Internet-Enabled Multimedia: An Argument for Alternatives to Browser-Based Learning Environments

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INTRODUCTION

The One Sky, Many Voices program (http://www.onesky.umich.edu/) has developed and evaluated inquiry-focused middle school Atmospheric Science programs over the past eight years. An essential component of our programs have been the design and design-experiment research (Brown, 1992) of our own software tools that currently do not follow the popular web page delivery model. The evolution of these Internet-enabled multimedia learning environment tools represents an independent strand of development for educational software. While other presentations and papers discuss the design of our learning approach and student and teacher learning results (for example Songer, 1996; Songer, 1998) this paper outlines our software design features and the justification for these decisions.

The Internet-enabled multimedia that has been developed represents a unique integration of content, technical and pedagogical expertise. The multimedia approach was chosen over traditional browser-based activities because it allowed a solution to technical and learning issues raised as part of our research. The issues included:

- The need to provide a fallback for situations when the Internet was not available,
- The desire to have a more immersive learning environment, and
- A wish to improve response time for relatively high-bandwidth interactive activities.

Our latest designs are centered on use of Internet-enabled CD-ROMs. This design allows us to augment information on the CD-ROM with real-time information and to dynamically modify and/or control CD-ROM based activities. With this design most of the supporting large animations and simulation models are local and network use is reduced to only that information needed for personalization, data updates and commands. Moreover those materials needed from the web can be anticipated and pre-loaded while the learner is engaged in other activities. When the Internet is not available the program automatically uses archival data stored on the CD-ROM and presented in the same user interface as real-time data.

LEARNING ENVIRONMENT DESIGN

The learning environment is enhanced by the careful incorporation of several key features including: multiple representations; multiple-level visualizations; integrated visualizations; dynamic scaffolding; animation; and personalization while maintaining Internet efficiency for low-bandwidth users.

- **Multiple representations** reinforce the exploration of real-time data by simultaneously displaying information in a number of ways. Figure 1 illustrates the rollover feature of a weather map where the learner sees the current weather represented in several dynamic forms including text, the thermometer, the changing of clothes of an avatar (bunny), and when appropriate, sound (rain, fog, thunder, winds, etc.).

- **Multiple-level visualizations**. Our version of multiple-level visualizations (Kozma and Russel, 1997, Kozma et al., 1996, Ainsworth et al., 1997) allow the user to select different perspectives of the data. In our learning environment this means the user can zoom into six regions of the continental United States. At the zoomed level the spatial density of data increases to allow more complete exploration of regional scale weather phenomena.

- **Integrated visualizations.** Integrated visualizations (Edelson, et al., 1997, Gordin et al., 1996) provide an overlay capability for exploring the relationships between weather parameters. This visualization allows various parameters (pressure, precipitation, winds, and frontal locations) to be overlaid on top of selected base maps (infrared and visible satellite image, relative humidity, temperature and wind chill). The application of these overlays is particularly useful for discovery of the relationship between concepts, such as the relationship between pressure patterns and wind speed and direction.

Figure 1. Screen shot from Kids as Global Scientists '99 software illustrating the multiple representations of real-time data afforded by use of multimedia. The weather data in New York City is represented by textual, instrument, avatar and, when appropriate, sound.

- **Dynamic scaffolding.** The dynamic scaffolding that is embedded into our software is our mechanism for the communication between content specialists and learners. The opening window of the software displays the "message of the day" from a meteorologist identifying interesting weather conditions today in the United States. This information helps guide teachers and their learners to interesting points of departure for exploration of current weather patterns and phenomena. We have found such resources essential in supporting teachers and students in their exploration of current weather events (Songer, 1998).

- **Animation.** Our research has illustrated that real-time weather animations are an essential tool for the representation of the dynamic nature of the atmosphere prior to student prediction-making (Songer, 1998). Animations can be downloaded on demand that provide a movie of the past 24 hours of satellite or temperature maps.

