An Interactive-teaching Virtual Museum: Implementation of a New Digital One-on-One Pedagogy for K-6 Students from a Multi-Cultural Society

Dan M. Davis
Information Sciences Institute
University of Southern California
4676 Admiralty Way
Marina del Rey, California 90292
(310) 448-8434
ddavis@isi.edu

Laurel K. Davis
Santa Monica-Malibu Unified School District
1651 Sixteenth Street
Santa Monica, California 90405
(310) 695-6080
ldavis01@attbi.com

Abstract

This nation faces critical needs for technical and scientific personnel. Current formal and informal science educational efforts have not been sufficiently successful to meet these needs. This is especially true in certain minority populations. Recent advances in research funded by the Department of Defense have shown new capabilities in realistically immersing humans in a computer-generated virtual reality with accompanying emotional engagement. A new initiative utilizing these techniques in an easily accessible program that realistically simulates a visit to a science museum will help enlist more of our students into science and technology. It will also better prepare the rest of our students to be scientifically literate citizens and help to ameliorate the current gender and ethnic imbalances in the populations of our technical professionals.

Executive Summary

New visualization techniques and interactive computer instruction show promise for opening up museums to wider populations and enabling a Digitized One-on-One Teaching Method for teaching science concepts more effectively. We believe this expanded audience and improved interactivity will be most effective if it allows for cultural and individual differences in each learner. Museums have well-developed public exhibits and have even larger closed collections. Both the public and the closed assets are not readily accessible by many who could otherwise benefit from this wealth of knowledge. Potential learners suffer from restraints due to geographical separation, economic hardship, and the restricted access to closed collections. Static and unidirectional computer and internet presentations of this material may not fully exploit the opportunities to introduce new subjects, foster increased sophistication in analysis, and motivate learners to appreciate science as a tool and as a potential career. We believe that closely emulating a real museum visit will make the information presented more compelling.

Experience indicates that the learner becomes more involved if exposed to the museum environment. There is evidence that true interactivity, both in the interface and in the presentation methodology, will further enhance learning and retention. The key question in this area is the efficacy of the combination of virtual environments and interactive teaching techniques in enhancing science education. Two other critical issues are the architecture of the compute/networking assets needed to economically serve such a program and the impact such a program might have on elementary school science students' achievement and attitudes.

We propose to show that the advances in computer visualization programs, high performance computing, and high bandwidth networking can be used in reducing the barriers of access and help correct the lack of effective evaluation of learning across a widely distributed and diverse population. The proposed site for testing these new technologies is the entire United States with initial emphasis on the states of Hawai'i and Alaska. Both states have diverse native and non-native populations and Hawai'i has a monolithic public education system, thereby lending itself to a statewide application. It is our intent to implement and test an anthropology element that will compare and contrast the cultures of the native peoples of these two radically different environments. We will assiduously apply rigorous pre- and post-training evaluations that will give meaningful and reliable data on which to analyze the impact of the program and to assist in identifying the need for further improvements. The program envisioned would automatically monitor progress of the participants.

We propose to implement lessons learned in interactive literacy programs, high performance computing, and electronic network dissemination of data. The Institute for Creative Technologies of the University of Southern California has developed several new techniques to enhance virtual reality. They are studying immersive training for the U.S. Army. We believe that innovative, culturally oriented feedback mechanisms can achieve the improvements in science education and the desired attitudinal changes in a measurable way. We intend to use the materials already developed by two of the premier museums in the country, The Bernice P. Bishop Museum, Honolulu, Hawai'i and the University of Alaska Museum, in Fairbanks, Alaska. These activities will require an on-going and close relationship with the University of Hawai'i, the University of Alaska, the Alaska and Hawai'i State Departments of Education, the Bishop Museum, the University of Alaska Museum and the people of Hawai'i and Alaska. From the outset, we will include teachers and school administrators to insure the applicability of our findings to the real world of formal and informal education.

