Remembrance of Things Past: Using Maps and Routes to Navigate through Virtual Environment Experiences

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Abstract

Collaborative Virtual Environments (CVEs) show great promise in domains such as education. Instead of using 3D space to weakly imitate physical classrooms, educators can create 3D spaces that directly reflect subject matter, and allow students to interact with it. Using non-physical 3D spaces creates potential orientation and navigation problems, which are best solved by means of (a) familiar metaphors and (b) repeated, gradually expanding experiences within the virtual space.

This paper explores the use of maps and routes to navigate not the 3D virtual environment, but the records of users' previous experiences in the environment. Our premise is that textual content (whether lecture or lab material, or chat transcripts) can be more effectively navigated using appropriate temporal and subject-oriented aids, instead of relying on scrollbars or textual searches. We are exploring these concepts within the context of Unicron, a collaborative virtual environment for education.

1. Introduction

> *In modern Athens, the vehicles of mass transportation are called metaphorai. To go to work or come home, one takes a "metaphor" – a bus or a train. Stories could also take this noble name: every day, they traverse and organize places; they select and link them together; they make sentences and itineraries out of them. They are spatial trajectories.*
> *-De Certeau* [10, p. 115]

Collaborative Virtual Environments (CVEs) represent a unique environment for learning. In presenting students and instructors with a virtual environment in which data and users achieve a shared sense of understanding, CVEs show great promise in facilitating individual and collaborative learning methods. However, typically educational CVEs fall into the trap of trying to mimic real world conditions of learning. There are reasons to use familiar classroom settings to engage students in learning, but in doing so, CVEs risk replicating top-down instructor-student methods of learning that do not incorporate the unique communicative qualities of a CVE in supporting both individual and collaborative learning approaches.

Instead of mimicking real world classroom space, CVEs should provide a malleable, extensible space for instructors and students to carry on conversations of learning. Using the metaphors of maps and routes, this paper develops a framework in which individual and class learning can be tracked via the use of pedagogical maps and routes. The goal of using these metaphors is to facilitate student learning by offering them (a) familiar metaphors of space and (b) repeated, gradually expanding experiences within the space that reflect individual and collaborative learning efforts.

This paper is organized in the following manner: The first section discusses learning methods that are appropriate to virtual environments such as CVEs. This is followed by a section that discusses the distinction between space and place and how this pertains to a collaborative virtual learning environment. Then we present a design for a system that tracks collaborative and individual learning experiences in a CVE and give a scenario for its use. Finally, as the design of this system has not been implemented, we are exploring the benefits and drawbacks of the design. We are in the process of building this system for Unicron, a collaborative virtual environment being developed at New Mexico State University.

2. Learning Methods

Traditional approaches to learning envision the individual student as learning through repeated experiences with course material as related by an instructor. These approaches use a top-down pedagogical model in which instructors have the necessary knowledge and students must transfer that knowledge into their heads. However, with the advent of online learning through the Internet, much research has been done on how social constructivist forms of learning can be applied to online learning environments [1], [4], [20].

Social constructivism emphasizes learning methods that utilize instructor-students/ student-student collaboration and active problem-solving skills (cf. [19], [23], [13], [7], [16], [6]). Instead of assuming that learning is associated with the static transfer of knowledge content, collaborative learning is created through collaboration and consensus by a group of people working together to construct knowledge that sees the world "not as a static reality, but as a reality in process, in transformation" [13, p.64]. According to social constructivism, learning is achieved if a community of people uses shared activities, tools and artifacts in order to create a commonly shared collaborative meaning and social context. In sharing this meaning, people are encouraged to take on an active role in their own learning processes. As should be clear, CVEs lends themselves well to facilitating social constructivist learning by providing a 3D environment in which students and instructors construct their own spatial representations of collaborative knowledge and learning. Indeed, recent discussions on CVEs address the capability of CVE environments to support Problem Based Learning (PBL) which utilizes problem-solving skills of students [3], [25].

