Virtual Reality and the Future of Publishing Archaeological Excavations: the multimedia publication of the prehistoric settlements on Tsoungiza at Ancient Nemea

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Abstract

The Nemea Valley Archaeological Project is a study of settlement and land use in a regional valley system in Greece extending from the Upper Paleolithic until the present. As a result of advances in electronic publishing, plans for the final publication of the Nemea Valley Archaeological Project have evolved. Complete publication of the excavation of the prehistoric settlements on Tsoungiza at Ancient Nemea will appear in an interactive multimedia format on CD/DVD in Fall 2000. This project is planned to be the first electronic publication of the American School of Classical Studies at Athens. We have chosen to publish in electronic format because it will meet the needs and interests of a wider audience, including avocational archaeologists, advanced high school and college students, graduate students, and professional archaeologists. The multimedia format on CD/DVD will permit the inclusion of text, databases, color and black-and-white images, two and three-dimensional graphics, and videos. This publication is being developed in cooperation with Learning Sites, Inc., which specializes in interactive three-dimensional reconstructions of ancient worlds (http://www.learningsites.com). The Nemea Valley Archaeological Project is particularly well prepared for the shift towards electronic publishing because the project's field records were designed for and entered in computer databases from the inception of the project. Attention to recording precise locational information for all excavated objects enables us to place reconstructions of objects in their reconstructed architectural settings. Three-dimensional images of architectural remains and associated features will appear both as excavated and as reconstructed. Viewers will be able to navigate these images through the use of virtual reality. Viewers will also be able to reference all original drawings, photographs, and descriptions of the reconstructed architecture and objects. In this way a large audience will be able to view architectural remains, artifacts, and information that are otherwise inaccessible.

The Nemea Valley Archaeological Project (NVAP), in the northeast Peloponnesos of Greece, is a study of long-term patterns of settlement and land use within a regional valley system and of the interaction between the region and the outside world. The valley is a well-defined geographic unit that was selected for its capability for supporting settlements at different times in the past ranging from the Middle/Upper Paleolithic until the present. The results of this project complement those of the excavations of early Iron Age through Byzantine remains in the Sanctuary of Zeus at Nemea (excavated from 1924 to the present). The Project focuses on the environmental, socio-political, and economic conditions that encouraged different modes of land use and settlement, and caused periods of abandonment.

Another central focus of the Project is the study of the changing interaction of inhabitants of the valley with the external political economies of the larger centers outside it. The valley lies within a strategic zone that commands a number of important routes of transportation between the Corinthia and the Argolid, central areas of ancient and modern Greece. Although located near such historically important centers as Corinth, Mycenae and Argos, the valley area is also slightly off the beaten track since the major routes of transportation run around the valley at its southwest and southeast. The Project explores when and why inhabitants of the region functioned autonomously or were incorporated within larger social systems.

These goals guided the structure of the Project's field research. Active field research was conducted by four teams between 1981 and 1990. The first component was an intensive, systematic surface survey of archaeological remains in the region. Second, and closely related to the first, was a social anthropological study of modern settlement and land use based on historical archives and ethno-archaeological and anthropological studies of recent settlement. Third was a team assigned to excavate the succession of prehistoric settlements on Tsoungiza at Ancient Nemea. Fourth, historical ecologists, a palynologist, and a geologist formed the environmental component of the research.

The Nemea Valley Archaeological Project is directed by James C. Wright, Professor of Classical and Near Eastern Archaeology at Bryn Mawr College. The Project is sponsored by Bryn Mawr College under the auspices of the American School of Classical Studies at Athens. Support for the Project was provided by The National Endowment for the Humanities, The National Geographic Society, The Institute for Aegean Prehistory, the Hetty Goldman Fund of Bryn Mawr College, and private donors. A major preliminary report on the Project appeared in *Hesperia*, the Journal of the American School of Classical Studies at Athens (Wright 1990). Forty-five additional journal articles resulting from specialists' studies have appeared or are in press.

A project of this magnitude and scope requires careful systematization and coordination of record keeping. Good records are also the result of methods of fieldwork that produce information that advances the goals of the project and permits subsequent research and analysis not anticipated by the original goals. We decided in 1983 to standardize all records and to coordinate them using relational databases. All data were entered into portable computers in the field. At that time we envisioned using our databases to facilitate research as we prepared traditional print publications.