PROBLEM

Background and Definition

While many current computer information systems use the word interactive, it is frequently the case that this means little more than the user calls up the next quantum of information by "clicking with a mouse." This rather static and "flat" presentation of material does not reflect the skills of a good teacher or the findings of the developmental psychologists. The interaction of a teacher, in either the formal classroom or the informal setting such as a museum, relies heavily on both feedback from the learner and the teachers' ability to react appropriately. The authors have participated in some of the early studies of making the computer more interactive in the "human" sense. While there was promise in this early work, limited power and early programming techniques conspired to keep this new pedagogical instrument from gaining acceptance. We have observed that both computer power and programming techniques have dramatically improved. (Nash, J. 92)

The need for a program to interact with the learner in much the same way a teacher does, by alternating presentations with questions and testing, can now be satisfied on a practical level. Leading and motivating a student to new learning and to an increased appreciation of science by the use of a truly interactive learning environment is what we have termed the "Digital One-on-One Method." The Information Sciences Institute (ISI) has done research in this area. (Johnson, W. et al., 97) Contacts with professional researchers and educators at the Bishop Museum in Honolulu, the University of Alaska Museum in Fairbanks and the Getty Museum in Los Angeles have elicited the uniform desire for a more effective way to reach and teach potential learners. There was also unanimity in recognizing the desirability of having the learning be interactive, measurable, and sensitive to the individual learners' needs and capabilities.

Another issue of importance is the utility of the program after it is developed. We have witnessed programs that do not adequately investigate the needs and desires of the classroom teacher or are not responsive to the feedback the campus-oriented researcher receives. We have begun where the action takes place, working in the classroom with the teacher, using technology to lighten their load, not increase their burden. We have structured our early thinking to respond to their needs and desires and have further worked with District and State-level administrators to assure a useable and helpful product. We intend to bolster that early investigation with a formal research effort into science education curricular areas in need of assistance. We do not intend to develop a program only of interest to us, and then try to convince the teachers to use it. We will carefully survey classroom teachers to insure we are meeting their needs.

Since recorded history, there have been social problems in societies where more than one cultural group had to coexist. Further, it has been argued that each culture has a unique way of viewing the world, often making cross-cultural education intrusive and ineffective. One has to look no farther than today's newspaper to see that 4,000 years of civilization have not changed human behavior. The problem we face today is no less of concern to us than it was for the ancients, despite all of our technology. These forces are at work today in the United States. Every state has a share of these difficulties. Imposed on top of these social concerns and difficulties, a "one size fits all" methodology is often applied. When one monolithic pedagogy is applied to all types of learners, there is the likelihood of ineffective education. In areas such as Hawai'i and Alaska, the lack of cultural knowledge and sensitivity can have detrimental impacts, such as social unrest. Many have tried to reduce this lack of knowledge and sensitivity with only limited success and even that success has not been well documented in all cases. One of the areas where problems of this nature have some of the greatest impacts is in teaching at the elementary level.

Access

One major aspect of our inability to teach what we know of the differences in various cultures lies in the limited audience for such instruction. Approaches to multi-cultural learning have limited impact on a society when only small segments of the society are being reached. Even in major metropolitan areas, it has been shown to be difficult to impact a significant portion of the population. To be more specific, across a unified school district, there is likely to be significant differences in how cultural concepts are taught and perceived.

> "In general, research suggests that substantive changes in attitudes, behaviors and achievement occur only when the entire school environment changes to demonstrate a multicultural atmosphere. … programs are instituted that permit interactions between students of different backgrounds…" (Diaz-Rico, et al., 1995)

Measurable Learning

Another aspect of these continuing frustrations is the lack of focus on what information was actually being learned and what attitudes were actually being changed, as well as how long they were being retained. In referring to the problems of this kind of training without verification, one critic noted

> "These programs are graded on how many teachers are trained and how many meetings are attended, not on how much is learned and retained." (LA Times, 1999)

Without a reliable method of verification of efficacy, it would appear that no reasonable conclusions can be drawn about the utility of such programs.

Retention of Knowledge

Even if the material from the course is learned and can be shown to be effective immediately after the course is over, it will not meet society's goals if the lessons learned are not incorporated into the user's knowledge base and attitudes. Evaluations of current educational techniques that attempt to increase retention may suffer from experimenter bias if the program teachers are asked to evaluate the effectiveness of their own programs. (Darder, 1993)

Crucial Questions

Viewing available technology and pedagogical insights, we believe a new and effective breakthrough can be made by combining a virtual environment and a "one-on-one," question/answer technique for teaching. This combination is enabled by the advanced computer and networking technologies now coming on-line. The following crucial questions seem to flow from this concept:

- Is the combination of virtual environments and interactive teaching styles uniquely efficacious?
- Can this approach ameliorate the decline in performance/attitudes in science students at the elementary level?
- Can a suitable architecture of computers and networking be developed to support such a program?