This paper builds on problem based learning and social constructivist theories of learning by suggesting the use of the real world metaphors of maps and routes as representational tools to indicate collaborative and individual knowledge and learning. By the use of these metaphors, students and instructors alike are given a sense of place and belonging to a Collaborative Virtual Environment, which in turn will facilitate more active student and instructor collaboration and learning.

3. Space versus Place

The contrasts between space and place have been explored by Tuan [22], De Certeau [10], and Harrison & Dourish [14]. Spaces are transformed into places when used by people. Over time, a space becomes many places as it is used for different purposes. A school gymnasium may be a concert hall, a dance parlor, and a basketball stadium at different times. In order to utilize the educational benefits of a CVE, the distinction between space and place needs to be further explored, because classrooms function for many different social purposes.

Our proposal to use maps and routes comes from the framework developed by De Certeau. Writing about the history of cartography, De Certeau distinguishes between "maps" – which assume a natural geometric mapping of space – and "tours" – which include the personal observations and experience of those traveling the space. De Certeau makes his distinction in order to point out that maps encourage *seeing* as the dominant mode of using space, whereas tours narrate the role of the agent in *acting* in that space and thus creating a sense of place. De Certeau's point is that traditional utilizations of space often create relationships in which the agency of the individual is reduced by social, historical and cultural conventions for using that space. De Certeau's points can also be applied to the environment of an educational CVE. Instead of only emphasizing and mapping real-world classroom conditions, educational CVEs in addition need to offer students the ability to narrate their own tours and routes of learning, which encourage more invested and active ways of looking at and acting in that space.

Harrison and Dourish [14] have used the distinction between space and place to criticize collaborative environment designs that use real-world spatial metaphors to facilitate human interaction. As they note, places are constructed by social uses of space by humans. In this framework, space can be designed to aid in developing a sense of place, but only users can explicitly appropriate space and turn it into a place of social meaning and interaction. Harrison and Dourish thus note that human behavior is framed more by the cultural and social roles we associate with a place rather than the structure of the space in which it is located.

In using CVEs for educational purposes, a similar distinction should be made between space and place, and maps and tours. Often, students see the classroom in traditional pedagogical terms, as a space where the instructor talks and the students listen. As is obvious, in many online learning environments, this dynamic is changed with an increased ratio of asynchronous to synchronous learning. As Sorensen [21] has noted, collaborative online dialogues complicate the natural relation between time and space due to their reliance on asynchronous communication. Though regular classrooms also involve asynchronous learning moments (for example, writings on a board, class notes, etc), these are assumed to be natural occasions anchored in the synchronous learning experienced in a traditional classroom that meets at a particular time and place. In contrast, educational CVEs offer a different spatio-temporal environment, because they cannot necessarily enforce synchronous natural time and space

relations. Educational CVEs need to mark time and space relations more to encourage learning interactions. Similarly, CVEs also have other difficulties that distinguish them from regular classrooms: the difficulty of avatar movement related to network performance [8], incorporating persistent multi-user objects in CVEs [15], performing common gestures through traditional computer interfaces [17], [2], and the difficulty of indicating shared objects in a CVE [9].

Though many of these problems still need to be worked out, educational CVEs show great promise in facilitating different types of (synchronous and asynchronous) collaboration between users. Dix [11] has distinguished two types of collaboration: communication-centered (based on exchanging messages and content, such as chatting or a video conference) and artifact-centered (based on visual artifacts that can be manipulated and shared directly within an environment). Further, Zhang & Furnas [24] have noted that while other programs are much more efficient at facilitating communication-centered collaboration, CVEs have a good capability to integrate these types of collaboration along with supporting artifact-centered communication. By representing objects and data that can be directly manipulated by users, an educational CVE can therefore encourage collaborative learning through artifact- and communication-centered collaboration. Yet, as is made obvious from the above, many difficulties will need to be overcome in creating an educational CVE in which different forms of synchronous and asynchronous collaboration is facilitated between instructor and students.