As a result of advances in electronic publishing, however, plans for the final publication of the Nemea Valley Archaeological Project have evolved. Complete publication of the excavation of the prehistoric settlements on Tsoungiza at Ancient Nemea will appear in an interactive, multimedia format on compact disks/digital versatile disks (CD/DVD). These settlements include remains from the Early Neolithic period (6th millennium B.C.E.) through the end of the Late Bronze Age (ca. 1200 B.C.E.). The goal of the multimedia publication project is to publish the results of the excavation in a format that will meet the needs and interests of a wide audience, including avocational archaeologists, advanced high school and college students, graduate students, andprofessional archaeologists. The presentation is organized so that everyone from the general public to the experienced researcher can easily follow pathways through the publication to information appropriate to the reader's level of interest (Fig. 1). Readers have the option of selecting their own level of interest at the beginning by selecting the general, student, or professional edition. The general and student editions provide text edited accordingly for that level. Readers have the option of moving to a different level as their interests expand.

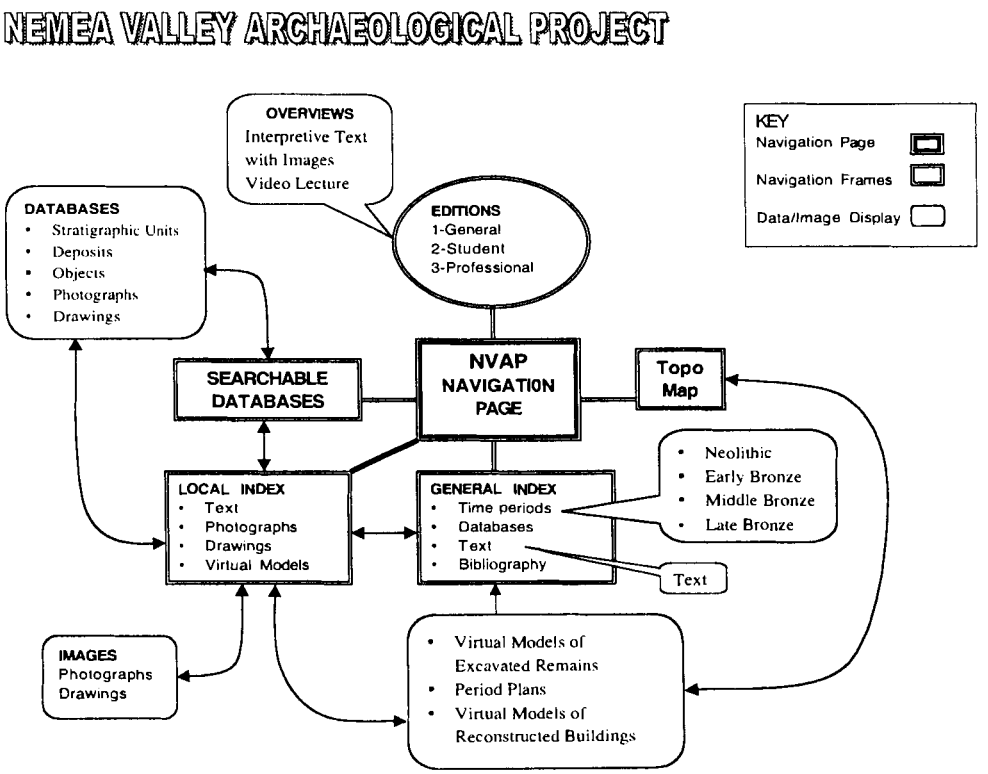

Fig. 1

Multimedia publication on CD/DVD permits the inclusion of text, databases, color and black-and-white images, two and three-dimensional graphics, and videos. At the core of the publication are interactive three-dimensional reconstructions of the remains (architecture and artifacts) accessible through virtual reality. The reader can walk over the virtual landscape of the archaeological site and explore the architecture and associated artifacts in different time periods. Interpretive text, appropriate to the different levels of audiences, guides the reader through the remains of each time period. The text summarizes the data and relates each phase of settlement to the results of the regional study as well as to the archaeology of the Aegean area. By selecting the professional edition, scholars can have unlimited access to all field-collected data (field notes on stratigraphy, pottery analysis notes, catalogs of artifacts and non-artifactual remains, photographs, and drawings) using the publication's sophisticated search capabilities. All this information is linked to the original find context.

