Inquiring the Course Paradigm with CALM

Christian M. Adriano[1], Armando L. N. Delgado[2], Luiz G. Silveira Jr.[3], Raquel C. Bosnardo[4], Ivan L. M. Ricarte, Léo Pini Magalhães

***Abstract* — The configuration of theoretical courses complemented by "hands on" laboratories has been shown effective to internalize theory, give concrete context and enhance skills. However, learning the "hands on" tools dispenses usually unaffordable time; that is particularly true for computer programming, since the amount of programming language taught during theory does not suffice to the lab practice. To lessen such problem by supporting extra-course apprenticeship, a collaborative learning system was discussed and developed. CALM–Computer Aided Learning Material is the resulting proposal with an underlying philosophy of complementing the traditional course paradigm with a goal directed learning strategy.**

***Index Terms* — Lab Support, Goal Based Scenario, Computer Supported Collaborative Learning, Recommender Systems.**

I. Introduction

Student learning from computer laboratories can be very unsatisfactory, specially when: Theory is not used as basis of practice, application of important concepts is blurred by unaffordable implementation details, and tasks become jammed, because proper skills could not be adequately developed. A usual strategy to solve the problem is to precede lab-only courses by theory-only courses. This solution addresses partially the first problem, the latter two still persist due to the lack of specific and complementary skills necessary to master the a lab activity. Such skills relate frequently to the programming language, simulator tool, or hardware manipulation. In the respective theoretical course, practical knowledge is used only to illustrate some topics; therefore deep understanding on them is not acquired and skills are not practiced. By the time of lab practice, the lack of deep understanding and skill reduce the possibility to carry on more complex projects, since the student must spend appreciable time in the first activities being aware of the "hands on" tools.

In addition to realizing these difficulties, a discussion [1] about Goal Based Scenarios (GBS) versus course approach was followed. According to Schank [2], the GBS model aims to provide a simulated role for a student and then, by performing a task, this individual applies concepts and acquires, as a byproduct, the intended skills. This idea fetches well with the lab practice time, when students are mostly performing as scientists or as junior professionals of their own areas.

1. Supported by FAPESP; 2. On leave from UFPR, supported by CAPES/PICDT; 3. Supported by CAPES; 4. On leave from IAC
F. A. Christian M. Adriano, FEEC Unicamp, medeiros@dca.fee.unicamp.br; S. A. Ivan L. M Ricarte, FEEC Unicamp, tel. +55-19 778-3771, fax. +55-19 289-1395, ricarte@dca.fee.unicamp.br.

Thus, an envisaged solution was that, "A computer supported extra-course material that could recommend lessons regarding student's defined learning goals". The aimed extra-course material could not be, for example, a course on programming language. The student will be already engaged in a course, so such an approach creates a parallel strategy, disconnecting again theory from practice. Another point is that the needs of students in a lab activity cannot be generalized as being the same as in theory. Objectives are different. In theory the goal is abstraction and generalization, while lab practice aims to illustrate a nuance of theory and, furthermore, to develop skills. According to these opposite goals, nevertheless complementary, a single strategy – e.g. a course in programming language will not fit properly both theory and practice needs.

Moreover, learning needs in lab seem to be more punctual and vary a lot from one student to another. This happens specially when students are left developing different projects and, by revising each other work, are motivated to collaborate, as in the Software Design Studio [3]. According to these motivations, a computer supported extra-course material with some adaptability to student's individual learning goals configured itself as being a reasonable hypothesis of solution.

The choice was to discuss and develop CALM - Computer Aided Learning Material, which is inspired in a GBS approach, focus in lab practice problems and supports three actors: student, teacher, and author.

Therefore, CALM in its essence:

(i) Recommends lessons regarding a student's learning objective and profile;

(ii) Supports interaction among actors and a learning material.

CALM can be viewed as a kind of recommender system [4]. Recommender systems work on sets of texts to assist and augment the social process of recommendation. In such processes a set of recommendations on a given subject (e.g., URL's in a newsgroup) is aggregated and delivered to an appropriated destination (a person or a repository). The main characteristic of these systems is the ability to choose and to classify recommendations from input, based on weighted voting and combined with content analysis.

The difference between CALM and traditional recommender systems is that the latter work on sets of texts, while CALM, due to its specific educational purpose, regards to student's already done subjects, learning materials available, and the aimed subjects to be learned. CALM recommendation is a composition comprising the desired subjects, and additionally a set of recommended subjects that are supposed to be known. Recommendations can be enforced or not by the system.