Since educational CVEs cannot supplant the richness of face-to-face encounters of traditional classrooms, more emphasis should be put on their malleable and extensible qualities of representing persistent conversations of knowledge and learning in *spatial* and *visual* ways. Though CVEs can mimic traditional classroom space in certain ways, they cannot support the richness of real time interaction. With the opportunity to do asynchronous and synchronous collaborative work in the CVE, students will therefore need a system to keep them informed as far as the class activities performed in the CVE, collaborative projects, as well as their own notes. More importantly, such a system could be central to their learning, allowing students to backtrack on their learning experiences over time or enrich their current understandings and knowledge of a learning subject in spatial and visual ways. Since learning in the social constructivist view takes place through language use, with shared contexts, tools, and artifacts, educational CVEs provide a visual learning domain in which users of the CVE can represent these learning experiences in direct and meaningful ways.

While traditional classrooms provide opportunity for collaborative work, often times students believe that learning is an individual process. Traditional classroom spatial configurations encourage individual learning by having students focus their attention on the instructor in front of the class. However, many of these beliefs run counter to the social-constructivist idea of collaborative knowledge developed through the social context(s) of the classroom. Seeing as CVEs encourage such collaboration, rather than supplanting real world classroom metaphors, educational CVEs need to use metaphors of learning and transition that emphasize time and space. In doing so, students are not only given familiar metaphors that they can relate to and that make sense in a real world context, but are also given a way to control and make sense of their own learning experiences. In other words, in CVEs students should be asked to take on the social constructivist view of learning by building up spatial and visual representations of collaborative learning and their own individual learning. Rather than seeing the instructor as a location of knowledge and learning, students are asked to build up their own narrated tours and routes of learning. It is important that students get a visual analogue not only of the artifacts and exchanges of learning (lecture notes, assignments, completed work by others), but also a device that helps keep track of their progress of learning.

In our proposed system, students track their class notes, watch recordings of classroom chats, video instructions, read lecture text, lab material, as well as see the progress of collaborative class activities. In using maps and tours in our educational CVE, students are encouraged to take on an active role in transforming the CVE into a place for collaborative and individual learning where classroom conversations, class notes and material for class activities are easily found and shared through the use of familiar metaphors of space and time that allow them to personalize their experience of learning. As in the real world, in the classroom we constantly travel between familiar and unfamiliar places when learning new material. To facilitate learning, instructors must use old concepts already learned (or expected to be in the possession of students) in order to introduce new concepts.

The introduction of spatio-temporal concepts of tours and maps in an educational CVE provides students with a visual representation of their collective and individual learning experience. In representing individual and collective learning experiences, we hope that students are encouraged to participate in persistent conversations with their own learning process and that of others happening inside and around the CVE and classroom environment. Further, in providing a recursive learning environment that represents overall learning progress and provides visual mnemonic aides, we hope students make richer connections between class concepts and their own learning progress.

Sorensen [21] describes the value of "scaffolding" and "meta-reflection" in online communities as good methods to provide students with reflection and intellectual amplification of learning (pp. 256-257). The idea of scaffolding is a teaching concept based on Vygotsky's *Zone of Proximal Development* (ZPD) [23]. Vygotsky notes that the ZPD is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" [23, p.86]. Since an online learning environment provides collaborative learning and self-guided study, scaffolding is based on the idea that instructors should provide a supportive environment in which students collaboratively are introduced to new concepts that outstrip their current individual knowledge. After a while, with the support of the instructor, students internalize these concepts and are allowed to build more advanced structures of learning with less of a prominent role by the instructor. Scaffolding therefore promotes student development by collaborative participation and a meta-awareness of their own learning process through independent problem solving.

Indeed, in a comparative study of problem-based learning, Zumbach, Hillers, and Reiman [25] found that feedback mechanisms of learning improved student learning dramatically. Comparing students given feedback mechanisms for their learning experience through work and interaction histories with those who did not, they found the former "presented significantly better results in knowledge tests, created qualitatively better products in the end, produced more contributions to the task and expressed a higher degree of reflection concerning their organization and coordination" [25, p. 98]. This indicates the need for a visual and spatial structure in an educational CVE that provides students with metadata of collaborative and individual learning experiences.