This project is planned to be the first electronic publication of the American School of Classical Studies at Athens. The American School of Classical Studies at Athens is a non-profit educational institution which co-sponsors archaeological research projects in Greece with American universities. Traditional paper publication of the results of School-sponsored projects has resulted in expensive and often cumbersome large-format printed volumes containing numerous illustrations. The limited market for these print publications makes their production cost prohibitive without large subventions (Darnton 1999). The need to limit illustrations to reduce costs contributes to a restricted presentation of the field-collected data.

The large scope and interdisciplinary nature of the Nemea Valley Archaeological Project created information that is not suited to the linear, hierarchical structure of print publication. The large quantity of data and images generated by the Project is not economically reproducible in printed form, nor will all readers need to use all the available information. In print publications, archaeologists have been restricted to presenting a limited amount of the information recovered. The advantage of multimedia publication is its ability to present large amounts of data and images in an interactive format that dramatically increases the readers ability to access and visualize the information and interpretations (Arcelin 1997).

This publication is being developed in cooperation with Learning Sites, Inc., an educational and research company which specializes in interactive three-dimensional reconstructions of ancient worlds (http://www.learningsites.com). They use virtual reality to create digital reconstructions of archaeological sites for museums, education, and scholarly research. Their other projects include work on Nemrud Dagi in Turkey, Vari in Greece, and Nimrud in Iraq.

There are many definitions of virtual reality (VR), and the term has become so overused in the past few years that many people are unclear as to exactly what the term refers. Further complicating matters is the frequent use of the adjective "virtual" in contexts quite divorced from any relationship to true virtual reality, other than that it is usually online and meant in some way to indicate an electronic simulation of the noun which it is referencing (as in *virtual museum*).

For our purposes, the term virtual reality will be defined as an interactive, self-directed, multi-sensory, computer-generated experience providing the illusion of participating in a synthetic three-dimensional environment. Along with the multi-sensory aspect of VR, comes the degree of immersion of the experience; how many senses are involved and how easily does the participant believe in the *reality* of the experience.

Our virtual reality is different from QuickTime VR (QTVR) or photo bubble technology. QTVR constructs a spherical universe, the inside of which is tiled with photographs seamlessly stitched together. The viewer is placed at the middle of the sphere and can look in all directions by sliding the cursor in the direction he or she wishes to gaze. The space appears realistic, although in some instances there may be a fisheye lens-like distortion to the scene, depending on how the images were created (by camera or by renderings from a three-dimensional model). The user may zoom in toward an object in the images, as if moving toward it in real time.

The resolution of the images is dependent on the quality of the initial photographs, which presents a practical limit to the amount of zoom that can be achieved before the image is reduced to pixels. Further, since the scene is composed merely of photographs pasted together, there is no true three-dimensional space through which users may wander. Movement through the room or space is simulated using the cursors and zoom function, but users cannot walk behind an object, climb a staircase, or look down into something.

The newest versions of QTVR can create hot spots in scenes that, when clicked on, activate other QT

