Interoperability and Reusability of Knowledge in a Constructivist Web-Based Learning CSCL System

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Abstract

Computer Supported Collaborative Learning (CSCL) is an evolving field that emphasizes the collaborative aspects of learning by means of artifacts deployed over a group. CSCL targets the development of problem-solving skills by means of a collaborative process of knowledge construction. Unfortunately most recent e-Learning systems lack of the fundamental characteristics that guarantee knowledge sharing such as accessibility, interoperability, durability and reusability. In this paper, we propose the use of the Shareable Courseware Object Reference Model (SCORM) as the technological foundation for a CSCL environment based on the scientific method. The contribution of this work is on showing the design of a web-based learning system that promotes the use of the scientific method as a general methodology for problem-solving by helping the participants to find, import, share, reuse, and export learning content in a standardized way.

1. Introduction

CSCL is concerned with studying the development of cognitive skills in the context of a social activity. This emphasis on the social aspects of learning over the individual ones reveals a shift towards the use of the technological environments and the technological artifacts deployed on the Internet. In this way, despite their disperse locations, CSCL provides to the participants the means to study perhaps at home but conducting the learning experience in group.

CSCL deals with a combination of resources and interactivity that can be defined as an open environment of distributed learning by using the Technologies of Information and Communication (TIC) and pedagogical methodologies to develop and to improve new strategies for constructing knowledge through significant social interactions.

Two characteristics distinguish CSCL systems at the moment: (1) priming knowledge generation over knowledge reuse; and (2) excluding interoperability among heterogeneous systems.

According to (1), recent CSCL system prototypes have helped to develop competence in problem solving skills by constructivist learning. Constructivist learning involves students in the active exchange of ideas rather than the passive acquisition of factual knowledge, while promoting, at the same time, their cognitive development by sharing goals and discussing the different perspectives to attain them. In the absence of feedback, students tend to reason at more personal level, developing attitudes that prevent the discovery and sharing of knowledge. Unfortunately, constructivist models have stressed considerable emphasis in the phase of experimentation for the generation of knowledge, but they do not encourage the practice of reusing knowledge generated outside the group.

According to (2), at the moment so many Learning Management System (LMS) exists in the market from different providers. For that reason, a search for interoperability standard among several heterogeneous LMS products becomes necessary for different systems and courses in order to integrate educational materials from any provider.

E-learning standards are the means through which it will be possible to provide some flexibility to the e-learning solutions, both in content and in infrastructure. They have opened a door towards a more coherent way to pack the resources and contents, for both students and developers. This convergence of e-learning technologies is very important for a learning community, because the products that adhere to these standards will not be obsolete in the short term, protecting better the investment of work and time.

The rest of the document is structured as follows. Section 2 describes the evolution of the e-learning system. Section 3 describes the currents standards for e-learning technology. Section 4 describes the use of
Learning Objects (LO) to reuse of knowledge as software artifacts in a constructivist learning environment. Section 5 explains the ECCLWeb system that use LO as a means to achieve interoperability and reuse of knowledge. Section 6 describes the related works that have been developed in this research area, and Section 7 provides some concluding remarks.

2. Evolution of the e-learning system

Advances in Web-based technologies have redefined the boundaries of e-learning by stretching its scope and deepening its interconnections. New learning interactions that were not perceived possible before can now be facilitated such as gathering experts from around the world to meet interested people, providing access to global resources, and the ability to compare and exchange information to construct knowledge.

The development of e-learning systems can be established in a process comprising four stages: (1) the use of Internet and the WWW, (2) the development of LMS, (3) the implementation of open systems, and (4) the fulfillment of interoperability and reusability of knowledge in e-learning systems.

2.1 Internet and the World Wide Web

The World Wide Web (WWW) is one of the most accessible tools for academic use. The WWW can be viewed as one enormous resource that is interlinked, and offers various opportunities for academics who wishes to contribute with and to retrieve pedagogical material. The insertion of the WWW, as a means of distribution of content and communication channel, has been widely accepted to impart courses. The educational materials become semantically rich by integrating interactive tools, external references of interest, news groups, etc. Generally, a Web site grouped all the digital material developed in a course. Publication of course material has been one of the most successful practices by their acknowledgeable results. Nevertheless, in the decentralized administration of all the resources, their management was troublesome and required many working hours for the instructor. In order to mitigate those difficulties the so-called Learning Management System were developed.