3.1. Summary of points

In proposing a system of maps and tours, the following points should be taken into account:
(a) Familiar metaphors enhance an online learning environment, and familiar metaphors such as maps and tours are a good way to introduce new learning material and concepts.
(b) Since maps and tours emphasize learning as a process of seeing (maps) and acting (tours) on the world, they are conducive to social constructivist and problem-based forms of learning in which students take on an active role.
(c) Educational CVEs provide artifact- and communication-centered collaboration, and have the capability of synchronous and asynchronous communication, and as a result need a clear time-space framework for collaborative work and activities.
(d) Collaborative learning experiences by students are enhanced through mechanisms such as scaffolding and metadata, which provide students with reflection on their learning process.

These points indicate that with the adoption of (a) familiar metaphors of maps and tours and (b) repeated, gradually expanding learning experiences (scaffolding and metadata) our CVE can enhance the learning experiences of students.

3.2 Maps+Tours=Persistent Conversation

In a course curriculum setting, maps help define what the conversation is about, while tours may be analogous to blogs that capture N users' views of the conversation. The instructor will highlight exemplary students' (partial or entire) tours, and draw upon students differing viewpoints for ammunition in subsequent discussions. In doing so, the instructor can also assess the progress of the class in learning crucial concepts for the course, as well as build a learning environment in which active learning is encouraged.

4. Unicron

Our educational CVE *Unicron* was developed for distance education purposes. Unicron is written in *Unicon* (http://www.unicon.org), an open-source multi-platform language which has special support for rapid development of CVE applications. Figure 1 shows some typical elements of the interface (3D view with live whiteboard, text/chat interface).

One difference between the virtual classroom and a real one is that the domain of discussion can take form as objects within the room (in this case, a tree data structure is shown) or students can be transported to other spaces entirely.

placing their own routes over the provided map, students can make their own connections over the framework provided by the instructor.

Individual and collaborative learning processes are tracked through familiar metaphors of traveling on