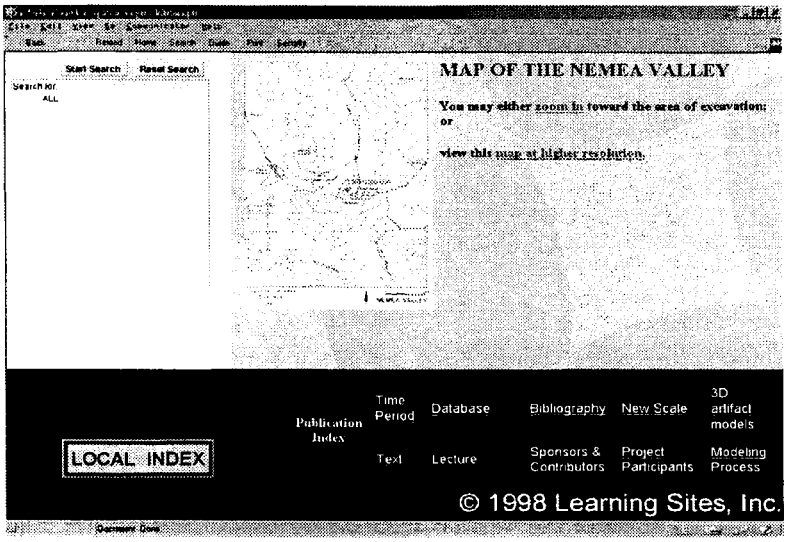

Fig. 2

sequences. This enhances the simulation of walking through an outdoor landscape or from one room into another. Sound can also be added.

Unlike QTVR, which is a simulated space, true virtual reality takes place within a true three-dimensional environment, usually constructed with special world-building tools or CAD programs. This type of virtual reality is created by actually constructing a computer-based replica of a real or imagined space. Such spaces allow freedom of movement anywhere within the world. Because there is a full three-dimensional coordinate system, users can explore anywhere, look underneath objects, and walk behind or inside objects, buildings, or spaces. Programming techniques, such as constantly switching the images that are used to simulate the textures and colors of the objects in the space, allow the scene in view to remain in continuously high resolution as visitors approach objects while at the same time blurring those items farther away, akin to real eyesight.

Three-dimensional virtual worlds simulate a multisensory experience by creating a world with independently moving objects and providing the ability to have more than one user walking through the space at any one time, each one visually aware of the others in the same space. Sound and direct tactile feedback contribute to the experience. All these features enhance the simulation of the real world in a way that QTVR cannot. The interactive three-dimensional reconstructions of the remains of the prehistoric settlements on Tsoungiza are true virtual worlds.

The use of VR to present the results of the Nemea project is intended to offer all readers a deeper experience of the remains and their environs than has ever before been possible. For example, by coordinating the VR reconstructions of the grounds of the site with the results of the paleobotanical research, the original plant life can be displayed. The Project's field records were designed for and entered in linked relational databases from the inception of the project in 1984. Now, taking advantage of advances in image management systems, scanned images of the original photographs and drawings are linked to the databases. Using hypertext, text reporting the analysis and results of scholarly work on the archaeological data is linked to the databases and images. Using virtual reality, the results of this scholarly work present manipulable three-dimensional recontructions of the terrain, architecture, and artifacts.

Our attention to recording precise locational information for all excavated objects enables us to place reconstructions of objects in their reconstructed architectural settings. Three-dimensional images of architectural remains and associated features appear both as excavated and as reconstructed. Viewers are able to navigate these images through the use of virtual reality. Viewers are also able to reference all original drawings, photographs, and descriptions of the reconstructed architecture and objects. In this way a large audience will be able to view architectural remains, artifacts, and information that would otherwise be inaccessible.

To achieve these results, the NVAP publication program combines several languages (JAVA, VRML,

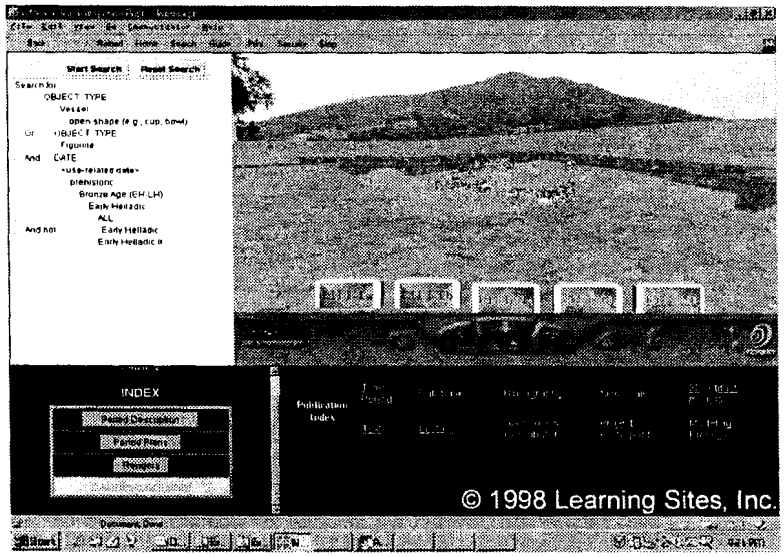

Fig. 3

HTML, and JavaScript) and is capable of running in different browsers on different platforms. These languages are so new and change so rapidly that earlier versions of the program had to be revised to work with the current browsers. Most programs are written in one language and run on only one or two operating systems.

