The COLDEX Project and Virtual Harlem's Collaborative Learning Network

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Background

When I visited Chicago in the summer of 2001 to see Virtual Harlem, I discovered that the way in which Jim Sosnoski had structured the project bore a remarkable resemblance to the COLDEX project that we had developed in collaboration with our colleagues in Germany, Portugal, Spain and Chile. The compatibility of our projects has opened the door for collaboration between our two research groups. We planned a series of meetings during the coming year to consolidate our efforts. In this essay, I will briefly describe the COLDEX experiment, noting the features that it shares with Collaborative Learning Networks described by Jim Sosnoski elsewhere in this volume. Let me begin with a summary of the features the two projects share and then I will describe our understanding of them drawing upon our project proposal.

COLDEX, which stands for "COllaborative Learning and Distributed EXperimentation," is an EU (European Union) funded research project aimed at developing a variety of learning environments that takes advantage of recent learning theory and technological advances. It shares a number of features with the design of Collaborative Learning Networks used in the Virtual Harlem project, the most significant of which are:

1) The use of virtual environments as learning environments
2) The emphasis on collaboration
3) The restructuring of the student/teacher relationship
4) The prominence of modeling as a learning strategy
5) The prominence of visual thinking

6) The role of experimentation in the network
7) The self-reflexive component
8) The use of interactive media to enrich curricula
9) The incorporation of multiple-perspectives on the subject matter being studied
10) The global perspective on learning
11) The importance of developing new approaches for learning about complex systems
12) The importance of "reflection on action"

The Virtual Harlem project, developed completely independently of our research, confirms our view of learning. It hardly seems accidental that two research groups on different continents and not in communication with each other should apply similar approaches for the design of learning environments. It is all the more remarkable since our emphasis is on scientific learning and theirs on humanistic learning. If you will forgive the proposal rhetoric, I would like to quote from the grant proposal we wrote for the COLDEX project, which will be inaugurated in March 2002. Except for the conclusion, the sections that follow are taken from our proposal.

Objectives of the COLDEX Project

This project aims at developing and using new IT (information technologies) approaches and computational tools to foster scientific experimentation, modeling, and simulation in distributed and collaborative settings in an inter-cultural community of learners. Our efforts will result in the creation of innovative pedagogical scenarios to address these issues. There is a common denominator for the learning content to be addressed: the study of visual and other perceptual phenomena from both a scientific and an experiential perspective, i.e. by combining scientific and engineering methods with the subjective inter-personal communication of phenomena in the learning community. Examples of the experiential phenomena to be studied are:

Astronomy (remote access to observatories)
Seismic phenomena (provision of continuous data of seismic activities in an "active region," e.g. Chile)
(Inter-)acting and navigating with limited perception in everyday scenarios (e.g. a blind person using the metro)
Reactions of plants, animals and humans to environ mental conditions (e.g. seasonal changes of climate, biodiversity)
Optical phenomena in mechanical engineering and chemistry (e.g. photo-elasticity)

The scientific and engineering approaches used to discover and explore these phenomena will consider the following aspects:

A) Generation and provision of source data: Here, a small number of remote sites will be established which generate data. Among these will be an observatory with a high quality telescope and a seismic measurement station in Chile. Technological challenges lie in the ease of use in accessing these data and in communicating the learners' requests and specifications to the remote sites. The stress is put on re-usable components and protocols which are not only tailored to the specific case.

B) Construction of realities: The "construction of realities" includes the setting of (real) experiments, the provision of 3D virtual scenarios, artifacts that support other types of perceptual experience (e.g., tactile experience). An important point here is the use of "mixed reality" technologies that allow for a smooth transition between the physical and the digital worlds.

C) Concrete modeling & design: The notion of concrete modeling and design refers to the use of concrete representations to model and simulate the phenomena to be studied. These range from 3D models, which include sound and tactile I/O to physical models with IT components (e.g. Lego Mindstorms). Here, we do not expect to invent new technologies but to adopt existing state-of-the-art techniques to educational needs.

D) Abstract and conceptual modeling: The question is to bring "paper work" (formulae, diagrams, sketches) used to analyze and describe the phenomena into the digital information cycle. This will be achieved through a combination of visual concept mapping tools with more formal representations such as "system dynamics" or other mathematical and computational formalisms.