2.2 Learning Management System

The Learning Management System is a software application or Web-based technology used to plan, implement, and assess a specific learning process. Typically, a LMS provides an instructor with a way to create and deliver content, track student participation, and assess student performance.

The valuable contribution of a LMS is its cost effective management. An LMS can typically make the following actions: register and schedule learners into online and offline courses, keep learner profile data, launch e-learning courses, track learner progress through courses, manage classroom based learning, support learner collaboration, automate use of competency maps to define career aptitudes, create questionnaires and administrate tests.

Two examples of well-known commercial LMS systems are WebCT [17] and Blackboard [2]. WebCT is the world’s leading provider of e-learning systems for higher education institutions and provides a highly flexible e-learning environment. Apart from them, there is also a large number of other commercial systems and academic systems that institutions have created to meet their own needs.

2.3 Open Learning Systems

Commercial LMS systems offer a desirable set of characteristics that not always are used by learners and instructors. Learning Open Systems make possible counting on software that, besides to offer certain functionality, easily allows adapting it according to the taxonomy of desirable characteristics in courseware and our necessities.

Example of well-known open learning system is Moodle [13], which is a course management system (CMS) a free Open Source package, designed using sound pedagogical principles, to help educators create effective online learning communities.

2.4 Interoperability and reusability of knowledge

The present stage is characterized by the noticeable interest in reusing the educational materials and the knowledge generated in any e-learning system. This interoperability entails to use the SCORM model. This model is a collection of standards and specifications for web-based e-learning. It defines how content may be packaged into a transferable ZIP file. The Reload Editor tool [16] is used to build the learning object.

3. Standards for e-learning technologies

In the present, solutions of e-learning the contents prepared for a system cannot be transferred in a simple form from one to another. The standards allow creating more powerful technologies of learning.
The desirable characteristics that define the standard in the area of e-learning are the following ones: a) Durability: that the technology developed with the standard avoids the obsolescence of the educational resources; b) Interoperability: that the information can be interchanged through a wide variety of LMS; c) Accessibility: that allow to monitoring of the behavior of the students; and d) Reusability: that the different educational resources and learning objects can be reused with different tools in different platforms.

Nowadays does not exist an e-learning standard available, what exists is a series of groups and organizations which develop specifications. Within the main initiatives of e-learning standard we can mention: AICC, LTSC, IMS and ADL.

3.1 Aviation Industry CBT Committee (AICC)

The Aviation Industry CBT (Computer-Based Training) Committee is an international association that develops guidelines for aviation industry in the development, delivery, and evaluation of Computer Based Training and related training technologies. It was the first organism to create a set of norms that allowed the interchange of courses between different systems. The AICC specifications cover nine main areas [1]. The referring publications of AICC to the specifications are denominate AICC Guidelines and Recommendations.

3.2 IEEE Learning Technologies Standards Committee (LTSC)

The IEEE Learning Technologies Standards Committee is in charge to prepare technical norms, practical and guides recommended for the computer science use of components and systems of education and of formation, in particular, the components of software, the tools, the technologies and the methods of design that facilitate their development, unfold, maintenance and interoperability [9]. What they was to gather the work of the AICC committee and to improve it, creating the metadata notion.

3.3 IMS Global Learning Consortium

The IMS is a partnership that groups producers, software designer and consumers of e-learning [10]. Specifications IMS cover an ample rank with characteristics that are tried to make interoperable between platforms that go from the metadata, the interoperability to interchange the instructional design between platforms. The IMS gathers the work of the IEEE. Its objective is the creation of specifications that include the recommendations of the own IEEE and the AICC.

3.4 Advanced Distributed Learning (ADL)

Advanced Distributed Learning (ADL) gathered best of the previous initiatives and refunded and improved creating its own specification Shareable Courseware Object Reference Model (SCORM).