Some collaboration and communication mechanisms, as adopted in WebCT [5] and AulaNet [6], were also desired. WebCT mechanisms are well suited for CALM, but a better support for document sharing and annotating, especially in the case of authoring, were aimed. BSCW [7,8] is an example of these collaborative intended features in a Web-based environment. Even though being a general-purpose approach, BSCW has complementary solutions to the use of chat, newsgroups or discussion lists, which would be valuable within a learning environment.

Having these previous solutions as an inspiration, CALM contribution comes in four aspects. First, it provides a solution for a real problem faced by students in computer lab courses. Second, CALM system is a concrete object to discuss how adequate is the course paradigm and the GBS approach, mainly when dealing with lab learning practice. Third, the actor role oriented interface, based on a browser paradigm, suggests that novel tasks should be added to common navigation commands. Fourth, CALM suggests the adoption of a framework to share educational software components among developers.

The development of CALM is in the context of an ampler project, SAPIENS [9], that is composed by an heterogeneous group of researchers and whose objectives are to discuss, develop and test educational technology.

Section 2 explains the CALM model. Section 3 describes the architecture. Section 4 exposes a scenario of practical use in an MC68000 assembly-programming lab. The conclusion enrolls experiences and the future work.

II. The CALM Model

Some of the concepts used in CALM were brought from the IEEE Learning Technology Standard Committee (LTSC) drafts [10], which will be used to explain important concepts used in CALM

CALM: It is in general lines what LTSC defines as CMI (Computer Managed Instruction): “The use of computer to register students, schedule learning resources, control and guide the learning process, and analyses and report student performance”. CMI will be used interchanged with CALM.

Topic: It approximates to the LTSC "Assignable Unit" concept: "The smallest element of a course that can be assigned by a CMI system to a student. One or more assignable units form a lesson". For lesson in CALM see Study Unit.

Test: Same as stated by LTSC: "In a learner assessment, a tool or technique intended to measure a learner's performance, knowledge skills". In CALM, Tests are used to self-evaluation and are made of objective question.

Exercise: It is a task related to a set of Topics. It has the purpose of connecting different Topics, what makes Exercises more complex and subjective tasks than Tests.

Material: It is an oriented graph of topics with some positions marked to suggest exercises.

Subject: It is an author-defined theme for a Topic, a Test, an Exercise or a Material.

Content: It is a file with some kind of media (text, sound, video or image) to compose a Test, a Topic, or an Exercise.

Catalog: A unique identifier. It has as a title, a retrievable key, version, author's name and a related Subject.

Learning Objective: The same concept stated by LTSC: "Is a description of a goal of training or learning in terms of knowledge, skills, or performance. Learning objectives may be associated with instructional units of any size." In CALM, a learning objective is actually a set of Subjects of interest defined by the Student.

Study Unit: Equivalent to the "Lesson" concept stated by LTSC: "A unit of instruction that includes learning content and associated learning objectives, and which may contain a student assessment part. It is intended to be mastered in a continuous effort." In CALM a Study Unit is effectively a composition of one or more Topics, Tests and Exercises.

Recommended Topic: It is a topic with some knowledge that is required to accomplish another topic.

Profile: Equivalent to "Performance Information" concept of LTSC: "Data describing results of mastering a learning content by some learner ". In CALM it is actually a record with all student's grades in tests. The concept "Learning History", also defined by LTSC, is not adequate for CALM, because it is based in the course paradigm of students being enrolled in an institution. This is not true for CALM.

Tutor: It is a software agent responsible to compose a Study Unit. The Tutor composes a Study Unit taking into account the student's Profile, the current Learning Objective and the available Materials.

Annotation: It is a content appended to a document, it has a defined frontier, it can be detached from the underlying document and is result of some cognitive effort.

Suggestion: It is an annotation made by an Author or Teacher providing additional explanations and references.

Doubt: It is an annotation used to raise a question.

Student: Same as "Learner" stated by LTSC: "An individual engaged in acquiring knowledge or skills with a learning technology system." The LTSC concept of Student is not used because for CALM information about enrollments does not matter. Student for LTSC: "A learner enrolled in a course of study in an institutional setting."

Teacher: It is responsible to adapt a Material set to a group of Students, to answer Doubts, organize the Frequent Asked Questions (FAQ), correct Exercises and place Suggestions on Topics' pages.