Beyond the science and engineering methodologies, we want to stress the formation of learning communities on different levels. Based on the known difficulties encountered with "virtual learning" approaches (Fischer,1999), we will start with local communities which share a rich everyday context as, for example, in a school class or in a study group of academic students. The target groups will range from higher secondary education to academic beginners. A rich potential of human resources will be taken into account (teachers, tutors, peer interaction).

Collaboration and networked interaction will arise from these basic groups, using both synchronous and asynchronous collaboration techniques. Yet, we do not simply intend to add both techniques but we see them related in a specific way: Synchronous collaboration tools (which may not only be used in remote scenarios but also in face-to-face group work!) should contribute to forming a "group memory" which must also be available in asynchronous mode. Conversely, the use of archives and repositories should also be tightly integrated with synchronous activities. We still see technical challenges in integrating these two learning modes under the notion of easy re-use and formation of group memories.

Only on a second level, basic learning communities will exchange their ideas, results and problems in an international network. We expect teachers to take an active role in creating, filling with content, and structuring this network. The specialty of COLDEX, on this level, lies in its origination from a European-Latin American cooperation incentive (Eurolat-IS). COLDEX is in this sense trans-continental: Whereas science and engineering are typically seen as "neutral" to different cultural and geographic backgrounds (which might also be questioned), this is certainly not the case for the experiential level. It is evident that, e.g., Swedish high school students would benefit from communicating with their South American counterparts to better understand the concrete meaning of seismic phenomena in everyday situations.

Innovations in the COLDEX Project

A variety of substantive issues confront educators with respect to supporting students learning increasingly complex knowledge. How can learners acquire and maintain deep understanding about difficult-to-understand subjects in science and engineering? How can scientific modeling and experimentation with complex phenomena be facilitated among learners? There is reason to believe that many of the core ideas associated with new ways of thinking about these complex topics may be challenging for students to learn. Considerable research has documented a variety of difficulties students have with learning concepts relevant to understanding complex systems that are currently taught in existing science courses (Kozma et al., 1990; Spector et al., 1999).

At the same time, current and emerging technological advances in information and communication technology (ICT) make it possible to develop interactive learning environments to support new ways of learning. Interactive learning environments (ILEs) play an increasing role in teaching and learning. In particular, those tools and methods that encourage and enhance discovery, creativity, thinking, and expression are very much needed (Shneiderman, 1999).

Over the past two decades, there has been a significant increase in our understanding of the developmental, cognitive, and social dimensions of learning. Emerging trends in education are increasingly moving towards learner-centered approaches. In these, learning becomes an active process of discovery and participation based on self-motivation rather than on more passive acquaintance of facts and rules (Sfard, 1998).

Recent social constructivist perspectives (Bransford, Brown, & Cocking, 1999; Jonassen & Land, 2000) regard knowledge as an emerging characteristic of activities taking place among individuals in specific contexts, to view learning as a developmental process occurring first in an interpersonal domain (i.e., socio-cognitive or between people) and later in an interpersonal domain (i.e., cognitively or within an individual), and to recognize that learning is a constructive activity that often requires active and substantial reorganization of existing conceptual structures. An increasing amount of research has been documenting how new constructivist models may be used to re-conceptualize curricula, teaching practices, and learning activities, and to effect significant and rich types of learning gains. Many new constructivist models of learning utilize new computational and communications technologies as part of learning environments in which students engage in challenging problem and project-centered learning activities(Cognition and Technology Group at Vanderbilt, 1997).

Furthermore, the notion of interactive tools for modeling and simulating is quickly gaining importance as a means to explore, comprehend, and communicate complex ideas (Turkle, 1997; Dowling, 1997). However, the extent to which it is helpful to attempt to use these interactive tools to model reality in too many aspects is less evident. While a number of features of the real world which are thought to be relevant to the learning process can be replicated to a certain extent by computer programs, others cannot, and indeed it may well be that maintaining a distinction between the real and the virtual is an important aspect of the transfer of learning from computer-based environments to the wider world. Frequently, the design of these “simulation-based” learning environments focuses exclusively on computers and the virtual environments they provide, excluding the physical environment. Moreover, few contemporary researchers or practitioners question the importance of interaction in computer-supported learning (Gavora & Hannafin, 1995). With the emergence of new technologies, and the continued refinements of existing technologies, design potential has expanded dramatically. What kinds of interactions should be cultivated, and for which types of learning tasks? How should differences in learning tasks influence the design of interaction strategies?

