

## Design and Execution of Dynamic Collaborative Learning Experiences

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**Abstract** — Computer Supported Collaborative Learning and Computer Supported Cooperative Work are research domains whose methodological instances are vaguely recognized and even more rarely modeled. The goal 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 pedagogical templates metaphor and also uses methodological services and opportunities given by the Web 2.0. In order to experiment the proposed approach, a tool purposed to design and execute dynamic collaborative learning experiences has been developed and experimented in formal e-learning settings.

**Keywords** — learning design, collaboration, e-learning, learning methods, adaptive learning, template, learning experiences

### I. INTRODUCTION

The research community on learning design recognizes that the collaborative dimension of a learning experience is one of the most important elements to take into account to ensure a high level sustainability of e-learning [1]. On the other hand, despite the collaboration is often used in informal learning contexts, it is still difficult to be integrated in formal ones and it still results as an experimental didactic modality.

In a formal learning context there are specific educational settings consisting of a distribution of complementary roles, explicit didactic goals to reach and levels of performance to gain as well as didactic models to apply. The didactic models, in particular, determine the design, the planning, the execution and the evaluation of learning activities. In this context, a collaboration process must have a well structured model to adhere to, with precise, predefined objectives connected with specific learning activities.

Structuring the collaborative learning process in an appropriate way is also relevant, since free collaboration does not necessarily produce learning [4]. As stated in [2], “never before has there 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 [3].

To overcome these drawbacks, we present in this paper 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 [6].

Pedagogical templates or patterns are used in order to capture and communicate recurrent learning design problems and opportunities [8]. Each pattern describes a problem that occurs over and over again and the core of the solution to that problem [20].

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 [21] and for instructional activities of different scale i.e. to organize a whole course or to define specific learning activities [22]. In this paper we consider the second definition.

The paper is structured as follows: in the second section a state of the art on collaborative learning experiences design is presented; the third section briefly describes the learning platform IWT which we used as basis to apply the defined approaches; the fourth section describes the proposed approach and the developed prototype; the fifth section reports some early experimentation results while the last section presents some conclusions and planned future works.

### II. RELATED WORK

Recently, 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 figures like 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: a synchronous tool where users may show functionalities of a software environment to other people and allow them to directly use it;
- audio conferencing: a synchronous tool where users may communicate by speaking and listening as in a phone call;
- chat and instant messaging: synchronous tools where users may interact by writing on a keyboard and sending short messages to other people;
- forum and online discussions: asynchronous tools where users may post subjects, problems, issues on what they want and may receive answers and comments so to establish a discussion;

- email: the typical asynchronous way to communicate by sending messages (and attaching files);
- news reader: an asynchronous tool that allows users to collect and read all news they are interested in;
- video conferencing: a synchronous tool where users may interact each other by means of audio and video communication;
- voting and surveying: an asynchronous tool able to collect votes and opinions very quickly and to create statistics on them;
- web tour: a synchronous tool that allows the users to surf the internet and share what they are watching or looking for with other users;
- whiteboard: 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 Learning Design (IMS-LD, [18]), an educational modeling language that enables the description of any learning process in a formal way.

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 IMS-LD is the possibility to synchronize actors in multi-actor process-based scenarios.

There are several IMS-LD editors available. As stated in [7] 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.

Teachers using a defined pedagogical approach (e.g. collaborative learning) would not need all 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.

Tools as Reload [9], CopperAuthor [10] and Cosmos [4] are examples of general purpose editors. If they were employed to model collaborative learning processes, they would have some limitations related to the need of defining groups or classes. Collaborative Learning Flow Patterns templates have been defined to overcome these limitations. Basing on these patterns, the Collage project [25] 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 have proposed an extension to IMS-LD (and to Collage too) that enables to specify several characteristics of use of tools that mediate collaboration [6].

An alternative approach is MISA [11], 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 [12] 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, though this new informal way it applies is still far to be completed.

Research activities in Computer Supported Collaborative Learning (CSCL) started working on modeling scripts and developing notational systems [13]. Collaboration scripts are the most important design elements in CSCL and aim to support learning activities by structuring otherwise deficient interactions [5]. A script describes the way 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.

These studies have led to projects like CPM [14] (a UML profile and system somewhere in between CSCL and learning design), Cool Modes [15] (a system that includes several visual design tools for learners and teachers) and other systems that include visual design languages.

Currently, only two systems are now being produced: the first one is LAMS [4], but it is still unable to overcome the quoted IMS-LD limitations; the second one is CeLS [16] (Collaborative e-Learning Structures), 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 have given our approach a definition 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 learner needs and preferences.

