning);
- A medium level of *confidence*.

The teachers were involved in qualitative analyse. About 10 out of them were interviewed and they found the prototype particularly interesting since they had the possibility to build specific groups, quickly and easily, with the same didactic preferences and to experiment and reinforce theoretical concepts through collaborative activities. In such a way they found that the learning quality had improved.

CONCLUSION

The goal of the work described in this paper is to propose a novel approach for the definition and the execution of dynamic collaborative learning experiences in formal learning contexts through the aggregation of learning activities on the basis of pre-defined schemas. This is done with the purpose of facilitating the design of fine-grained learning activities, placing teaching and learning at the center of the design process.

In order to experiment the defined approach in a real setting, we developed (and presented) a tool allowing teachers to build collaborative learning processes. The key feature of the implemented tool is the capability to adapt some learning activities to the specific didactic preferences of the learners. Indeed, through drag & drop techniques, it is possible to put onto the workflow, in any position, the specific didactic activities. To validate both the approach and the developed prototype, we experimented them inside a Computer Science Class at the Faculty of Engineering of the University of Salerno. Experimental results have turned to be positive from both learning and reflection level and the motivational level.

These first results encourage us to continue our work, to improve the methodology and the prototype, fully integrating it in the referenced IWT platform. In particular, we are improving the prototype by enriching the workflow language with conditional elements (i.e., elements that select when to execute an action basing on assessment results obtained by a single learner or by a group) and alternative flows (parts of the workflow that can be executed alternatively rather than concurrently). In Mangione et al. (2011) we defined a pedagogical template and improved the prototype presented in this paper to support the definition and the execution of a storytelling complex learning object. We are also working in the perspective to include import/export functions for IMS-LD.

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REFERENCES

Albano, G., Gaeta, M., & Ritrovato, P. (2007). IWT: An innovative solution for AGS e-learning model. *International Journal of Knowledge and Learning*, *3*(2-3), 209–224. doi:10.1504/IJKL.2007.015552

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language*. Oxford, UK: Oxford University Press.

Avgeriou, P., Papasalouros, A., Retalis, S., & Skordalakis, M. (2003). Towards a pattern language for learning management systems. *Journal of Educational Technology & Society*, *6*(2), 11–24.

Bergin, J. (2003). *Fourteen pedagogical patterns*. Retrieved from http://www.pedagogical patterns.org/

Capuano, N., Gaeta, M., Marengo, A., Miranda, S., Orciuoli, F., & Ritrovato, P. (2009). LIA: An intelligent advisor for e-learning. *Interactive Learning Environments*, *3*(17), 221–239. doi:10.1080/10494820902924912

Chappell, D. (2005). *Introducing windows workflow foundation*. Redmond, WA: Microsoft.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In Kirschner, P. A. (Ed.), *Three worlds of CSCL. Can we support CSCL* (pp. 61–91). Heerlen, The Netherlands: Open Universiteit Nederland.

Dillenbourg, P. (2004). Split where interaction should happen: A model for designing CSCL scripts. In Gerjets, P., Kirschner, P., Elen, J., & Joiner, R. (Eds.), *Instructional design for effective and enjoyable computer-supported learning*. Tuebingen, Germany: Knowledge Media Research Center.

Dillenbourg, P., & Fischer, F. (2007). Basics of computer-supported collaborative learning. *Zeitschrift für Berufs-und Wirtschaftspädagogik*, *21*, 111–130.

Dillenbourg, P., & Hong, F. (2008). The mechanics of macro scripts. *International Journal of Computer-Supported Collaborative Learning*, *3*(1), 5–23. doi:10.1007/s11412-007-9033-1

Durand, G., & Downes, S. (2009). Toward simple learning design 2.0. In *Proceedings of the 4th International Conference on Computer Science & Education*, Nanning, Guangxi, China (pp. 894-897).