GOALS

Easy Access by Population of Interest

For a new method of instruction to have any impact, it must reach a significant segment of the target population. The target population of this study will initially be the people of a few selected states, but eventually the entire United States. Teacher training and motivation, as well as the acceptance of the program as "their own," are necessary and seen as a major component of this project. The interactive training program itself must reduce as many barriers for the learner as possible or it may dissuade that learner from participating. Concentration on any one segment of populations will probably have an uneven impact, if all of the other populations do not receive the same kinds of training.

In diverse states such as Hawai'i and Alaska, trying to teach concepts using a slavishly uniform pedagogical approach across diverse populations has demonstrated this difficulty. Ignoring either learning styles of different individuals or traditional views of different cultural groups may just perpetuate and emphasize these cultural differences. The geographical dispersion of the populations will also reinforce the isolation of some of the groups. Our goal is to afford each person a more individualized experience in learning about science and about the various cultures. For different cultural "communities to enhance and perpetuate their cultures, a first step is to conduct and inventory of their resources, which are conceived broadly to include natural resources (topographic features, water resources, flora, and fauna), sacred areas, cultural aspects (language, ceremonies)." (ONLINE Headlines, 1999)

Verifiable Measurement of Learning

Quantitatively verifiable results are necessary for useful research. We fully intend to carefully establish what the desired results are in terms of useful knowledge and scientific sophistication. This will be done by rigorously interviewing education, government, and civic leaders in the target population. We then will identify the goals and re-visit the same group to insure the proper selection and articulation of these goals. The identified goals will then be quantified in a measurable way and test/retest validity established within the target population. Progress toward these goals must be assessed and we propose a three-step process for this.

- Pre-instructional assessment at the initiation of the training
- Periodic assessment as an integral part of the training
- Comprehensive assessment at the end of the training

These assessments will be focused on new or improved capabilities in the student. To insure that these changes are appropriate, constant feedback from community leaders will be sought and heeded. Sensitivity to cultural issues will be a central focus of not only content, but of methodology as well. However, the results sought shall comport with recognized scientific standards and be centered on:

- Understanding basic concepts
- Articulating the key concepts central to understanding
- Synthesizing facts, cultural understanding, and societal needs into appropriate plans of action
- Citing appropriate facts to substantiate a course of action

CONCEPT

Based on Internet Technology

One of the most useful technologies to become common in both the school and the home is the personal computer, the Internet, and its associated browser software. The near ubiquity of these technologies has made it one of the communications media of choice. These technologies are low cost, widely installed, easy to operate, and have a common interface across computer platforms, geographic areas and languages. The current plan envisions finding useful and visual data at the Bishop Museum in Hawai'i and the University of Alaska Museum and presenting a set of structured, interactive materials to lead the student through concepts of scientific knowledge and understanding. These concepts and the associated pedagogy are well described in the educational literature.

Figure 1: *Exhibits in the Bishop Museum*

The museum setting would be presented in the most immersive way using the technologies that are exemplified by the work at ICT (Hill, 1999.) The museum assets would be displayed as photographs, 3-D images, animated GIFs, MPEG movies, sound clips, and any new technologies that support the goal of presenting the material in interesting and meaningful ways. The Institute of Creative Technologies has developed many techniques for using advanced rendering, three-dimensional sound, well-prepared scripts, and other contributions from the entertainment industry. These represent the state-of-the-art that today's young people are expecting. Incorporating it into a museum visit would heighten the students' awareness and help emulate a physical museum visit with a visit's proven positive impact.

The sense of drama that has been honed in the entertainment community in Southern California will be implemented to give the feeling of excitement and create the environment of adventure that characterizes a visit to a museum by elementary school children. The museums have developed skills in making learning exciting that will be incorporated and these two information cultures will be synthesized to achieve the highest level of student interest possible.

Screens with text will have voice-over options for students who were more comfortable with "oral learning." The text would be sensitive to cultural differences in viewing the natural world, while maintaining the desirability, excitement, and utility of the scientific approach. Scientists, when personalized, would be represented by women and men of diverse ethnic backgrounds. Most importantly, though, is that the design will reflect the good science education practices of finding the "teachable moment," motivating in a culturally appropriate style, and drawing out the students' interests and capabilities

Figure 1a: Exhibits in the Univ. of Alaska Museum

The implementation in computer hardware will rely on existing technologies, but will involve applying newly developed techniques used in large-scale distributed simulations. (Messina, Davis, et al., 1997).