In this project we will focus our efforts on exploring the integration of physical and computational media for the design of interactive learning environments to support learning about complex scientific phenomena. This effort will involve the design of interactive learning environments to integrate systems supporting alternative ways of interaction with simulation and modeling tools:

A) with an emphasis upon support for shared interaction to mediate social aspects of learning, knowledge construction, reflection and design.

> These interaction paradigms integrate the use of computationally-augmented physical objects;
> B) to support and encourage face-to-face interaction among learners;
> C) with virtual objects - to provide computational support for the model underlying the simulation. Many models of learning and collaboration need to emphasize the creation of shared interaction, social structures, and cultural embeddings for meaningful learning.

In the next section, we describe a set of general design principles for creating learning environments and tools to help students understand scientific perspectives on complex phenomena.

Design Issues and Conceptual Framework

Researchers and designers need to identify frameworks for analyzing, designing, and implementing interactive learning environments that embody and align particular foundations, assumptions, and practices (Land & Hannafin, 1996). There is a need for learning activities that stimulate an interest for understanding complex phenomena, challenge current understandings, and facilitate experience sharing among learners. Instructional scientists and designers have not fully understood the socially situated learning perspective and its implications for human learning in and about complex domains. According to this, we lack a well-articulated design framework with sufficient detail to take us from a socially-situated, problem-based, collaborative learning perspective to the design of a particular learning environment for a particular subject domain.

In this research project we will investigate how best to design and support learning in and about complex phenomena. More specifically, we are proposing a general approach that might best be characterized as socially-situated, problem-oriented learning in authentic and collaborative settings. This design framework is based on an experiential, problem-based, and decision-based learning perspective. Figure 1 below illustrates the conceptual ideas of integrating all these approaches and their implication for design.

We suggest that the design of interactive environments for collaborative learning and distributed experimentation should be guided by:

> AUTHENTIC ACTIVITIES: presenting authentic tasks that conceptualize rather than abstract information and provide real-world, case-based contexts, rather than pre-determined instructional sequences. Learning activities must be anchored in real uses, or it is likely that the result will be knowledge that remains inert;
> CONSTRUCTION: learners should be constructing artifacts and sharing them with their community;

COLLABORATION: to support collaborative construction of knowledge through social negotiation, as opposed to competition among learners for recognition;
REFLECTION: fostering reflective practice;
SITUATING THE CONTEXT: enables context- and content-dependent knowledge construction; and,
MULTI-MODAL INTERACTION: providing multiple representations of reality to represent the natural complexity of the real world.

The different components of this design framework are rooted in situated cognition, which emphasizes the importance of situating thinking with complex contexts. Learners are expected to generate problems to be solved and then learn, develop, and apply relevant knowledge and skills through progressive problem generation, framing, and solving. The different learning activities that will be designed upon this framework require learners to identify research questions and variables, to set hypotheses, to build and construct experiments, to test results, to analyze observations, and then to refine hypotheses and casual variables accordingly. In the next section we present some examples of experiential phenomena to be studied during the project and the learning activities based upon

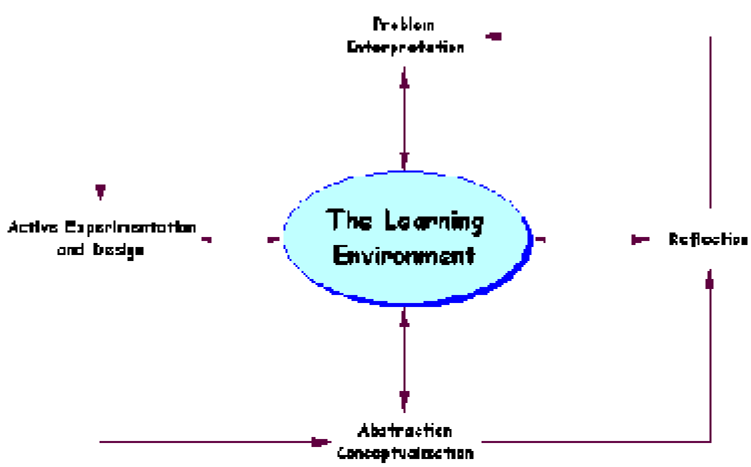

Figure 1: Design Framework

the ideas described in this framework.