The resulting problems that had to be overcome to write this program required technical innovations. When a Java program runs inside a browser, it is called an applet. Java applets have special security features that do not allow the program to access the local computer's hardware (disks, CD, printer, etc.). At the time this project began, there was no single source of information on how to make the program run inside a browser. It had to be pieced together from several sources. The licensing fees for the available server software that could have been used to access the database made its use prohibitive. Working with Inprise Corp. (formally Borland International, the maker of the Java compiler used in this program) we came up with the present design, which involved breaking the data up into many smaller files that are loaded only as needed.

The multimedia publication presents the reader with a navigation page divided into four frames (Fig. 2). All four frames remain visible as the reader accesses the information in any one of them. One frame contains the general table of contents. From it, the reader can choose to begin reading the text or to hear a lecture that provides an overview of the project. Alternatively, the reader can select a time period to investigate or a database to search. This frame also provides links to lists of authors and contributors and the bibliography. A second frame, the local index, provides a list of the available data for the time period, building, or artifact currently selected by the reader. These categories of data include text, photographs, drawings, and three-dimensional reconstructions. The third frame, the image frame, displays the text, photographs, drawings or reconstructions of the building or artifact currently selected by the reader in the other frames. The fourth frame displays the searchable database. These multiple modes of entry allow the readers to begin and continue their study of the data from any point.

For example, the reader can use the image frame to explore a VR reconstruction of the existing archaeological remains (Fig. 3). This allows the reader to "walk" around the excavated remains as if he or she was visiting the archaeological site. As one points the cursor at walls or artifacts, a caption describing the indicated object is displayed in the status line at the bottom of the screen. By clicking on the object, the list of available data about that object is displayed in the local index frame. The reader can then choose to look at descriptions, drawings, photographs, or three-dimensional reconstructions of the object.

Within the three-dimensional reconstruction of the existing archaeological remains, the reader can select a time period. Then only the remains attributed to that time period are displayed. He or she can also choose to display remains from a combination of time periods. Alternatively, from the beginning readers can limit their exploration of the

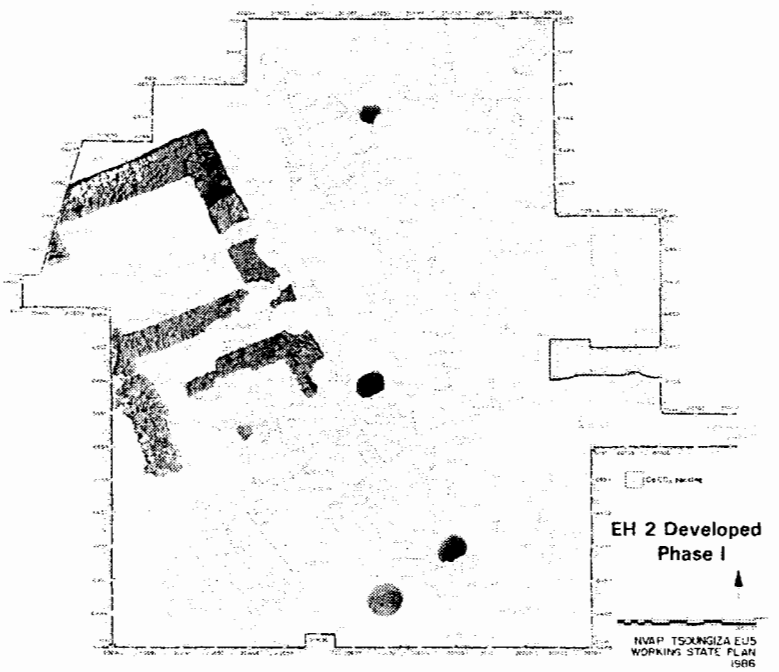

Fig. 4

remains by time period by selecting a time period in the general table of contents. Photographs of the remains for the selected time period, overlaid on the state plan, are displayed in the image frame (Fig. 4). As in the reconstruction, the reader may select a feature, such as a wall or a pit, and then choose to see the original photographs and drawings of the feature.