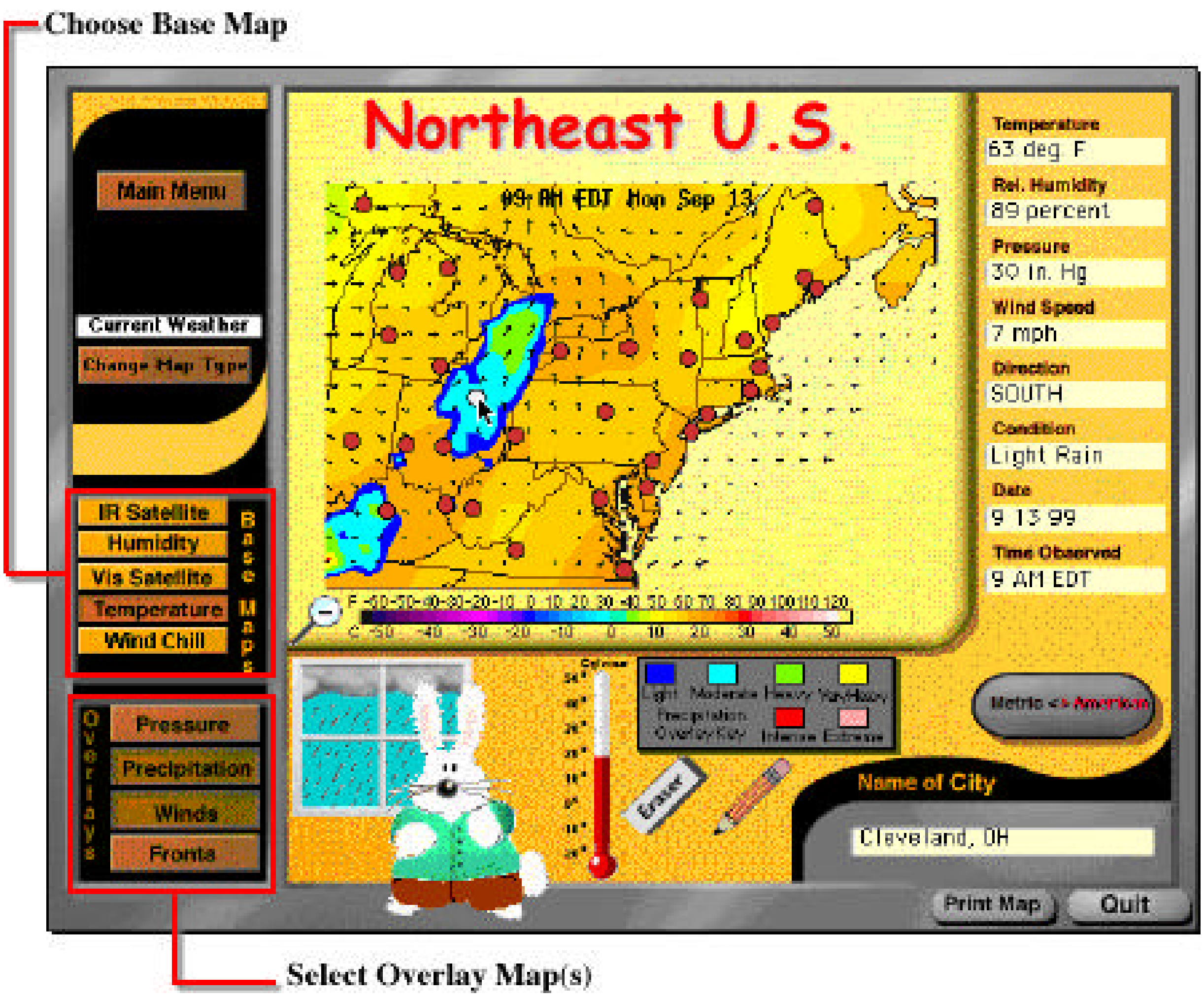


Figure 2. Screen shot from Kids as Global Scientists '99 software illustrating the integrated visualizations of real-time data afforded by use of multimedia. A base map of temperature is chosen with precipitation patterns and wind fields overlain. With this capacity the user can explore and discover relationships between parameters using real-time information.

- **Personalization.** The newest feature of our software allows the personalization of the learning environment through CD-ROM/database server interactions (Samson et al, 1999). This feature provides the ability of the instructor to dynamically add programmatic or content support for users as desired. Research on the effectiveness of this feature is currently being conducted.

- **Internet efficiency.** Finally, because of the unpredictable nature of network technologies in classrooms, internet efficiency has been an essential design consideration from the beginning. The multimedia design puts most large supporting animations and sounds on the CD-ROM installed in the user's computer. The Internet is used only for images and text needed on demand and in some cases these data can be preloaded when the program can anticipates the next Internet request.