Overcoming Existing Deficits in the State-of-Art

Many of the existing approaches to supporting learning in science and engineering by using information and communication technologies fall short in several respects:

> A) They generally do not take into consideration the global perspective of the phenomena being analysed. This means, these tools serve for an individual use or at most for a relatively small (culturally homogeneous) group.
>
> B) When applied to real educational situations, most efforts have been of short-term nature. This may be suitable for some domains (e.g. specific simulation experiments), but—to really contribute to the aim of supporting science education—a longer-term effort and more coverage of the curriculum is desirable.
>
> C) Many efforts claim to include virtual experimentation as the core of the student's activities. Usually, this excludes the "handcrafting" in the physical preparation of experiments on the part of the learner, which is one of the most important experiences students can get from laboratories. Realistically seen, curricula are typically organized in such ways that theory is not discovered in the laboratory but taught before. Thus, laboratory work can at best be about connecting theory to practice. Accepting these premises implies that hands-on experimentation should not be given up if it is easy to provide. We suggest concentrating on such virtual scenarios in which hands-on experience is not easily accessible.

To reach our goals, we will develop a framework consisting of systems and methodologies for enabling

> - students to carry out experiments on remote laboratories according to a defined workflow,
>
> - students to discuss and share results and subjective experiences aimed at fostering collaborative knowledge building,
>
> - teachers to easily integrate and make available new resources (which can be in particular real and/or virtual experiments, documentations to carry out the experiments, as well as multimedia material with relevant background information.)

The members of the project have considerable experience in developing and applying computer-based collaborative methods and educational environments. We do NOT conceive modern e-learning as the mere delivery of knowledge and the billing of knowledge downloads from learners (which could be described as the "e-commerce model of learning"). Although learning is ultimately an individual process, it can be enhanced, enriched, and better motivated by collaborative activities, especially if it brings learners with different cultural backgrounds together (Dillenbourg, 1999). The specialty of this project in CSCL (Computer Supported Collaborative Learning) terms is that it aims at developing methodologies to create and maintain large learner communities around complex experiential phenomena rather than focusing on small highly controlled laboratory situations.

The crucial factor that is responsible for the difficulties with building collaborative educational scenarios around computer-mediated communication is context. Computer-mediated communication can hardly capture the full variety of non-verbal signals and situational references. But this is not even the biggest problem: context stems from shared history, from shared external environments (e.g., on a campus), and from shared daily routines. All this is important in collaborative learning but hard to transmit through computer networks between humans who do not have regular face-to-face contact. So, when we say that the creation of global learning communities is a central issue for COLDEX, we have to consider the context problem. There are two consequences: (1) Build communities bottom-up, starting with local, usually face-to-face, communities such as school classes or study groups and let these establish contacts with other communities; (2) take subjective experience seriously (and not only scientific understanding). The problem of subjective experience and perception will be a subject of modeling and investigation in COLDEX.

Conclusions

I hope it is apparent from our description of the COLDEX project that its central features bear a strong resemblance to the central features of the Virtual Harlem project. In both cases, we develop a learning network through the use of computer-generated environments that enables learners to model what they are learning in collaboration with the other members of the network.

Based on the ideas presented in this chapter and those described by Jim Sosnoski elsewhere in this volume, we have gained critical insights into the design of interactive learning environments to support learning about complex domains. These aspects include:

> The importance of being able to represent multiple perspectives of a problem;
>
> The need to support learning as a shared, collaborative activity—particularly in the context of bridging those multiple perspectives;
>
> The need to support interaction, collaboration, and reflection both "around the virtual environment " as well as "beyond the virtual environment."

It is striking that, whereas our research team is concerned with science education, the Virtual Harlem group is concerned with humanistic education. It is even more striking that, in both cases, the groups stress the importance of combining the arts and the sciences. We firmly believe that the vision of collaborative learning in both our projects is what is called for as we enter the 21st century.

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Art and Drama in Virtual Harlem