Use new Interactive Interface

The most innovative concept in this project is the idea of a newly focused instructional interface using interactivity to improve learning. This will be done in a measurable way. This concept will be further developed as we proceed and its formal description is the most important of the deliverables we would propose. We will implement lessons learned from the Accelerated Reading Program (Cahners Research, 1997) and seek other similarly successful programs. We will develop several parallel layers of learning progression dependent on skill level, learning style, and cultural preferences. We will use different formats for the material presented, depending on the recorded interactions with the user. Here again, the game, movie, and TV production talents will be useful in designing engaging, as well as effective, interfaces.

Design for Intercultural Use

We are committed to insuring that each culture is honored by designing an interface that sensitively presents cultural data. The interface will also use culturally appropriate methodology and have concept applications in accord with that culture. The program will pose questions and will reward accomplishments in a way that will be sensitive to and respectful of that culture's values. One interest will be the optimal fineness of the grain of these differences. Do certain large groups have, within that group, different ways of understanding and analyzing data depending on the area of residence or socio-economic level? The answers to those questions also will be a valid and interesting research result. Local area experts on values, world-views, and traditions will be sought out and invited to join as collaborators in the project. This will help insure sensitivity and assure members of the community that our desire is to understand their culture, not change it. The results anticipated will require a significant amount of analysis and reporting.

Maintain Interest of Student

Also of particular emphasis will be our efforts to design the virtual environment and the instructional materials in such a way that the materials will be self-motivating and invigorating. We will unashamedly look at the popular intellectual games for cues as to what motivates game players to stay at the computer screen for hour after hour.

METHOD

Canvass and Analyze the Teaching Community

It is critical that this project be answering the real needs of educators, within and outside the classroom. A careful study of current needs, capabilities, and constraints will be conducted. Several key museum, computer and computational scientists have been interviewed to ascertain both the innovative quality of this concept and the need for such a program. Each of them has supported and encouraged the work and offered to attest to its necessity. Suggestions were received that we should make the code sufficiently modular to allow the easy insertion of new and different scientific data. Using a descriptive input template might adequately assist the teacher in selecting the types of data to be used. Examples of inputs might be a salient text element, a graphic image, and a critical question to be answered before proceeding. There will also be appropriate pacing for slow, average and fast learners. This template approach would dramatically widen the impact of this research, as teachers could design their own programs for study by their students.

Develop and Refine Interactive-teaching Algorithms

ISI is well known for its research into interactive-teaching via the computer/human interface. (E. Shaw et al., May 99) The capabilities developed there and the personnel resident there will be incorporated into this project as appropriate. That will help avoid using vital resources to re-develop existing computer/human interfaces. This entire effort is intended to be focused on the content and style of the material presented to the student. It is here that there is the most opportunity to achieve some new level of education at the critical elementary age. Like a good teacher, the program must do its best to motivate, instruct, and test so it can open new doors to science. Early conceptualization of the program envisions a range of different paths across several dimensions: ability, learning style, cultural viewpoints, and literacy.

Ascertain the Computer Assets Required

To serve this large a population, it is recommended that recent advances in PC Cluster technology and high-bandwidth networking be considered for utilization. We intend to demonstrate that the use of these technologies should be our method of choice. Using smaller computers, located at the teaching site, may at first seem attractive, but we believe that the benefits of a centrally located facility with network connections to the, remote areas is the best choice due to the:

- Ease of updating and maintaining software
- Centrality of monitoring activities
- Concentration of scarce technical personnel
- Uniformity of materials presented

Original estimates of scope have suggested a multi-node PC cluster would be the recommended compute asset for this program. One of the major goals of an initial study would be the more precise quantification of the compute requirements. The below listed estimates are based on the authors' experience with loads generated by students in similar situations. The authors have checked with Hawaiian education sources and they think such a program would have no more than 1,300 students on the network at one time. Alaskan loads are expected to be lighter.