When looking for a particular type of information, the reader can begin by searching a database. The databases include the Stratigraphic Unit (SU) and Square Meter Unit (SMU) databases that describe every discrete unit of archaeologically recovered remains (often called "loci" or "buckets"). These databases provide east-west and north-south Universal Transverse Mercator coordinates, top and bottom absolute elevations above sea level, soil descriptions (including Munsell color), and the relationship of the excavated soil to features (such as walls, pits, floors, and hearths). The pot notes database provides the major, latest, and earliest relative dates of the pottery from a single stratigraphic or square meter unit as well as the count and weight of the potsherds according to fabric and surface treatment. The deposit database describes associated stratigraphic units which form deposits (interpreted activity areas) based on analysis of the stratigraphy and the artifacts.

The object database provides descriptive information for all types of individually cataloged objects (Fig. 5). In order to search the database, the reader selects a combination of attributes from a hierarchically organized list. Boolean searches can be made. At the first level, the reader chooses whether to search under a specific object type, its physical attribute, date, or inventory information. Under Object Type, one chooses among architectural components, coins, figurines, fragments, jewelry, lamps, manufacturing by-products, tools, or vessels. At the next level, there is a choice among specific types of tools, vessels, etc. Thus, the reader is able to search at more or less refined levels depending on his or her interests. Under Physical Attribute, readers can select material, measurements, decoration, and preservation. Under Material are listed bone, clay, faience, glass, ivory, metal, mudbrick, organic material, plaster, shell, stone, or mixed materials, each with its own sub-categories. Under Decoration are listed painted (with sub-categories including pattern painted, linear painted, or solidly painted) or unpainted. Under Preservation are the terms intact, completely restorable, partially preserved but fully restorable, rim, body wall, handle, base, and combinations of the above. Back at the first level, under Date, the reader selects Paleolithic, Mesolithic, Neolithic, Early Helladic, Middle Helladic, or Late Helladic, each with its own more refined

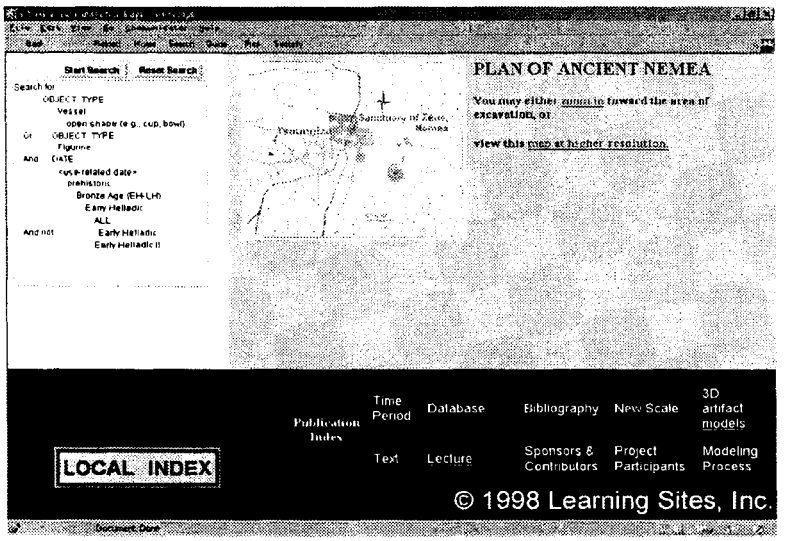

Fig. 5

subcategories. Inventory information includes options to search according to find location.

The results of the search are displayed as a list. By selecting one object from the list, the reader can access photographs, drawings, and VR reconstructions. The reader can also access the object in context. The VR reconstruction of the excavated remains will be displayed highlighting the location at which the object was found.