Gaeta, M., Orciuoli, F., & Ritrovato, P. (2009). Advanced ontology management system for personalized e-learning. *Knowledge-Based Systems*, *4*(22), 292–230. doi:10.1016/j.knosys.2009.01.006

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern language and design practice. *Australasian Journal of Education Technology*, *21*(1), 82–101.

Griffiths, D., Blat, J., García, R., Vogten, H., & Kwong, K.-L. (2005). Learning design tools. In Koper, R., & Tattersall, C. (Eds.), *Learning design, a handbook on modelling and delivering networked education and training* (pp. 109–135). New York, NY: Springer.

Hernández-Leo, D., Asensio-Perez, J., & Dimitriadis, Y. (2005). Computational representation of collaborative learning flow patterns using IMS learning design. *Journal of Educational Technology & Society*, *8*(4), 75–89.

Hernández-Leo, D., Asensio-Pérez, J., Dimitriadis, Y., Bote-Lorenzo, M., Jorrín-Abellán, I., & Villasclaras-Fernández, E. (2005). Reusing IMS-LD formalized best practices in collaborative learning structuring. *Advanced Technology for Learning*, *2*(4), 223–232.

Hernández-Leo, D., Villasclaras-Fernández, E., Asensio-Perez, J., Dimitriadis, Y., Jarrín-Abellán, I., Ruiz-Requies, I., & Rubia-Avi, B. (2006). COLLAGE: A collaborative learning design editor based on patterns. *Journal of Educational Technology & Society*, *9*(1), 58–71.

Keller, J. (2010). Media. In Keller, J. M. (Ed.), *Motivational design for learning and performance* (pp. 227–286). New York, NY: Springer. doi:10.1007/978-1-4419-1250-3

Kobbe, L., Weinberger, A., Dillenbourg, P., Harrer, A., Hämäläinen, R., Hàkkinen, P., & Fischer, F. (2007). Specifying computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning*, *2*(2-3), 211–224. doi:10.1007/s11412-007-9014-4

Laforcade, P., Barbier, F., Sallaberry, C., & Nodenot, T. (2003). Profiling co-operative problem-based learning situations. In *Proceedings of the 2nd IEEE International Conference on Cognitive Informatics* (p. 32).

Laurillard, D. (2008). *Digital technologies and their role in achieving our ambitions for education*. London, UK: Institute of Education, University of London.

Mangione, G. R., Orciuoli, F., Pierri, A., Ritrovato, P., & Rosciano, M. (2011). A new model for storytelling complex learning objects. In *Proceedings of the International Workshop on Adaptive Learning via Interactive, Collaborative and Emotional approaches held in conjunction with the 3rd International Conference on Networking and Collaborative Systems*, Fukuoka, Japan (pp. 836-841).

Miao, Y., Hoeksema, K., Hoppe, H., & Harrer, A. (2005). CSCL scripts: Modeling features and potential use. In *Proceedings of the Conference on Computer Supported Collaborative Learning: The Next 10 Years!* (pp. 423-432).

Paquett, G., Léonard, M., & Lundgren-Cayrol, K. (2008). The MOT+ visual language for knowledge-based instructional design. In Botturi, L., & Stubbs, T. (Eds.), *Handbook of visual languages for instructional design. Theories and practices*. Hershey, PA: IGI Global.

Ronen, M., Kohen-Vacs, D., & Raz-Fogel, N. (2006). Adopt and adapt: Structuring, sharing and reusing asynchronous collaborative pedagogy. In *Proceedings of the 7th International Conference on Learning Sciences* (pp. 599-605).

Weinberger, A., Fischer, F., & Stegmann, K. (2005). Computer-supported collaborative learning in higher education: Scripts for argumentative knowledge construction in distributed groups. In *Proceedings of the Conference on Computer Supported Collaborative Learning: The Next 10 Years!* (pp. 717-726).

Wilson, S., Liber, O., Johnson, M., Beauvoir, P., Sharples, P., & Milligan, C. (2006). Personal learning environments challenging the dominant design of educational systems. In *Proceedings of the First European Conference on Technology Enhanced Learning*, Crete, Greece.

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