Activity	**Text Search**	**Path Analysis**	**Text Retrieval**	**Data Analysis**	**Image Retrieval**	**Room Rendering**	**Object Rendering**
Students							
<100	0.5	0.7	0.8	1.0	1.5	2	3
1-500	2	3.5	4	5	7.5	10	15
0.5-1K	5	7	80	10	15	20	30
1-2K	10	14	16	20	30	40	60
2-5K	25	35	40	50	75	100	150
5-15K	75	105	120	150	225	300	450

Figure 2: *Estimated Compute Requirements in GigaFLOPS*
(The 1-2K line is the authors' estimate of actual load)

Define the Networking Requirements

While some study of networking requirements is planned, no unusually costly upgrades are anticipated. Most of the areas have at least DS-1 (T-1) access and cable modem or DSL capabilities are becoming more widespread. Any one of these should be sufficient for the transmission loads anticipated. Most schools have sufficient network connections. Students working at home should be able to successfully complete the work on 56K modems and schools should easily function with ISDN, DSL, frame relay, or cable modems. The major task for this project will be to implement the new technologies in a way that optimizes data flows and minimizes disruptive disconnects.

Assess Local Technical Competencies

One of the issues, most common in the authors' experience, the prevents the uniform and beneficial adoption of new technology is the uneven technical training available to classroom teachers, individual schools, and school districts. It is not uncommon to run the gamut from library science majors with no technical training to trained engineers acting as technical directors for school districts. The range of technical competency in the classroom itself is even more varied. This leads to both the inappropriate use of the available technical resources or the abandonment of the program altogether.

Design for Teacher Acceptance

By starting with the classroom teacher, the envisioned design will more likely meet their needs and not over-stretch their competency. Incorporating their needs into early planning will produce integrated instructional materials to be delivered with the product. Continued classroom evaluations will identify needs for remedial education and motivation, as well as highlight successes and areas of need.

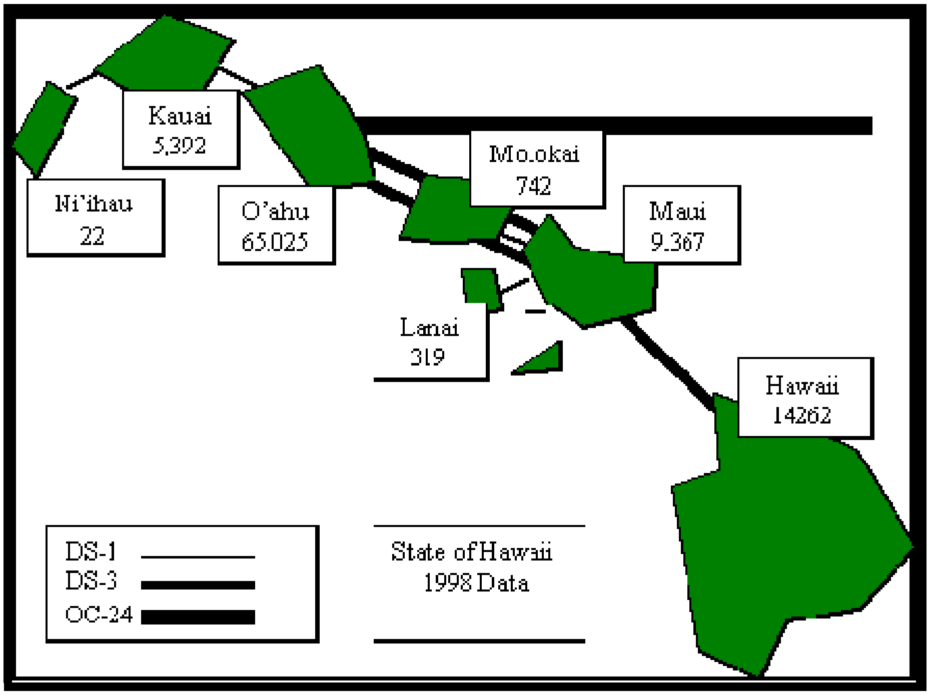

Figure 3: *Conceptual Map of Hawaiian Island Networking Capabilities (Numbers under island names are public K-6 Student enrollments)*

Design to Allow Student to Choose Path

In terms of the interface, we think it is critical for motivational and retention purposes to allow the learners to have some real degrees of freedom in choosing their own paths. The concept of the" teachable moment" also emphasizes the desirability of conveying data when the learner is most open to receiving it. Further investigation should help us understand the best ways to optimize this freedom without losing control of the subject matter.

Design to Allow Student to Choose Pace

Similarly, we think it is critical for motivational and retention purposes to allow the learners to have some real degrees of freedom in choosing their own paces for learning. Many studies have shown the benefits of individually self-paced study. The schedule to meet overall goals would still be under the control of the program teacher.