Author: It is responsible to create and update several instances of a Material. Authors can also make suggestions.

III. The CALM Architecture

The CALM system architecture has three parts (Fig. 1): Server side, actors’ interfaces and communication medium.

The server side manages persistent data storage and access. Actors’ interfaces implement a browser paradigm, in which each actor has a proper tool bar. The interfaces run as local applications, while the server is a remote application at a WWW server machine. The actor interface defines the access permission, because the server has no access-control schema wired to the persistent objects. This was a decision of not "hard wiring" CALM to a specific set of actors and objects. It helps enhancing and adapting the model to other similar contexts. The communication medium is the Internet, which more than providing CALM with de facto standard technology, fosters access to other educational worthy resources.

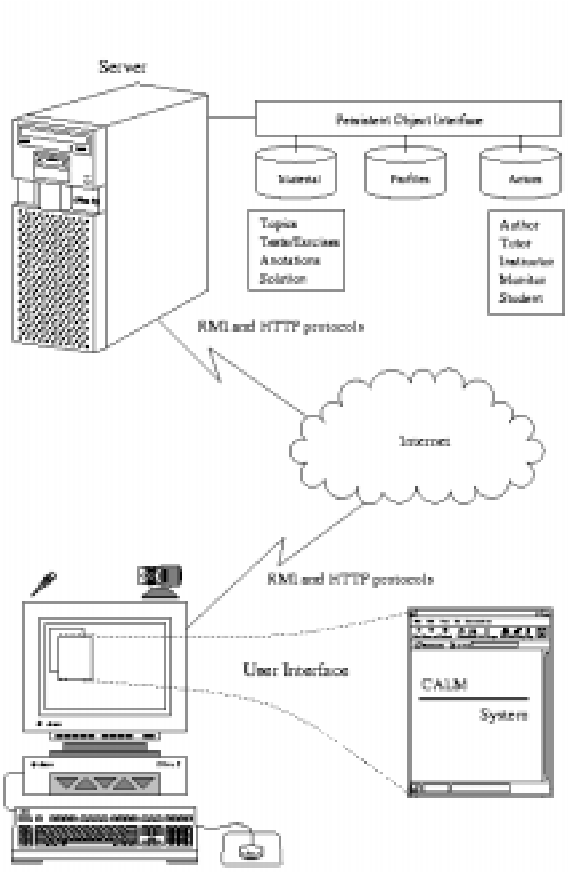

Fig. 1 CALM Architecture

A connection of a few public software components implements the CALM system architecture (see [11] for downloading these components). The development technology was compliant with World Wide Web (WWW): Hypertext Markup Language (HTML) documents, Java™ applications and applets, and the JavaBeans™ [12] framework. The main conveying decisions were two. First, to provide a common and standard material access to students and teachers. Second, by strictly use of WWW technology, to adopt a framework over that would be easy to add resources.

IV. A Scenario of Use

CALM supports a goal directed strategy by a mechanism of selecting subjects to learn. This kind of support approximates better to a learning through scenarios approach, which is expected to be as close as possible to multidisciplinary real problems. Such diversity of subjects is exactly the case in which a course material is not well suited for.

Furthermore, since subjects in CALM can relate to entire materials as well to a few topics in different sets, the Learning Objective strategy holds a reasonable flexibility about how deep is the desired knowledge to be acquired. It would be of little use to suggest whole materials, when student's goal can be satisfied by a short sequence of topics.

According to the Learning Objective orientation, here is explained a scenario of use within a MC68000 assembly programming lab. To complement this course with CALM, a proper material was specially designed. This material has the following topics: Assembly Fundamentals, MC68000 Registers, Addressing Modes in MC68000, Stack Resource, Conditional Branch, Unconditional Branch, Test and Decrement Branch. Each topic has a main subject and several related subjects; for example, the subject "Loop in Assembly" is the main subject for the topic "Test and Decrement Branch", while its related subject is "Branches".

The first step a student takes is to logon. After successful logon, a systems home page is automatically generated for the student. This page displays the current learning objectives, links to already done topics, student's workbook and FAQ lists ordered by subject. The workbook is an arrangement of personal annotations.

The second step is to set a learning objective. Suppose a student wants to learn how to program a loop. This student should press the button "Learning Objective" and then choose, among the available subjects, those that best fit his/hers needs (Fig. 2). According to the generality of the choice, the suggestion may relate to a material or to topics inside different materials.

