

# Virtual Sambor Prei Kuk: An Interactive Learning Tool

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## ABSTRACT

MUVES (Multi-User Virtual Environments) are a new media for researching the genesis and evolution of sites of cultural significance. MUVES are able to model both the tangible and intangible heritage of a site, allowing the user to obtain a more dynamic understanding of the culture. This paper illustrates a cultural heritage project which captures and communicates the interplay of context (geography), content (architecture and artifacts) and temporal activity (rituals and everyday life) leading to a unique digital archive of the tangible and intangible heritage of the temple complex at Sambor Prei Kuk, Cambodia, circa seventh-eighth century CE. The MU6VE is used to provide a platform which enables the experience of weaved tangible and intangible cultural heritage. This, we argue, turns static space into meaningful place. Further, this kind of digital model has the potential to bring together Jean Lave and Etienne Wenger's theorizing on the importance of community in education and more recent theorizing on the impact of Virtual Worlds on learning by James Paul Gee.

**Keywords:** Multi-User Virtual Environments (MUVES), New Media, Tangible Heritage, Intangible Heritage, Place-making, Hinduism, Temple, Education, Cambodia

## 1. INTRODUCTION

The Virtual Reconstruction Project of the central temple at Sambor Prei Kuk in Cambodia is an attempt to apply a twenty-first century CE technology to a circa seventh-eighth century CE cultural heritage. Sambor Prei Kuk provides the earliest record of Khmer temples, predating the better known (and better preserved) Angkor Wat by several centuries. Hence, the study of Sambor Prei Kuk is crucial for understanding the Khmer, pre-Angkorian tradition and the subsequent development of temple cities in the region. Sambor Prei Kuk has been studied by archaeologists and other scholars for many years.<sup>1</sup> Their work has provided much knowledge of the culture and the period, especially about the eastern expansion of Hinduism

<sup>1</sup> For the classic studies in the art and architecture of the Khmers, see the following introductions: Parmentier, *L'Art Architectural Hindou dans l'Inde et en Extrême-Orient* (1948); Dupont, *La Statuaire Préangkorienne* (1955); Chihara, *Hindu-Buddhist Architecture in Southeast Asia* (1996); Dumarçay and Royère, *Cambodian Architecture* (2001).

along the trade routes from its Indic origins into Southeast Asia—one of the great cultural assimilations in human history.

Much of this important work has, so far, remained the exclusive province of researchers, hidden from the general public who might find it justifiably interesting. Further, the advent of immersive, interactive, Web-enabled, Multi-User Virtual Environments (MUVES) has provided us with the opportunity to tell the story of Sambor Prei Kuk in a way that can help visitors experience this remarkable cultural heritage as it might have been in the seventh-eighth century CE. MUVES are a new media vehicle that has the ability to communicate cultural heritage experience in a way that is a cross between filmmaking, video games, and architectural design. Unlike a film, it allows the observer to be an active participant in the experience. Unlike video games, its objective is to teach, rather than entertain. And unlike architectural design, it models, in addition to the built environment, the people who inhabited the site and their rituals.

The project has two major audiences: (1) students and other non-specialist visitors: the model enables non-specialists to gain access to the Khmer's unique cultural heritage through these new media technologies. Further, the construction of interactive narratives permits visitors to experience cultural heritage in a different way and (2) local heritage site authorities: the project provides Southeast Asian conservationists with digital representations of places through spatial and cultural data, for example, laser scans of endangered structures.