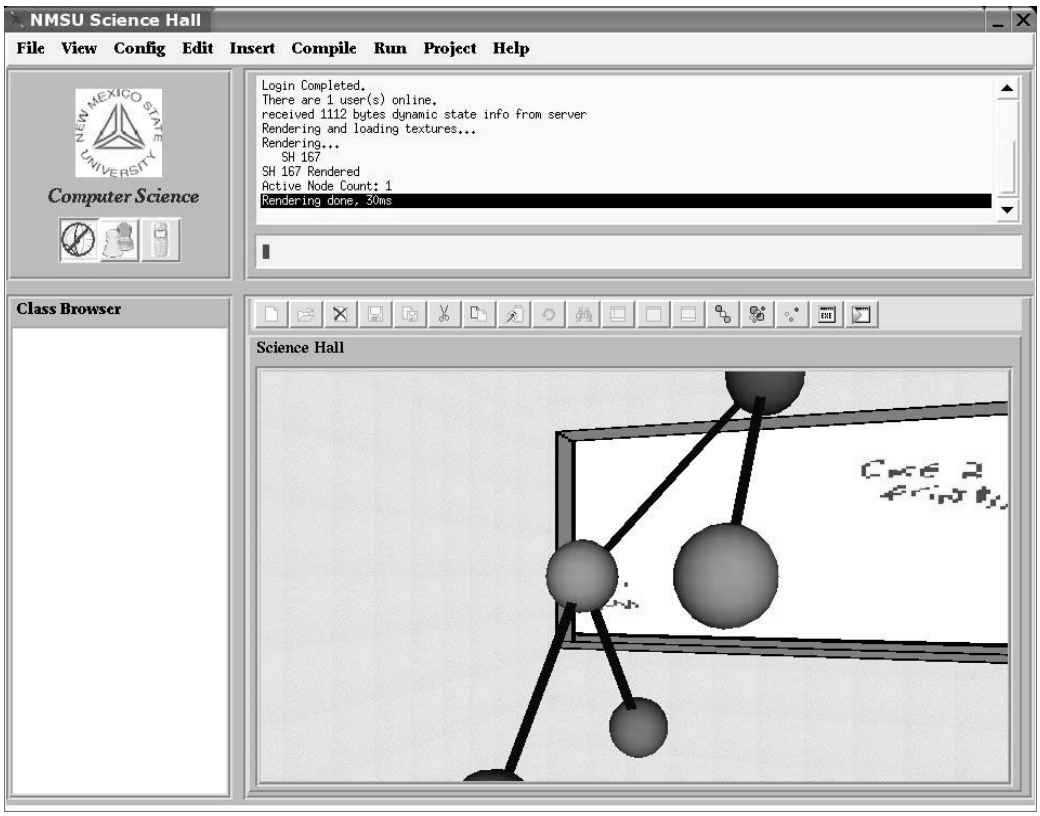

Figure 1: The Unicron CVE supports class lectures, text and voice chat, collaborative work, and class notes, along with domain-specific virtual objects.

5. Description of System Elements

In the system we are developing for *Unicron*, navigation is aided through maps and tours of learning. A *map* portrays a collective learning experience structured by an instructor (further populated by collaborative class activities), and a *tour* recalls the learning experiences of an individual students in which they can collect class notes, observations, and chat data.

Students and instructors alike have access to the map, but the instructor defines the parameters of learning by mapping the trajectory of learning. In addition, students are allowed to post collaborative (publicly visible) work. Each individual student can superimpose their own routes on top of the pedagogical map provided by the instructor. In

a map in time and space. In our system, we generally differentiate between shared classroom experiences offered by an instructor and the experiences of the class members.

An instructor creates "learning stations" on the class map, in which instructor's notes, prerecorded lectures, assignments, and classroom instructions and activities are made accessible to students. By clicking a learning station, a student will then be taken to a prerecorded class lecture, instructions, etc.

For students, an individual tour is a way for them to create their own "knowledge routes" that reflect their own learning process. Students could therefore create and navigate their own notes in the knowledge track and enrich these notes by coupling them with the learning material presented in the learning stations (see Figure 2). Whenever

they access content on a learning station, they can create notes that reflect on the class content and specific concepts, which they can then store on their own tour as knowledge routes.

In addition, collaborative tours are created when course activities or projects involve substantive shared effort. Collaborative tours are a team's record of its joint work, and are readable and extensible by other team members. Students can post items they have collected in their knowledge routes in order to contribute to collaborative projects. After they post an item, a new station appears on the collaborative tour.