Fig. 2 Defining a Subject as a Learning Objective

As the student selects the subjects "Loop in Assembly" and "Branches", the CALM Tutor is requested to suggest topics or materials related to these subjects. In the current scenario the Tutor recommends the topics: Conditional Branch, Unconditional Branch, Test and Decrement Branch (Fig. 3). The student may request a summary of each topic to better decide. Repetition of topics in the list would mean that a topic appears in more than one Material, what actually gives different contexts to a same Topic. The expression context is very meaningful, because the Material concept is completely transparent to students. They recognize only a sequence of topics following one or more graphs (actually Materials).

Fig. 3 Defining a Topic as a Learning Objective

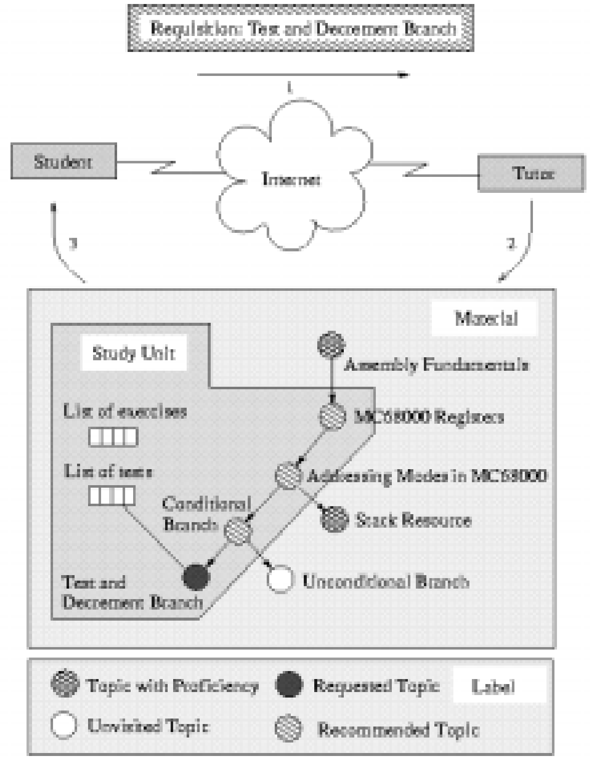

Fig. 4 Study Unit

As the student chooses the topic "Test and Decrement Branch", a learning objective is set. The student can keep elaborating and setting different learning objectives, what enables a student to be engaged in several learning objectives. However, only one Learning Objective could be performed at once.

The next step is to request a Study Unit that is done by pressing the button "Study Unit". After it, the student will receive a list of learning objectives (actually names of topics) and will be asked to choose one among them. Then, the Tutor will be requested to compose a Study Unit of it. The Study Unit provided has a Topic, a Test, an Exercise, and a list of Recommended Topics (Fig. 4).

As the Study Unit arrives, the tool bar provides new request buttons to make a Test or an Exercise and to request Study Units on the recommended topics (Fig. 5).

Interaction with the Study Unit happens by raising doubts, answering tests and exercises, and taking notes (Fig. 5). The button for taking notes is located among the navigation buttons. This design decision follows the hypothesis that, "User centered and specific purpose applications are desired in response to particularities that could not be full filled by off-the-shelf solutions. Therefore, a browser tool committed to a learning process must provide complementary resources to standard ones. According to it, a common resource of navigating, when speciallized to learning contents, involves novel implicit tasks, as for example the practice of taking notes while browsing." Due to the stated hypothesis, the first resource provided was the annotation capability.

Annotations in CALM are made persistent and left available by author and teacher for the students. Using the annotations collaboratively, author and teacher can provide suggestions to the students. To finish a Study Unit, the accompanied Test can be fullfilled correctly or skipped.