It is important to note that the audience for this MUVE is not specialists in pre-Angkor Khmer architecture and religion, at least not in this iteration. That is, the goal of the project was not architectural verisimilitude, nor did it attempt to portray a perfect simulation of pre-Angkor religious practice. Let us take up each issue briefly before moving on to describe what we did do. First, to achieve architectural verisimilitude—for example modeling the lintels on the shrines with great detail<sup>2</sup>—would increase the computational size of the model to the point where it would not function on an average computer. Certainly, we could have created a much more detailed model, but then

<sup>2</sup> Lintels are a great example of detail that we had to do without. Much is known about the style of lintels at Sambor Prei Kuk, one could look at, for example, Dupont, "Les Linteaux Khmers du VIIe Siècle" (1952), especially pp. 40-52. However, these kind of small details on every building would make the computational size of the model massive.

visitors would need a dedicated, powerful computer to visit it. Once we decided to engage the general public, and by general public we mean those with common access to the worldwide web, we had to make sure the model functioned on a home computer of average computational ability with access to average levels of bandwidth for its multi-player option. With that said, we did obtain a high quality laser scan of the central shrine  $C_1$ . From this we modeled a *relatively* detailed object (see Fig. 3 below). However, many of the other buildings, and even more so the avatars, had to be rendered in a less detailed way to make the world actually function.

The issue with modeling religious practice was the opposite of the above: while there is too much data to include in the architecture of the site, there is too little unproblematic evidence as to what kind of religion was practiced at such shrines. We chose not to leave the site empty of intangible cultural heritage—that is empty of people actually doing something—and the only solution here was to use imperfect evidence (which we alert the reader to throughout the paper).<sup>3</sup>

Despite these technical and scholarly limitations, Sambor Prei Kuk, we believe, is an excellent example of a site which benefits from the interactive nature of a MUVE. Its political and religious ideologies are intimately intertwined with its built form, and therefore they must be experienced together to get a full understanding of the site. A full version of this paper would begin with a detailed history of the site including the ideologies which drove its construction and use, as well as discuss the link between kingship, religion, and the concept of the *mandala* in seventh-eighth century Southeast Asia. However, in this version of the paper, due to length limitations, we forgo most of these important preliminaries and begin with a description of the data used and decisions made in modeling both the tangible and intangible heritage (§2 and §3). We then detail how we wove together these two forms of heritage using the metaphor of a stage play (§4). We then lead the visitor through the MUVE starting at the market and working inwards to the middle of the temple complex (§5). In the final section (§6), we offer some reflections on the methodological and pedagogical issues relating to education that arose in the course of the project. We do not have firm solutions to these issues, but we suggest ways that we might go about engaging with them in future projects.

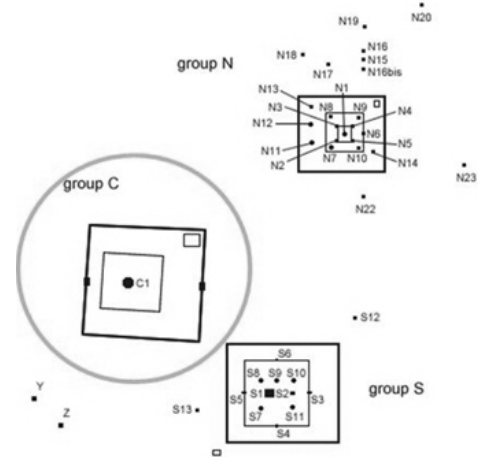
## 2. MODELING THE TANGIBLE HERITAGE

The Sambor Prei Kuk Temple cluster has been identified as the capital of the kingdom of Ishanapura founded by Ishanavarman I (r. 616-635 CE). The Chinese knew this region as Chenla and wrote about it as a unified state. But rather than a unified state, Chenla was in fact a loosely tied together set of polities in constant flux. At times there would be less cohesion, and then under the leadership of particularly strong ruler, such as Ishanavarman I or Jayavarman I (r. 657-690 CE), the polities would come together with the power radiating out of the center, only to separate out again as the power centre either shifted or lost legitimacy. The primary technology used to integrate the political realm was religious ritual, and the primary religion of the state was Shaivism. The link between religion and the state was instantiated by the ideology of the *mandala*. In both Hindu and Buddhist ritual, a *mandala* is a complex geometric design,

<sup>3</sup> For a review of the issues pertaining to religion and state formation in pre-Angkor Cambodia, see Michon, "Pre-Angkor Religion and State," pp. 28-36.

most often either a circle or a square, meant to harness the energy of the cosmos as it replicates, in miniature, the nature of the cosmos itself. The source energy of the *mandala*, and thus the cosmos, emanates from the centre, flowing outward and decreasing in power as it reaches the periphery.