EVOLVING DESIGN IMPLEMENTATIONS

While the One Sky, Many Voices has created web resources for its curriculum (see http://www.onesky.umich.edu/) and weather information (http://cirrus.sprl.umich.edu/wxnet/) the emphasis has been on development of stand-alone Internet applications tailored to learning and content needs. The evolution of our learning environments has systematically added learning environment features starting with content-centered delivery and evolving to integration with curriculum.

Blue Skies

The Blue-Skies software (Figure 3) was created in 1992 as a gopher client to facilitate an interactive visualization of weather information (Samson, et. al., 1994). Its unique feature was the addition of rollover interactivity for graphics images. Created before World-Wide Web browsers became popular, this model succeeded in delivering multi-representational weather information in a relatively fast manner. This stand-alone gopher client predated similar capacity made possible years later with the development of Java™ (http://cirrus.sprl.umich.edu/javaweather/). The user could choose from a number of background weather maps that were updated hourly. The user could also zoom into a region to get more detailed information, providing multiple-level representations.

While this software was used in the initial Kids as Global Scientists curriculum (Songer, 1996), its design considerations were driven less by pedagogical considerations than by the desire to deliver weather content in a novel and intuitive manner. Nonetheless, the lessons learned on how to create the necessary imagery and to deliver the information to an exponentially growing community of users was valuable for what was to follow.

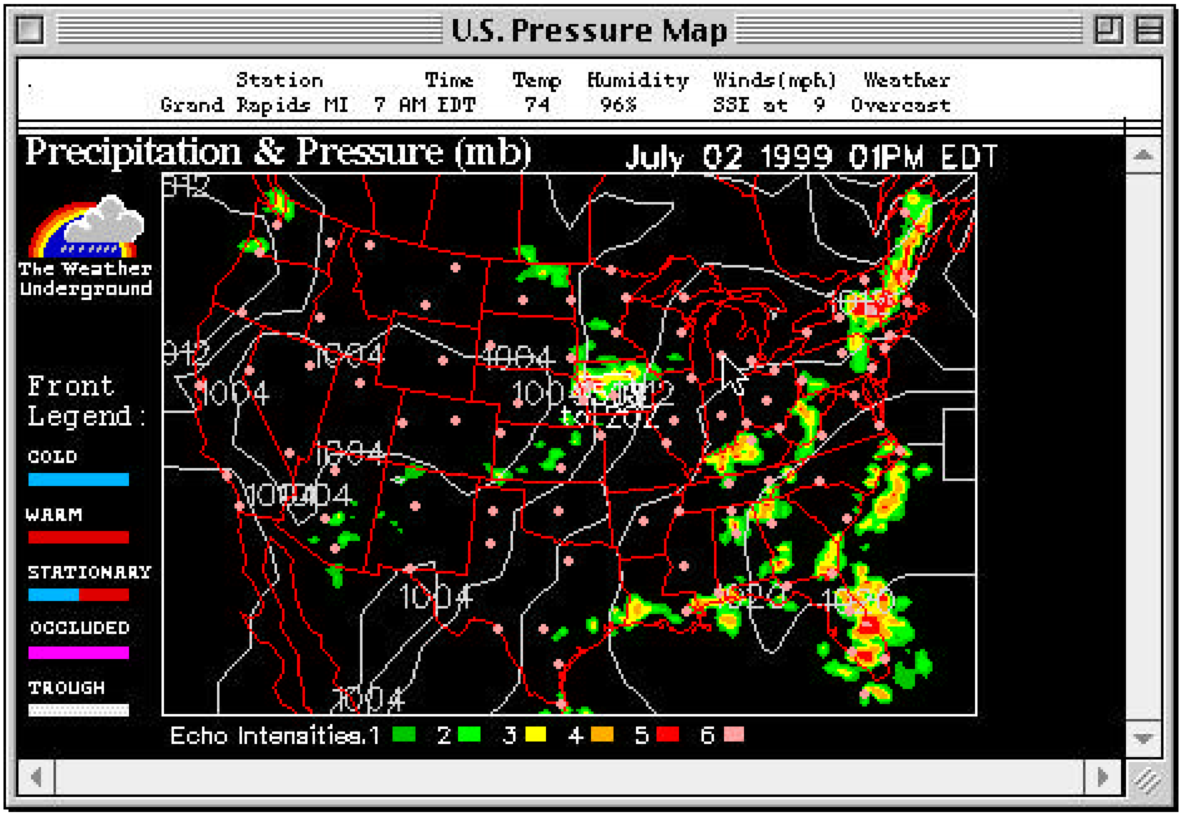


Figure 3. Screen shot of Blue-Skies 1.1 using multiple representations (visual map and textual) to display the current weather information.