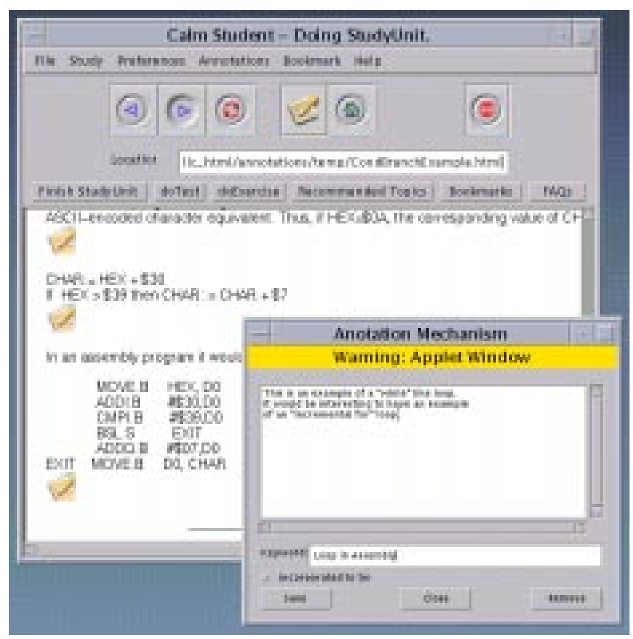

Fig. 5 Interaction through Annotations

V. Conclusion and Future Work

Since discussions over computer aided learning tools are mostly centered in distance learning issues, there is a gap in the context of lab courses. CALM model and assumptions have been used as a concrete object for discussions held by the SAPIENS project.

The absence of a decision for a common framework is a difficulty in the current educational technology development. Most solutions of reusable software are in the direction of producing applets. Complex and open educational systems can not be build only with applets; therefore, the exchange of software components following a common framework is paramount.

Several deficiencies could not be overcome yet. Students in lab courses are enrolled in collaborative activities, but collaboration in recommender like systems does not seem trivial. Students do not necessarily pursue the same objectives in CALM. Another deficiency is the author/teacher interface. Both roles share the same interface. It happens due to an unclear definition for the Teacher role in CALM.

Thus, some questions remain: Which are the educational issues involved in providing collaboration in recommender systems like CALM? Which collaboration opportunities should be fostered? What would be the Teacher's role in such system that an Author could not perform?

The next steps will be to improve the annotation mechanism in the following directions: types of notes (doubts, author notes, etc), other media than text (mainly voice and video), means to exchange and browse repositories of annotations.

Changes in the mechanism that decides whether a student is able or not to get to the next Study Unit are on the move. Currently, the mechanism uses an author-defined grade as the cutting edge between topics. The idea is to change this grade to a fuzzy like cutting edge.

CALM is to be probed by a group of students in a Java™ programming course and also by a group of pedagogy students at the Unicamp Institute of Education.

References

[1] R. C. Schank, "Horses for Courses", Communications of the ACM, vol. 41(7) pp. 23-25, July 1998.

[2] R. C. Schank, A. Fano, B. L. Bell, M. Y. Jonea, "The Design of Goal Based Scenarios", The Journal of the Learning Sciences, vol. 3(4), pp.305-345, 1993-94.

[3] S. Kuhn, "The Software Design Studio: An Exploration", IEEE Software March/April 1998, pp. 65-71.

[4] P. Resnick, and H. R. Varian: "Recommender Systems", Communications of ACM, vol. 40, no. 3, March 1997, pp. 56-58.

[5] M. W. Goldberg,: "Communication and Collaboration Tools in World Wide Web Course Tools (WebCT)", in Proceedings of the conference Enabling Network-Based Learning, May 28 - 30, 1997, Espoo, Finland. http://homebrew1.cs.ubc.ca/webct/papers/enable/paper.html

[6] Lab. of Software Engineering (PUC-RJ): "Projeto AulaNet: Ajudando Professores a Fazer seu Dever de Casa", in http://aulanet.les.inf.puc-rio.br/aulanet .

[7] R. Bentley et al.: "Basic Support for Cooperative Work on the World Wide Web", International Journal of Human Computer Studies: Special issue on Novel Applications of the WWW, Spring 1997. http://bscw.gmd.de/Papers/IJHCS/IJHCS.html

[8] Vliem, M.E.: "Using the Internet in University Education: the Application of BSCW within Student Projects", Internal report, Ergonomics Group, University of Twente, Enschede, 1997. http://bscw.gmd.de/Papers/Uni-Twente/BSCWEval.ps

[9] L. P. Magalhães, I. L. M. Ricarte, "SAPIENS Project", http://www.dca.fee.unicamp.br/projects/sapiens/

[10] Learning Technology Standards Committee Glossary Group, "Working Draft Glossary: v.1.0, v1.1, v2.0", http://grouper.ieee.org/groups/ltsc/gloforum/gloforum.htm

[11] CALM download page: http://www.dca.fee.unicamp.br/proj/sapiens/ calmDownload.html.

[12] http://java.sun.com/beans/index.html