SCORM is a collection of standards and specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content. The SCORM Document Suite is a ZIP file that contains all SCORM components and describes components used in a learning experience, how to package those components for exchange from system to system, how to describe those components to enable search and discovery, and how to define sequencing rules for the components. SCORM sets out detailed criteria for learning platforms as well as for learning objects.

4. Learning Objects in a constructivist learning environment

Constructivist is an educational perspective that encompasses a wide variety of views, theories and instructional models [3], [4], [5], [11]. These views seem to converge on at least two principles: (1) that learning is an active process of constructing rather than acquiring knowledge and (2) that instruction is a process of constructing rather than communicating knowledge. Learning Objects system present yet another technology based on an instructional delivery environment with exciting features and attributes that can empower learner-driven experiences and promote cognitive processing.

The convenience of reusing knowledge and educational resources independently from diverse learning environments has lead to the use of Learning Objects (LO). LO are platform independent units of instruction that can be reused in multiple contexts [18]. LO are generally understood to be digital entities deliverables over the Internet, meaning that any number of people can access and use them simultaneously [7]. The use of LO have great advantage, since it avoids reinventing solutions made before, allows to increase the reach and the benefits of each new solution, allows to construct materials of high quality with less efforts. The great versatility of the elaborated educative contents from LO favors the application of the constructivist theory to the design of instruction.
The figure 1 illustrates the approach for discovery (search) and dissemination (publication) of knowledge as LO in adaptive learning courses. This search mechanism can be explored from different Learning Objects Repositories and be shown according to the student needs.

![Diagram: Adaptive Presentation of Contents Using Learning Objects]

Figure 1: Adaptive Presentation of Contents Using Learning Objects

The description of each LO has associated nine main categories metadata: General, Life Cycle, Metadata, Technical, Educational, Right, Relation, Annotation and Classification [6]. A metadata describes as it is the content of an educational object and identifies its more important characteristics, like for example: title, author, description, version and state.

5. ECCLWeb: a web-based framework for a course of logic circuits

We are developing the ECCLWeb system (from the Spanish Eseñanza Constructivista de Circuitos Lógicos en la Web, Constructivist Approach to Education in Logic Circuits). ECCLWeb is as scaffolding that provides facilities to produce and conduct a course of Logic Circuit Design [15] and implements the educational model based on the scientific method from a constructivist point of view and contributes in the CSCL field by enforcing in the students the practice of the scientific method in most of the academic activities.

The scientific method consists of:

1. Formalizing the statement of the problem.
2. Searching for any related material – Learning Objects (previous known solutions, discussions about the different aspects of the problem, computational artifacts like simulators) in the ontology of terms and concepts called the knowledge repository. If any solution to the problem or part of the problem is found, collect all resources published.

3. Forming a hypothesis. It involves the elaboration of a theory (computational model) that explains the logical relationships among the elements introduced by the problem in terms of the collected resources borrowed from the knowledge repository.
4. Planning the experiments. It means, from our point of view, to conceive the solution of the problem. Dealing with a complex problem generally implies its decomposition into smaller ones. Solving the problem demands a collaborative effort of groups to coordinate the reconstruction of the solution from the solutions found of smaller problems.
5. Performing the experiments. It involves the construction of the proposed solution of the problem that may evolve from a prototype to a solution with varying degrees of sophistication.
6. Analyzing experimental data. By contrasting the experimental results against those predicted by the theory, the student (or group of students) may provide some evidences about the validity of the hypothesis.
7. Interpreting results and drawing conclusions. The analysis of the evidences may either confirm or not the working hypothesis. If the evidences are not conclusive, new hypothesis or experiments can be proposed.
8. Communicating results. Dissemination of the knowledge (as Learning Objects) acquired from this process is submitted for its publication in the knowledge repository after a reviewing process.

Under this conception, our model enables the student to discover, analyze and experiment with the resources obtained from the knowledge repository utilizing the built-in components provided by ECCLWeb. Then, by actively pursuing the solution of the problem, the student may suggest, develop and validate the solution found. Finally, the student disseminates all the resources that implement the solution.