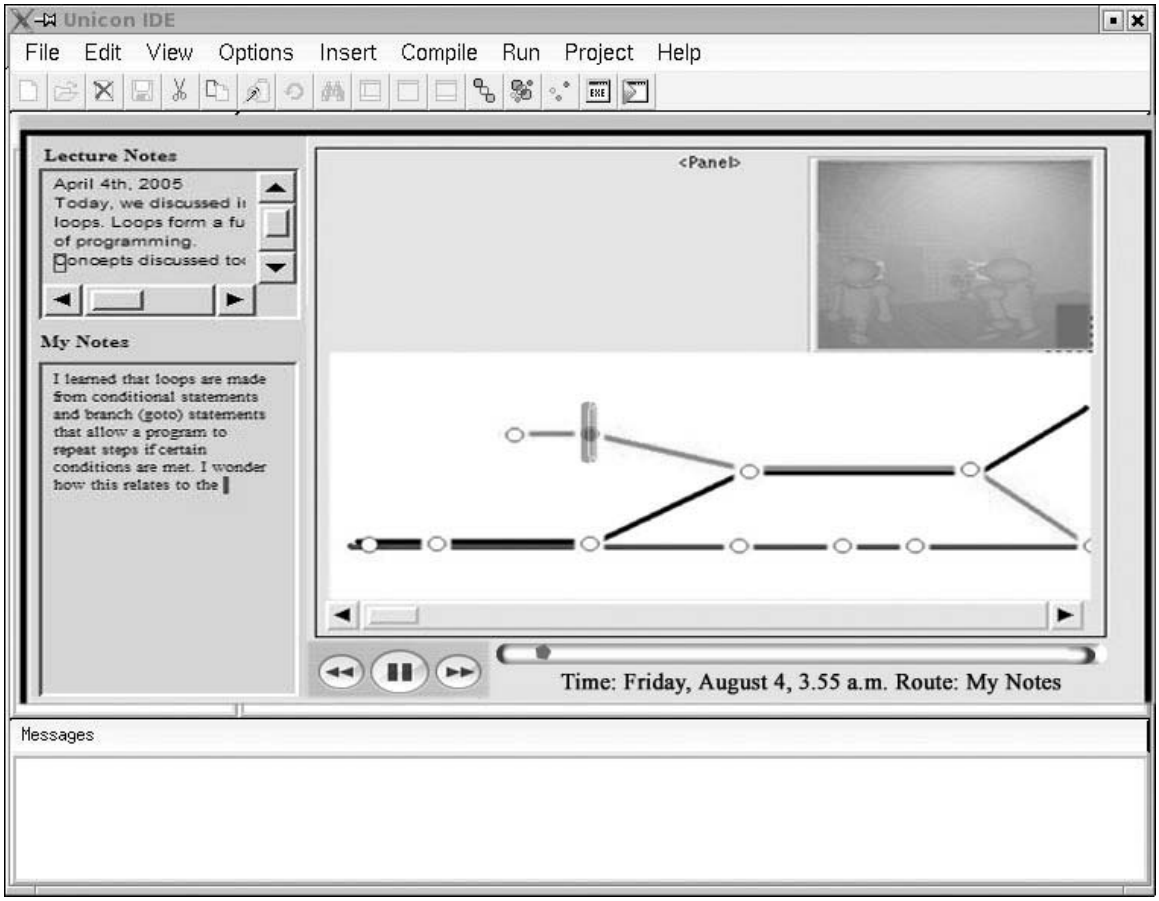

Figure 2. The map organizes different class concepts according to different routes with various learning stations. By clicking on any of the stations (represented here as circles), lectures and class notes are displayed, along with a relevant screen-shot of the CVE. The red line represents the student route with notes, whereas the blue line maps the instructor's learning stations and the black line represents ongoing collaborative projects to which students can add.

The map is organized according to class progress as reflected through time. Time runs along the horizontal axis, with various routes of learning concepts mapped vertically in order to distinguish solitary experience from shared ones. This allows users of our CVE to see when certain activities take place, and allows them to also track what they have missed. In using the map, students are thus encouraged to revisit their collaborative learning process by accessing the lecture notes as prepared by the instructor, the class activities on a particular day, collaborative work, and relevant screen shots of a particular date in the CVE. Likewise, using the routes encourages students to make up their own individual tracks of learning, allowing them to access their own notes during class activities or instruction, which is similarly organized around the time and the date of the activity. Next to this, our system will include a repository of collaborative work where people can access collaborative projects.

Bouras, Hornig, Triantafillou, and Tsiatsos [5] distinguish three different general training scenarios in an educational CVE:
(a) *synchronous training* where a instructor provides a lecture on materials for the course,
(b) *asynchronous training* - where students use the materials of the course to do work on their own
(c) *collaborative training* – where students (and perhaps, the instructor) work together collaboratively on a project.
All of these scenarios provide opportunities for students to reflect on the concepts they are learning through the work done in the CVE. As Fjuk & Krange [12] argue, next to collaborative reflection on learning experiences, students also need individual reflections to assess their learning and make meaningful connections to class concepts. In providing students use of the artifacts of the collaborative map and the individual tour, students are encouraged to reflect on both their collaborative and individual learning experiences. With the learning stations and knowledge routes, synchronous, asynchronous and collaborative forms of training are all facilitated: next to accessing the instructor provided map with learning stations that provide lecture recordings and notes, students can access stations onto the collaborative project line, as well as create their own individual tours of knowledge routes for their class notes and see how these relate to class concepts offered by the instructor. The instructor thus becomes a tour guide whereas students become participants as passengers of routes of learning that determine their own experiences in taking the guided tour, taking notes and snapshots of relevant learning moments and storing this in their individual knowledge routes.