### III. 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. [17]. IWT allows to generate personalized adaptive learning experiences and relies on three main methodological interacting modules: the educational knowledge model, the learner model and the planning procedures [24].

The *educational knowledge model* is composed of three abstraction levels. The lowest level is the Learning Resource.

Learning Resources are learning object 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 a 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, 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. 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 is an ordering suggestion between two concepts [19].

IWT uses a *learner model* to collect information about the learner's Cognitive State and Learning Preferences. The Cognitive State means all acquired competences about Domain Concepts. The Learning Preferences refer to the way each learner prefers to learn content on a domain.

The *planning procedures* are capable to build a course satisfying all the learner's requirements taking into account 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 his/her Cognitive State). This sequence is called Learning Path and, in the delivery phase, it 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 below.

- 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 learners to share ideas on close or open topics. Educators can fix or make explicit the expressed knowledge.

- Podcasts. It is a simple way to capture and spread video/audio learning content. Podcasts can be used to record and disseminate teacher's lectures. They can be also used as output of 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 learners' tasks.
- Social Networking and Bookmarking. They are used by users to informally keep in contact each other; to set up a study group; to find people having the same skills, preferences, learning styles, interests, etc.
- Knowledge Forums. They are used to post questions and to answer, to tag and to 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.

#### IV. THE PROPOSED APPROACH

##### A. The Theoretical Model

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 [18].

A collaborative strategy is seen as a given configuration of learning parameters like learning type, orientation, types of course content, educational goal, learning focus and interactions.

TABLE I. LEARNING PARAMETERS

<i>Learning Parameter</i>	<i>Feasible Values</i>
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

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. 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 broadly accepted technique mostly among practitioners when structuring learning activities [6]. 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.

### B. The Software Prototype

In this section we present software tools we developed to design collaborative learning scenarios oriented to Web 2.0 and to execute them inside IWT.

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.

Fig. 1 shows the prototype user interface. From the control panel it is possible to chose what the users will do

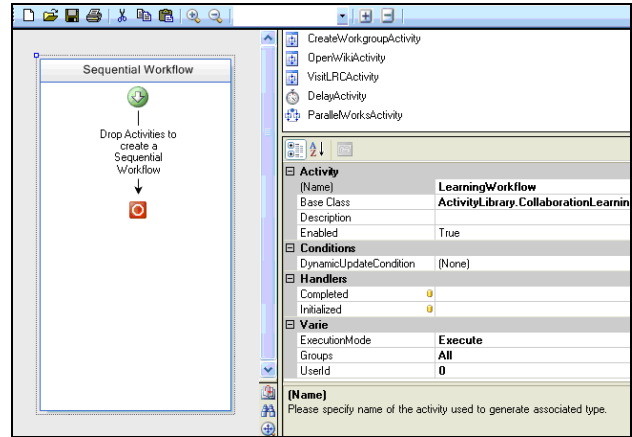


Figure 1. Prototype user interface.

when they take part in collaborative learning activities. In particular the teacher (or the instructional designer) may define activities to:

- *create workgroups* i.e. to group users that access the execution flow;
- *open a wiki* i.e. to access a shared wiki page;
- *visit an LRC* i.e. to access any kind of Learning Resource Component (object or service) available in the delivery phase;
- *delay* i.e. to delay the execution flow (useful in synchronous activities or after a parallel session involving different users or workgroups);
- *parallel works* i.e. to allow to create 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 provided to extend with an **execution environment**, where teachers are able to bind activities with groups, users and resources and, then, learners can take part in collaborative learning activities.

These two environments have been developed using the Microsoft Windows Workflow Foundation [23]. 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*. Designed workflows may be executed and managed by the Workflow Engine.

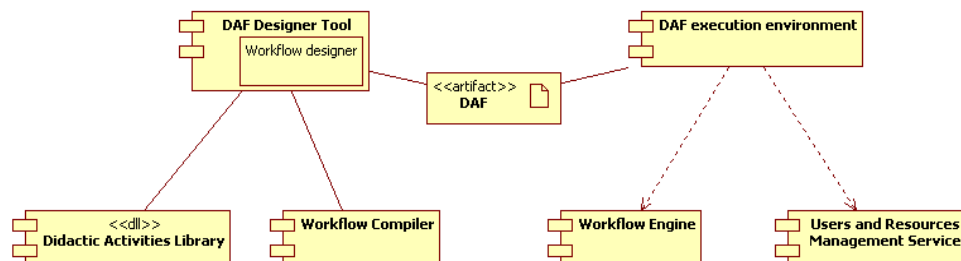


Figure 2. Components for composition and execution of a DAF.

Fig. 2 shows prototypal components that manage both the 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 (through the *visit an LRC* activity) and, on the other side, 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.