One Sky, Many Voices

The creation of the One Sky, Many Voices program in 1996 allowed us the opportunity to redesign our technology to be more responsive to the educational goals of the curricula. The design process was to co-locate educational, technical and content specialists with the task of discussing the needs of the curricula and the potential and limitations of various technologies. Based on those discussions and consideration of feedback from previous enactments of Kids as Global Scientists a decision was made to base the learning environment development on multimedia with extensions to the Internet as opposed to working within HTML. The goal was set to provide multimedia CD-ROMs that were Internet enabled.

Networked CD-ROM Design

The strength of the World Wide Web is its power to deliver enormous volumes of information through user defined queries. Classroom activities may take advantage of this through open exploration and/or guided inquiry delivered by specific resource and curriculum sites. While for many activities the ability to browse can lead to active exploration by the student, too often the information obtained provides minimal supporting explanation or the supporting explanation is at a level inappropriate for the student. Thus the user's experience may not result in the desired level of learning. Likewise, the exploratory strength of browsers also can lead to off-task inquiry that distracts the student from reaching their learning objectives.

Second, the reliability of Internet connections, while improving, is still not sufficiently robust to support scheduled classroom activities in many situations. Hardware and software failures, unavailable dial-in access, and server failures are among the issues that may prevent a classroom from successfully participating in a scheduled Internet activity.

To address these concerns the One Sky, Many Voices program created networked CD-ROM's which support our curriculum by providing real-time but prescribed weather information from the Internet. This information is selected by content experts in meteorology in support of defined learning objectives. The model this represents has potential for a wide range of distance learning applications. The selection of CD-ROM multimedia was based on the observation that combining technologies provides important features for the educational community (Table 1).

The quality of a networked CD-ROM for educational purposes is judged by its ability to meet its educational goals within predefined technical constraints. At the outset it is necessary to define the typical user, the expected frequency of use of the CD-ROM resources, the network demands inherent in use of the program and what level of customization was desirable for the student. Table 2 lists, as an example, the criteria used to design the Hurricanes'98 CD-ROM.

Hurricanes'98

Activities in the One Sky, Many Voices program have varied from curriculum to curriculum but the model has been to build a knowledge base through active exploration that leads to a prediction activity. In Hurricanes'98, for example, the students were provided archived hurricanes and tropical storms as well as a "fly-through" hurricane. These resources lead the student to understand the morphology of a hurricane and the conditions that lead to hurricane intensification and decay.

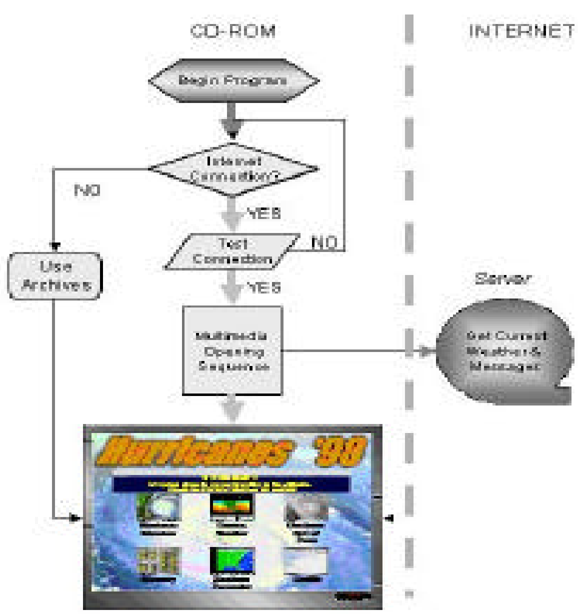
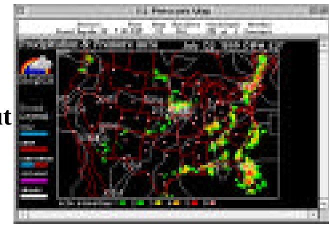


Figure 4. Basic flow of multimedia initialization with interactions between client and server to set personalization and obtain information updates.