Below (Figure 3) is an example of the system as we intend to implement it within Unicron. The learning stations map should be small enough to enable navigation. Ideally, the map could be traversed in two ways: as a *linear* time progression in which the map is traveled as a whole and class material along with individual student notes are displayed, or as a *non-linear* progression where the user clicks on specific routes or stations of learning.

A media file interface plays and pauses individual "knowledge routes" and can also play through the whole map. Below a message screen informs the user of new messages.

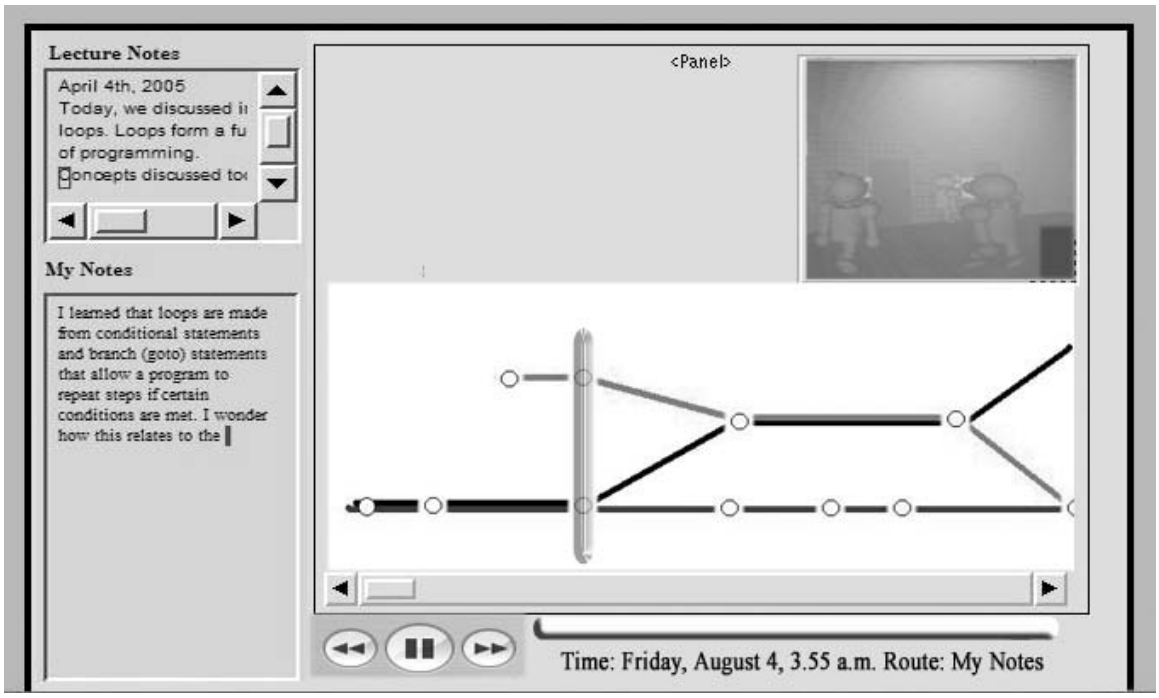

Figure 3. Both Linear and Non-Linear learning progress is enabled by clickable routes that can be played and paused like a regular media file. Various options allow the screen to be configured according to the wishes of the user.