Design to Allow Program Teacher to Check Progress

To insure that the learner is benefiting from the program, it is critical that the program teacher be able to check the progress of the learners individually and as a group. We now have the compute power to help the program teacher understand progress, trends, weaknesses and opportunities for assistance. Our experience in scientific visualization will provide many new directions for study and improvement in data presentation.

Design to Allow Program teacher to Guide Program

It is also critical that the program teacher be able to guide the direction of the program for the learners, individually and as a group. As an adjunct to this program, a separately funded program to develop other didactic materials seems desirable and the need and direction for such a follow-on program will be studied and reported.

Assess Learning by Interactive Questioning

Learning will simultaneously be achieved and assessed by the process of interactive questioning. This will happen when the user first logs on, during the learning and after the course is completed. That is part of what the authors believe is true interactivity. It will be more than just responding to a series of questions, but using those responses to drive the next series of actions, be those actions more questions or different types of instruction. This process will be unobtrusive, that is it will seem to the learners to be just a conversational dialog with the computer. The computer however, will be carefully calculating the optimal next step in the learning process.

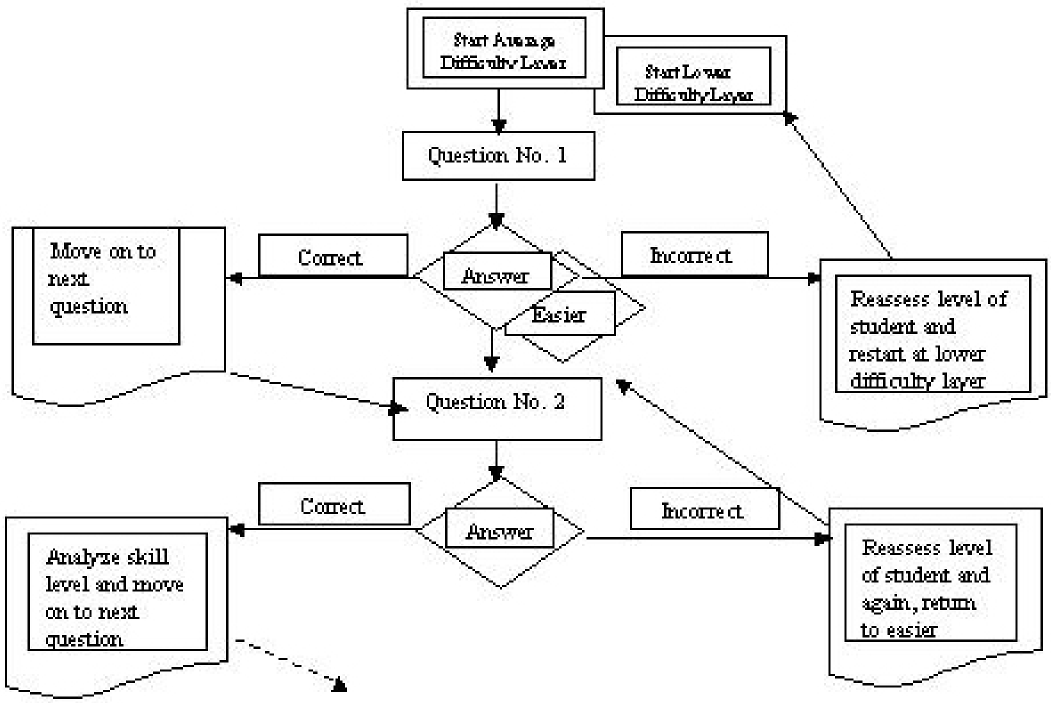

Figure 4: *Flow Chart of Sample Interactive Questioning*
(Corresponding layers of more or less difficulty not shown)

The computer will also be recording results and doing some of the initial student progress data reduction and visualization to enhance teachers' ability to see trends, problems and opportunities.

Insure Cultural Sensitivity

All the materials will be designed for, and reviewed to insure, cultural sensitivity, *e.g.* would the depiction of religious articles on the computer offend members of that culture. The project personnel will collaborate closely with the various ethnic and native cultural leaders to insure that the local view of the cultures is honored. A common mistake of an outsider is to not recognize the differences within a group, one that the outsider views as homogenous. Once these issues have been defined, an on-going relationship with local experts will be maintained to insure adjustments are made as their society changes and as their mores adjust to meet the needs of future trends. This, of course, will be done in such a way as to avoid sacrificing scientific objectivity. We see these as inviolable obligations of the researchers.