This construction of a knowledge base was followed by an activity where students were to predict the motion of either an archived tropical storm or, had nature provided, a live hurricane. The design allowed participating students to forecast which coastal cities of the United States and Latin America should receive hurricane watches or warnings.

The Hurricanes'98 software tested whether network capability existed by searching for a file on our server. If the attempt times-out the network is assumed to be unavailable and further communication attempts are canceled. If the initial file is successfully returned the file contains information on the existence of tropical storms in the Atlantic. This information is transmitted to the user on the opening navigation screen (Figure 3) so they can choose to explore real-time imagery. Likewise the Hurricane Prediction game is switched to a live mode to facilitate forecasting the current storm.

TABLE 2. Design criteria for development of One Sky, Many Voices learning environment technologies reflecting evolution of components.

Design Goal	Blue Skies	Hurricanes'97	KGS'99
Basic Layout			
Multiple representations	· Graphical weather maps. · Rollover of cities yields textual current weather readings	· Selected current satellite imagery. · Rollover of hurricane locations yield location and intensity information.	· Graphical weather maps. · Rollover of cities yields textual representation, visual representation as instrument readings and changing bunny attire, and audio representation for cities with rain, thunder, etc.
Multiple-level visualizations	1. Can select six regions from national map 2. Clicking on city yields current weather forecast.		1. Zoom tool takes user to six regions. 2. Clicking on city yields current weather forecast.
Integrated visualizations	Multiple independent images could be accessed each containing different parameters.	In hurricane forecasting activity the user could overlay wind field images on base maps.	Base maps can be overlaid with multiple parameter fields.
Dynamic scaffolding		1. Automatic notice in opening window if tropical storms are present. 2. Animated glossary and archived hurricane data support learners.	Automatic downloading of message of the day with content or pedagogical guidance.
Student constructions	N/A	Hurricane forecast	User can draw on resulting maps and print them out. Student observation entry.
Animation	Animations of current weather could be downloaded on demand.		Animations of current weather could be downloaded on demand.

The power of this design is the interaction between the CD-ROM as the user's graphical user interface and our database server. The database server is designed to store user preferences, including location and name of their school, their data inputs (weather observations) and forecasts, as well as technology use data. At the same time information is transmitted from the CD-ROM to our server identifying when the software was started, which sections are accessed, and whether the program terminates normally. These data are stored in support of our research on technology utilization.

In Hurricanes'98 the communication between CD-ROM and database server was exploited in the capstone forecasting activity where participants were challenged to forecast the movement and strengthening or weakening of a hurricane. As the likelihood of hurricanes in October when the program was run is relatively low we provided both a 'canned' hurricane on the CD-ROM for those without Internet connectivity and a simulated hurricane to be broadcast the third week of the activity via the Internet for participants to study and forecast. As fate would have it however the participants were challenged by the development of two hurricanes during our study period. The stronger of the two, Hurricane Mitch, wandered slowly through the Gulf of Mexico and presented a unique challenge for the technology as students from across the United States forecast its movement.

Using the CD-ROM the students could observe the location of the storm (as dots projected live onto current background maps of their selection (see Figure 4). This visualization is unique in it allows interaction with the data when the user's cursor is moved over the track of the storm to explore its intensification over time. It also allows simultaneous projection of several fields such as the current satellite view of the are with an overlay of current steering winds