The temple complex at Sambor Prei Kuk is comprised of three "clusters" of temples, labeled Northern (N), Southern (S), and Central (C) group. We chose to model only the Central group as it was the most simple (Fig. 1).



**Fig. 1** The three major temple clusters at Sambor Prei Kuk.

The center of group C is occupied by a central sanctuary ( $C_1$ ),

... the cella is large (8.35 x 5.5 m), the walls are divided into panels by pilasters with neither bases nor capitals,<sup>4</sup> and which seem to support the ceiling inserted into a semi-circular hollow created into the whole of the circumference at the top of the walls. Externally the sanctuary rests on a molded base, interrupted on the four sides by a flight of steps, the string walls of which were decorated with lions.

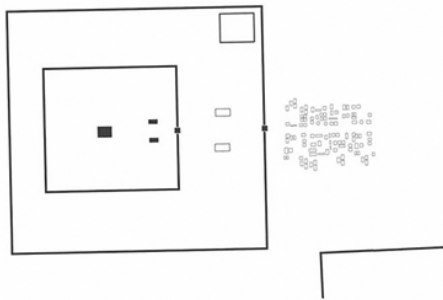
(Dumarçay and Royère, 2001, p. 43)

The two lions, indicating the royal nature of the temple, have inspired the most popular name of the temple: Prasat Tao, 'Lion Temple'. A causeway leads from the central shrine  $C_1$  to the inner wall *gopura*, or entrance gateway, straight to the outer wall *gopura*. On either side of the causeway in the inner courtyard, there may have been two smaller structures used as ancillary shrines.<sup>5</sup> On either side of the causeway in the outer courtyard are two pools most likely used for decorative landscaping. In the far northeast corner of the outer courtyard is another pool with steps leading down to it; this pool was most likely used for ritual bathing before performing rituals. Beyond the outermost wall we modeled a market since religious sites

<sup>4</sup> This is a common architectural feature of these temples, that is, pilasters without bases or capitals. Georges Coedès refers to such 'pilasters' as *piédroits* in his *Inscriptions du Cambodge*, 8 vols. (Paris: EFEO, 1937-66).

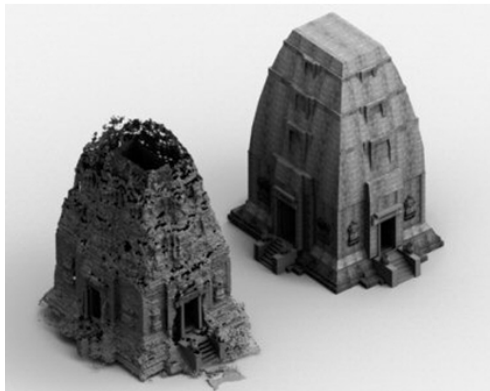
<sup>5</sup> There are no extant structures there, but the archaeological evidence suggests that two structures did exist. We chose to recreate these two buildings based on the number of shrines in both the northern and southern groups.

like this one attracted many people, promoting activity in support of the temple and for its own sake (Fig. 2).



**Figure 2** Site plan of the reconstructed Central group.

Our modeling of the site was facilitated by a laser scan, provided by Dr. Takeshi Oishi of the University of Tokyo, in Japan. This technology uses a radar-like device, which shoots a laser ray at the object being scanned, and records the time it has taken the ray to reach its target. The result is a point, defined in 3-dimensional space. Since the device repeats this procedure thousands of times every second, the result is a ‘cloud’ comprising millions of points, which together define the surface of the object. This point cloud is then processed through software to generate a three-dimensional model of the object (Fig 3).