Incorporate High Performance Computing Capabilities

New advances in high performance computing have shown new capabilities for reaching and teaching learners of all backgrounds. These will be incorporated. The power that is the most efficiently represented in a PC Cluster can be utilized to provide for visualization of exhibits, analysis of appropriate next steps for instruction, progress reporting and other tasks. This power should enable the program teacher and the learner to entirely focus on their task: Learning. To adequately perform the many complex tasks necessary to present a truly Interactive Virtual Museum, the project must incorporate both the latest advances in supercomputers and the most efficient methods of using that hardware.

Incorporate High Bandwidth Networking Technology

Recent improvements in high bandwidth networking have also demonstrated new capabilities for communicating with learners of all backgrounds. The latest technology and the most advanced operating techniques should and will be mobilized to get the best product for the student. Clearly, if visualization is done in a central location, bandwidth will have to be sufficient to transport many graphics files simultaneously. Previous work in distributed simulations has shown that careful programming is as important as adequate hardware. It is not anticipated any new networking investments will be necessary in the target area.

AUTHORS

Dan M. Davis, Director JESPP Project, Information Sciences Institute, University of Southern California, received a B.A. in 1973 and a J.D. in 1975, both from the University of Colorado in Boulder. He has been active in researching supercomputer uses in the K-12 area and in large-scale intelligent agent, distributed simulations. An additional interest is the Beowulf PC Cluster technology, for which he has organized introductory and training sessions. Prior to coming to ISI, he was a Director of the Maui High Performance Computing Center, Associate Director for Strategic Development at ISI, Assistant Director of the Center for Advanced Computing Research at Caltech and Software Engineer on ASAS (a large government data fusion project) at NASA's Jet Propulsion Laboratory. He has served as the Chairman of the Coalition for Academic Scientific Computation and Chair of the Coalition for Academic Supercomputing Centers.

Laurel K. Davis received a B.A. in 1996 and a M.Ed. in 1999, both from the University of California at Los Angeles. She is CLAD certified and has taught at several multi-cultural schools in the Los Angeles area. Her Master's research was on the impact of various pedagogies on multi-cultural classroom instruction. She currently advises parents and students on a range of educational issues. Her clientele is largely from the South Los Angeles area and is comprised of multi-ethnic and recently immigrant families.

BIBLIOGRAPHY

Cahners Research, “Technology Usage in the K-12Market.” School Library Journal, March 1997

Darder, Antonia, "How Does the Culture of the Program teacher Shape the Classroom Experience of LatinoStudents? "Handbook of Schooling in Urban America, 1993

Delpit, Lisa, "The Silenced Dialogue: Power and Pedagogy in Educating Other People's Children "HarvardEd Review, Aug 1988

Diaz-Rico, Lynn, Kathryn Weed, “TheCrosscultural, Language, and Academic Development Handbook,” Allyn&Bacon, 1995.

Ogbu, John, "UnderstandingScientific Diversity and Learning" Educational Researcher, November 1992

Online Headlines; Applying Computing Technology to Preserve Cultural Inheritance, 1999

Hooks, Bell, "Transformative Pedagogy and Multiculturalism" Practice of Multicultural Education,

Hill, Randal, "Perceptual Grouping and Attention in a Multi-Agent World," Proceedings of the Third International Conference on Autonomous Agents, Seattle, WA, May 1999

Johnson, W. Et al., “Using Agents to Overcome Difficulties in Web-Based Courseware.” AI-ED'97 Workshop on intelligent Educational Systems on the World Wide Web, August, 1997.

Los Angeles Times, quote from unidentified teacher, p AA44, May 2, 1999.

Messina, Davis, et al., “Synthetic Forces Express: A New Initiative in Scalable Computing for Military Simulations.” Proceedings of the Distributed Interactive Simulation Conference, Orlando, March 1997

Nash, Christopher John, “Interactive Media in Museums”, Museum Management and Curatorship, pp. 11,171-184,1992

Pasternak, Michael, “Helping Kids Learn Multicultural Concepts: A Handbook of Strategies” 1979, Research Press,

Shaw, E. et al., “Building a Case for Agent-Assisted Learning as a Catalyst for Curriculum Reform in Medical Education.” In Proceedings of the Int'l Conf. on Artificial Intelligence in Education, July, 1999

Shaw, E., et al., “Pedagogical Agents on the Web.” In Proceedings of the Third Int'l Conf. on Autonomous Agents, pp.283-290, May, 1999