In addition to VR reconstructions of the existing archaeological remains, the reader can explore VR recontructions of the original appearance of selected structures (Fig. 6). The process of creating reconstructions in the virtual world demanded a complete analysis of the existing remains and comparanda. Every aspect of its original appearance had to be considered because the reader is able to look at the reconstruction from every viewpoint. For example, the appearance of the underside of the roof cannot be finessed as in three-dimensional iconic reconstructions. VR models of selected artifacts found in the reconstructed buildings are included in their original contexts. The reader can then choose to view the model of the

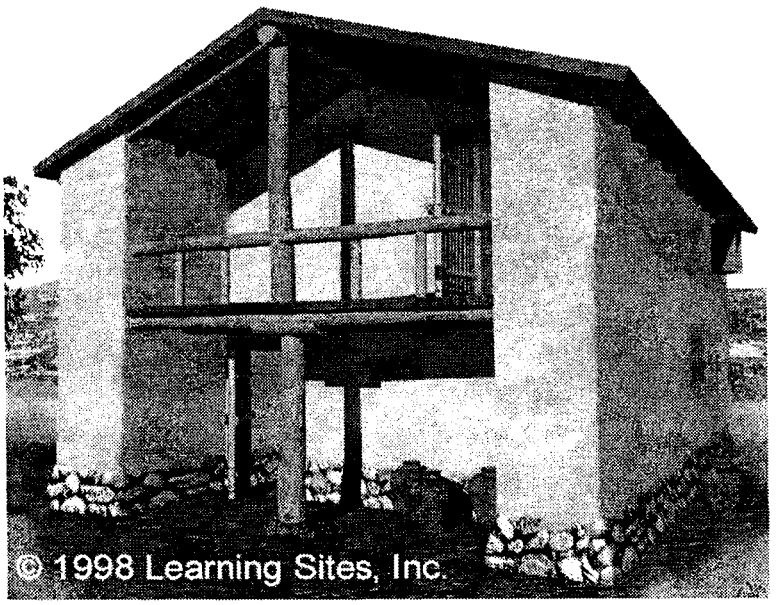

Fig. 6

artifact by itself, rotating it so that it can be viewed from any angle (Fig. 7). The reader can also choose to display the object with a three-dimensional scale surrounding it. As with the reconstructions of the existing archaeological remains, the reader can easily refer back to the original descriptions, photographs, and drawings on which the reconstructions are based by selecting a feature or artifact and using the local index.

The facility with which one is able to refer back and forth from conclusions and reconstructions to field-collected data and images is one of the ways in which this multimedia format surpasses other currently available multimedia presentations, not to mention print publications. In an electronic publication it is possible to provide the complete archive of field-collected data and images and to make them accessible through databases. The use of virtual worlds to present reconstructions challenges the archaeologist to consider every aspect of the data in drawing conclusions. Moreover, it makes it possible for the general public and students to visualize the archaeologist's conclusions. Finally, the virtual worlds of the excavated remains and artifacts allow a large audience to see and understand an archaeological site that is now largely reburied and artifacts that cannot be seen on exhibition in a museum.

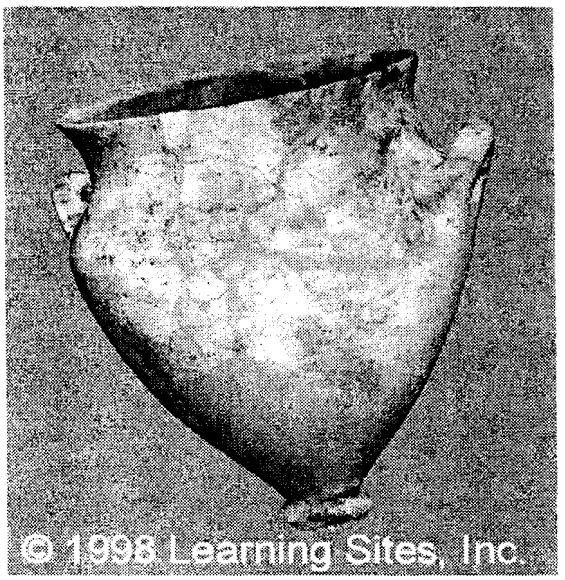

Fig. 7

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