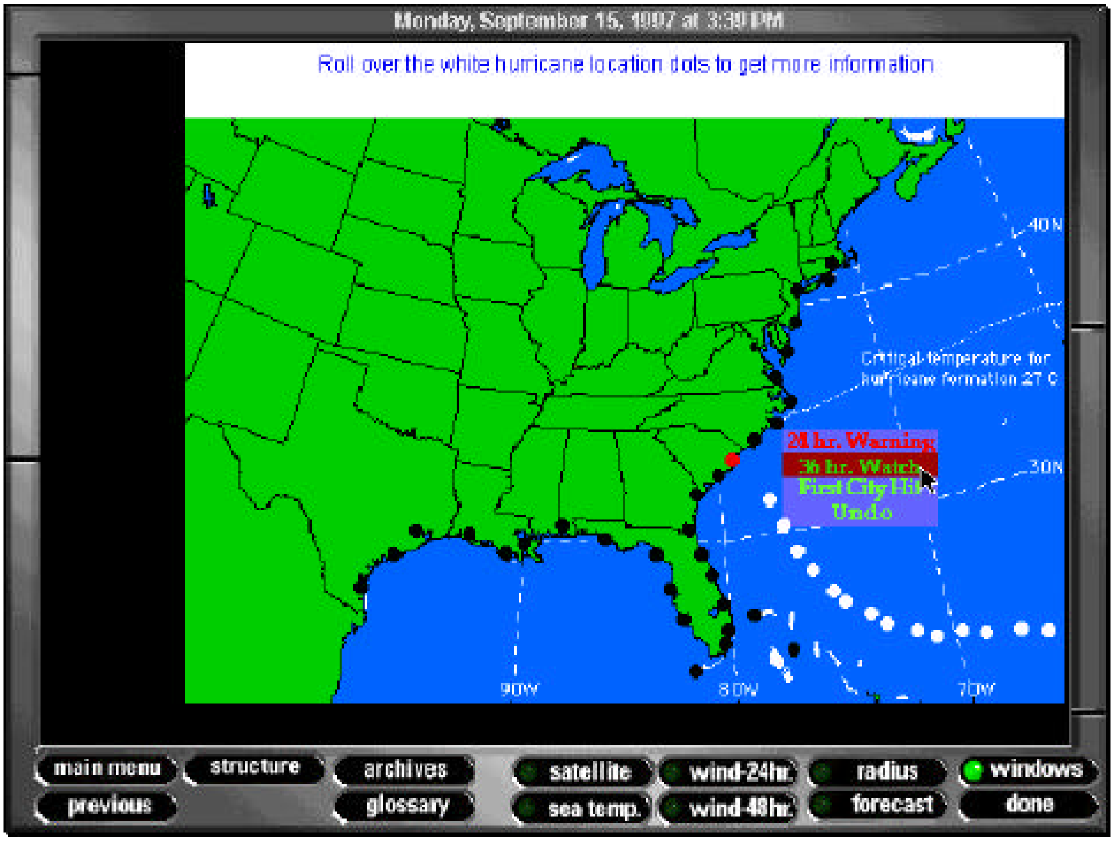


FIGURE 4. The design of interplay between student activity and technology for forecasting hurricane movement.

Kids as Global Scientists'99

The evolution in technology for Kids as Global Scientist reflected an ever increasing level of sophistication in development and a stronger influence of pedagogical issues. This software attempted to allow students to enter and retrieve data, and the use of multiple representations was increased.

(Clearly this needs to be completed. I will continue the technical descriptions next week)

REFLECTIONS

Continued Evolution

Methods to present sophisticated data sets in a supportive environment to enhance the likelihood of student learning are evolving rapidly. Advances in authoring tools provide new opportunities for creative delivery of both static and dynamic data. The evolution of these tools with their increasing capacity to include direct ties to dynamic servers for personalization and data updates provide educational technology with extraordinary opportunities to rethink the design of classroom activities.

The challenge in this growth is that the technical developments by themselves are necessary, but not sufficient, criteria for continued evolution. Educational technologists need also to be informed by

- Pedagogical issues

  How will learners implement this technology? What role will the teacher or other learner facilitator play in supporting its use?

- Professional Developments

  What training or other support will the teacher need to feel comfortable adopting the new technology? What content training or support is desirable?

- Assessment methods, and possibly

  How does one measure the value of the technology to the learner or the classroom or community?

- Marketing concerns

  How does one approach the self-sufficiency of the artifacts created for education? How is the design influenced by the realities of marketing research in the commercial sector?

The evolution of these new technologies must occur in an interdisciplinary environment. The team needed to address the issues posed above requires the open collaboration of education specialists, content specialists, technologists and interface design specialists at a minimum. These groups must learn to forgo discipline-rigid approaches to learning issues and allow the mutual resource of the whole group to guide the development. Moreover as the tools evolve there must also be serious thought given to its sustainability over future years. This will require that the team may need to embrace ever wider interdisciplinary approaches including marketing, finance and business skills.

This is a moment of opportunity in educational technology. The collaborative nature of the Internet allows expansion of learning beyond the classroom. The challenge is to foster this development in a way that encourages use even at the low end of technology capability. The Internet-enabled CD-ROM is one model for how to meet these goals.

SUMMARY

In summary, while the technological tool is only one feature of the learning environment we have created, we continue to explore the value of various design features on the learning experience of student and teacher participants. This paper documents our continuous efforts to design and test the best possible immersive, interactive experience for learners' exploration of real-time information.

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