5.1 Study Case: Design of a Full Adder

The course is structured 5 topics: Logics Gates, Combinational Circuits, Sequential Circuits, Registers, Memory and Logical Design of Processors, and each one is divided in Subjects; each subject is boarded in different Sessions. The Figure 2 shows to the interface of presentation with the subjects of the course and the methodological orientation that must be followed.
In order to illustrate the operation of the scientific method, we will exemplify it with the session dedicated to 'Full Adder Design', belonging to topic 2: Combinational Circuits. The session begins with the exposition of the problem that is desired to solve, and the student must follow the following procedure to compliment the method:

a) Discuss the problem in the group. In order to guarantee that the student understands the problem, it is asked to respond some initial questions, for example to determine the number of variables to represent the inputs and outputs for represent this circuit. The student helping of the communication tool can communicate with the professor and the students can ask and consult. Typical examples of questions are the following: there exist some component in the base knowledge that makes this function?, how they interconnect to each other?, how to validate this design?. Once clarify the problem one goes to the following stage.

b) Examine the previous solutions: Fundamental element of the constructivist process of our model is to motivate to the student to analyze all the previous solutions and make a process of "discovery" of the previous experiences in that respect. For this end, the system provides a search tool that allows describing the component based on the functionality of the circuit that is desired, the amount of inputs and outputs, as well as of the type of learning object that the student wishes to examine: text, diagram, simulation, etc. Figure 3 illustrates the use of the search tool.

c) Experiment with new solutions: It is fundamental part of the process, with the data obtained previously. The student can design a circuit and experiment with it as a solution to the problem. Figure 4 shows to the use of the tool for edition / simulation of circuits.

d) Validate solutions: Once finalized the design phase, the student ask for an evaluation of the solution to the professor. If the solution is not correct, the student must return to the phase of experimentation.

e) Publish solutions: When the student makes a novel or interesting solution, the professor authorizes its publication. For it, the student uses the authoring LO tool and specifying the parameters necessary to make public this new knowledge in the form of LO.

6. Related Work

The main efforts in the area of e-learning since their rise have been directed to development environments teaching – learning. Among the several reported systems we can mention the following ones:

Kurhila proposes alternatives to support communities of learning on line. EDUCOSM system [12] has been used as platforms for several courses and offer tools for the construction of the knowledge by means of annotations and commentaries for all the other users. The constructivism is seen here like the replacement of the transmission of the knowledge by the construction of the knowledge.

Gallardo proposes a prototype for the virtual learning of the course Operating System framed in the significant and constructivist learning that it orients to the student towards the independent learning, offering him to new forms of learning and the development of competitions doing use of the TIC [8].

Zhuge reports the implementation of tools and the prototype of courses for the support of constructivist learning [19]. For this author the constructivist learning is an educational variant centered in the student, who
motivates to the student by means of the rating of processes of interactive learning, investigative and active. The system proposes the incorporation of intelligent agents and a highly interactive hypermedia.

Mor describes the design of WebReport system, which supports collaborative work based on network oriented to find new ways to represent and to express mathematical and scientific knowledge in learning communities [14].

All there implemented approaches constructivist in the education tools - learning insists on the part of generation of new competitions, nevertheless they do not guarantee that the search of information and the reusability are made of suitable form.

At the moment the open systems, for example Moodle [13], supports the use of for the design of the courses and the used educative materials, but it lacks a mechanism to generate a constructivist environment of the learning. In our system the constructivism is seen as the combination of generation, publication and reusability of the new knowledge as LO.

7. Conclusions

In this paper we analyzed of the main standards that are emerging in the scope of e-learning and we illustrate how the ECCLWeb system that support the reusability of knowledge in a constructivist environment of education using Learning Objects from SCORM model.

The SCORM model defines the specification to bring together diverse and disparate learning content and products to ensure reusability, accessibility, durability and interpretability for e-learning systems.

The ECCLWeb system integrates automated tools cradles in services that make flexible the actions and allow the reusability of the generated knowledge as Learning Objects from SCORM model in a constructivist learning environment.

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9. References


[16] Reload Web site: http://www.reload.ac.uk/