Both could be accessed in the way a media file is accessed, with a time bar indicating the progress in terms of times and dates and an indicator moving along the map or route. In addition to our map with the "learning stations" and the student's individual "knowledge routes", our screen also features two different text spaces to reflect content: one for important lecture notes or concepts added by the instructor, and one with the notes of the student. Depending on the user, the class notes can be clicked on and enlarged to display a large version of the lecture notes or the student notes, or both can be displayed in smaller versions. A visual window provides captured relevant screen-shots of lesson moments. A color block in the corner indicates the associated tour(s) to which the screen-shot belongs. This enhances not only their reflection, but also lets student make important connections between concepts, their visual memory and their learning.

6. Scenario

This section describes a typical use of the system. In our scenario, the instructor has uploaded content such as a lecture into the CVE. A student clicks on the class map in order to see their progress in the class. The student sees three messages pending, one from their instructor and two messages from classmates. The message from the instructor points out some new learning stations available on the course map for the class, which students can select to access a prerecorded lecture or read assignment instructions.

One of the other emails is from a classmate asking a question about their team project. The student goes to the class map in order look for an answer. While reviewing a past lecture, he might get an idea and create a station in the collaborative tour that will help his teammate solve the problem. Seeing the note in the collaborative tour, the classmate can review the same section of the lecture later.

The other email is from one of our student's other teammates that report progress on their project. Our student visits the collaborative tour and sees a new station added by his teammate. Visiting the material, he sees that he should visit his own knowledge route in order to add the material that he has been preparing for the project.

7. Evaluation of system design

This section assesses the potential benefits and drawbacks of the navigational subsystem design presented in this paper. A more thorough evaluation including user experiences will be needed after the system implementation is complete.

7.1. Limitations

In order for the system to do much good, students may need to somewhat actively keep track of their own learning experiences. The degree of benefit over an instructor-provided outline will be proportional to student involvement.

Having a collaborative environment does not ensure that collaboration takes place; it is up to the instructor to ensure that course goals are achieved in the area of collaboration. For example, an instructor can make collaboration a part of the participation grade in the class.

However, the instructor can also encourage students to take ownership of their learning experience by taking screen shots, and recording lectures or chat conversations in the CVE. In turn, we hope this might be a stimulus for students to start using our system.

7.2 Benefits

Maps and tours that support the navigation of collective experiences in a CVE give students a context with which to reflect on their past learning experiences. Students' snapshots of classroom moments and record of their own on-line conversations augments the CVE's more fundamental capabilities such as recording entire courses' lectures or on-line content.

Since CVEs are conducive to social-constructivist learning methods, our system design also provides students with a way to share their constructed meanings with others in the CVE. Because students are given the opportunity to create their own place to reflect on their learning, they are also given a scaffolding tool that allows them to develop a meta-awareness of the progress they have made in learning the concepts outlined in the course map. In turn, they can share these meanings in collaborating with others in the CVE.

Perhaps the primary benefit of maps and tours for persistent conversation is the associative aid they provide for recollection and recall.

8. Conclusions and Future Work

This paper presented a design for navigating the persistent conversations in CVEs. Overall, the metaphor of maps and tours provides an alternative to traditional methods of information retrieval that rely on search engines and scroll-bar enabled lists of information. Though search engines are effective in quickly retrieving information, they are less effective in giving contextual clues beyond the time and the date. Maps and tours will provide students and instructors with a richer context by giving them a way to keep track of their learning progress and impressions by taking snapshots, notes, and connecting that to the overall learning progress in the class. In doing so, we hope that our system allows students and instructors to carry on persistent learning conversations and make deeper connections with the material in the course.

Not only do students get the opportunity to reflect on their own learning by a system of metadata, they also get support through text, visuals, and spatial representation of their learning within the CVE at the time they were learning a particular concept. In providing students with visual contextual clues from which to compare their learning, students are encouraged to relate earlier concepts and experiences to later ones.

In giving students the ability to represent their own learning progress through tours, feedback and scaffolding is encouraged, and students improve their own sense of learning and involvement on top of the framework provided by a instructor. Finally, in incorporating text, visuals, colors, time and space, stronger connections are made by students between the experiential real world and the CVE that can enhance their learning experience.

9. Acknowledgments

This work was supported in part by NSF award DUE-0402572.

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