**Fig. 3** Laser scan (left) and model (right) of the central temple (C<sub>1</sub>) at Sambor Prei Kuk.

The site model was developed in 3DStudioMax (a modeling software made by Autodesk Corp.), and exported to Torque (a game engine made by Garage Games Corp.), which powers our virtual world. Like other similar engines, Torque incorporates a physics engine whereby ‘gravity’ is imposed, solidity of objects can be enforced, and time of day and weather phenomena can be included. Torque also provides mechanisms to support PCs and NPCs (player characters and non-player characters), which were useful for implementing the actors.

### 3. MODELING THE INTANGIBLE HERITAGE

The first step was to create a three dimensional, digital model of the physical attributes of the central temple group at Sambor Prei Kuk. Three dimensional recreations of ancient sites are

now quite common—a simple search on the web will return many such models. However, the three dimensional model of a city captures only the static, tangible heritage of the site; it only models the space. Static *space* becomes meaningful *place* only when the it is used in particular ways. As Steve Harrison and Paul Dourish argue, place is “rooted in sets of mutually-held, and mutually-available, cultural understandings about behavior and action . . . Space is the opportunity; place is the understood reality” (Harrison and Dourish, 1996, p. 68). Lived daily life transforms space into place, and the only way to explore the place-ness of a city is to inhabit it with people performing activities. Thus, the physical attributes of the space frame the activities that ‘take place’ there and provide its inhabitants with a socially shareable setting for their activities in terms of cues that organize and direct social behavior that is appropriate for that particular space. Thus, the Sambor Prei Kuk MUVE moves beyond static spaces and creates livable places that can generate new insights into how the site functioned.

The accuracy of the modeling of the physical environment, the tangible heritage, of the central group, while certainly simplified as explained above, is quite secure. There is plenty of evidence from archaeological remains, and any gaps in that knowledge can be filled with confidence by comparing the central group to the northern and southern groups as well as to other contemporary temple complexes within the greater Sambor region. However, modeling the *intangible heritage*, that is the actions of the inhabitants, is much more speculative. There is very little evidence concerning the type of daily rituals from contemporary Sambor Prei Kuk, therefore, we had to turn to two other sources: (1) inscriptional evidence from ninth-eleventh century CE Cambodia, and (2) contemporary Shaivite texts which originated in India in the early medieval period, that is the fourth-ninth century CE, but are extant most often as palm-leaf manuscripts from late medieval, that is tenth-thirteenth century CE, Nepal. In the case of (1) we have the same geographical region but a significant temporal gap, and in the case of (2) we have a similar temporal frame but a significant geographical displacement.

The spatial configuration of the sacred area of the central group at Sambor Prei Kuk suggests the very division of religious ritual which was key to Shaivism’s success.<sup>6</sup> That is, Shaivism maintained a hierarchy of religious ritual that is mirrored in the physical division of the site. The inner courtyard would serve Shaivism at the most elite level. It is here that the royal chaplain (the *rajapurohita*), on behalf of the king and his court, would perform rituals that would benefit the king personally, but also his household, lineage, and ultimately his whole kingdom. The most powerful ritual, the worship of the Shiva *linga* alone, would have been centered on the *linga* in shrine C<sub>1</sub>. Outside shrine C<sub>1</sub>, but still within the inner courtyard, ancillary forms of Shiva would be worshiped in the two small shrines located to the east. These practices would evoke the broader mythological resonances of Shaivism rather than the specific individual and royal concerns addressed at shrine C<sub>1</sub>. Further, we have chosen to place a particular Shaivite initiation ceremony, the *mandala* initiation, within the inner courtyard as well. This ceremony would only be for those in the inner circle of Shaivites and

<sup>6</sup> For more details on Shaivism in early and medieval Cambodia, see Sanderson, “The Shaiva Religion Among the Khmers” (2003) and Sanderson, “Shaiva Officials in the Territory of the King’s Brahmanical Chaplain” (2004).

would not be on public display, but we chose to include it in the inner courtyard to give visitors an idea of how it might look.<sup>7</sup>

The outer courtyard would serve the ‘lower’ levels of ritual and worship. We chose to model two brahmanical forms of ritual. The first is the fire sacrifice, in Sanskrit *yajna* or *homa*. Here, brahmins would perform more mundane rituals for the health, wealth, and fortune of the common people with full sanction from the ruling class. The second ritual is that of bathing to establish purity. Finally, outside the ritual enclosure altogether there is the non-sacred, profane market.