## V. EXPERIMENTAL RESULTS

Developed prototype tools were experimented in a formal setting. Fig. 3 shows a concrete scenario we have realized through the developed prototype. It is divided in two learning phases: an instructive phase and a phase of collaboration and artifact production. In the first instructive phase, the activities are related to the creation of a course. Then, a parallel session has learners involved in taking part into the course while the teacher assigns them exercises to do.

Another parallel session has learners involved in doing exercises while the teacher is preparing the second part of the course. The second collaboration phase is characterized by parallel works: the learners are divided into groups for executing their activities. A learner leads the group and the others to do research and collaborating activities.

Meanwhile, the teacher is involved in revising executions of the previous exercises. After that, a synchronization point is fixed. All groups complete their works and send results to the teacher. Finally, the teacher closes the course by organizing a classroom meeting.

This scenario was carried out with teachers and learners in Mathematics Courses at the Faculty of Engineering of the University of Salerno. It was mainly purposed to validate

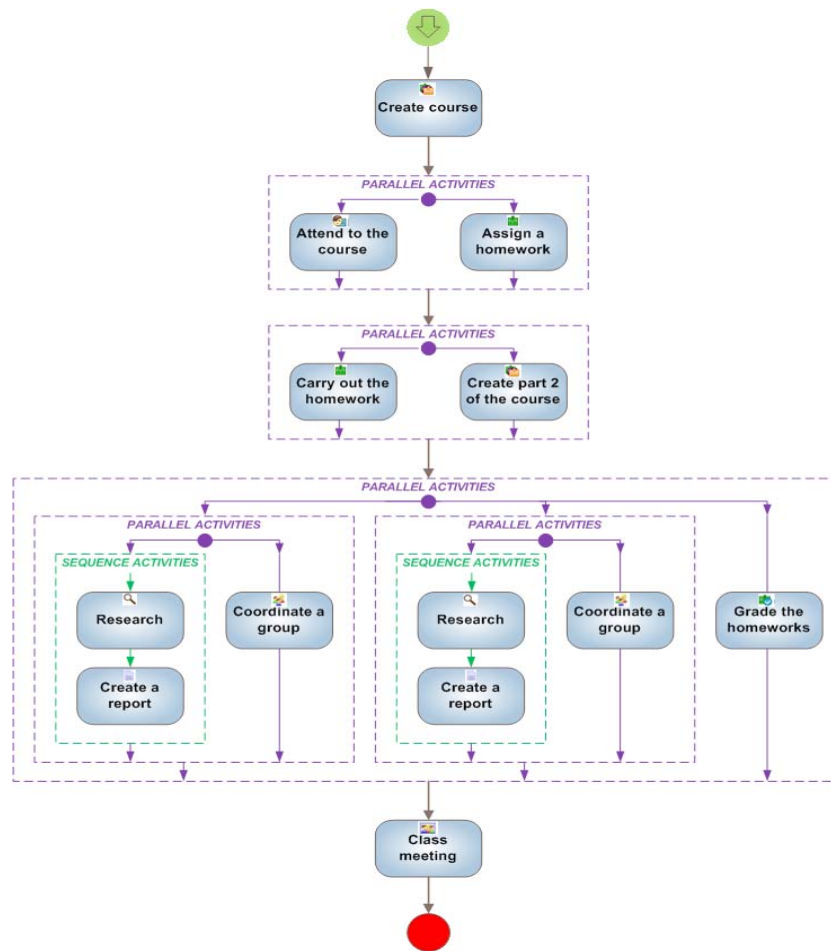


Figure 3. Workflow of a collaborative learning scenario.

both the prototype and the underlying methodology.

More than three hundred learners were involved. One hundred of them were interviewed and they found the prototype particularly interesting since they had had the possibility to experiment and reinforce theoretical concepts through collaborative activities. Teachers were enthusiastic too, given that they were able to build specific groups, quickly and easily, with the same didactic preferences. In such a way the learning quality was ameliorated.

## VI. CONCLUSIONS

The goal of this paper was 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 centre of the design process.

In order to experiment the defined approach in a real setting, we developed (and here presented) a tool allowing teachers to build collaborative learning processes. The key feature of the implemented tools 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 in the workspace, in any position, the specific didactic activities.

In order to validate both the approach and the developed prototype, we experimented the latter inside Mathematics Courses at the Faculty of Engineering of the University of Salerno. From interviews conducted with teachers, our tool resulted to be easy to use, without any specific competency, to quickly build learning resources. Learners as well found the learning processes made with our tool particularly engaging.

These first results encourage us to continue the work, to improve the methodology and the prototype, fully integrating it in the referenced IWT platform.

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