#### 4. WEAVING THE TANGIBLE AND INTANGIBLE: PLACE AND PLAY

New media reconstructions of historically significant sites, artifacts, and activities bring new opportunities to the practice of preservation, to the communication of information, and ultimately to the education of the public within the field of cultural heritage. Non-linear storytelling, immersion, and interactivity affect each aspect of the practice. But their critical implications are not limited to the technical aspects of representation. Rather, new media have the power to transform the practice of cultural heritage preservation, communication, and education wholesale, possibly affecting the meaning of the heritage itself.

The relationship between a representational technologies and the cultural heritage they communicate is as ancient as civilization itself. It can be traced back to cave drawings from the upper Paleolithic age, some 40,000 years ago, which supposedly were used to help bring hunts to successful conclusion. The oral epics of Homer and others were used as a social instrument to communicate cultural heritage from one generation to another, only to be replaced by written versions in the form of scrolls, and later by codices, each of which exerted its own influence through the process of remediation: while oral renditions allowed for variations due to the skills of the bard, written forms codified the story, creating an ‘official’ version. The invention of photography early in the nineteenth century had a particularly strong impact on the representation of cultural heritage. The impact was even more profound with the invention of cinema—a medium able to capture the passage of time itself. The advent of digital game technology—the new medium of remediation—has the potential to affect cultural heritage in even more profound ways than before.

The guiding metaphor we chose for such modeling is the concept of *place*. A ‘place’ is a setting that affords the entire spectrum of human activities, including physical, social, and cultural activities, while affecting, and being affected by, those activities. We chose this metaphor to guide our work because it pertains to both physical and non-physical settings. On one hand, place is often used to describe the territory that we

<sup>7</sup> The inclusion of the *mandala* initiation ceremony is the most historically inaccurate (and speculative for that matter) of the whole reconstruction. But after a long discussion, we decided to include it to help us practice certain modeling techniques. If this model was to be presented as an ‘historically accurate’ model, we would remove these initiations. The problem of accuracy is a tough one, and it is dealt with in more detail in below and in §6.

occupy. The boundaries of this territory are defined by a sense of being inside—inside a region, a town, a neighborhood, a building. But that boundary is identified not by a demarcation of its edge, but by the feeling of coherence of the spaces, objects, and activities within it, a coherence which gives rise to a competence in the way a place is inhabited. We value such places because they give us a feeling of being *somewhere* as opposed to just *anywhere* (Chastain, 1998). The physical attributes of the place frame the activities that ‘take place’ there, and provide its inhabitants with a socially shareable setting for their activities and rituals, in terms of cues that organize and direct social behavior that is appropriate for that particular place (Harrison and Dourish, 1996).

To help us organize the model, we chose to compare our virtual place-making to a stage-play, which comprises a stage (a context), a narrative (the play), and actors (which include the audience, or visitors, in our case). The notion of place as a stage-play drives literary works, films, video games, and architecture. It provides a framework for understanding the individual contributions of the components, and their mutual interactions.

The ‘stage,’ or context, comprises both space and time. It affords spatial and temporal grounding for the entire model, and includes spatial components like buildings, trees, topography, sky, etc., and ‘props’—objects that can be manipulated by the actors or can act on their own, such as animals, fire pits, the Shiva *linga*, etc. The ‘actors’ include avatars, or PCs (player characters), which are human characters controlled by the people who are logged into the system (the visitors); as well as agents, or NPCs (non-player characters), which are pre-animated, semi-autonomous entities, that perform pre-scripted roles, and sometimes have action modification capabilities based on some sensory input (e.g., they can start some action sequence when an avatar approaches them). The ‘play,’ or narrative, includes both cultural heritage aspects and the activities that take place in the environment (known together as simulation/action). They tell the story (or stories) and afford the freedom to participate in the story (Fig. 4).

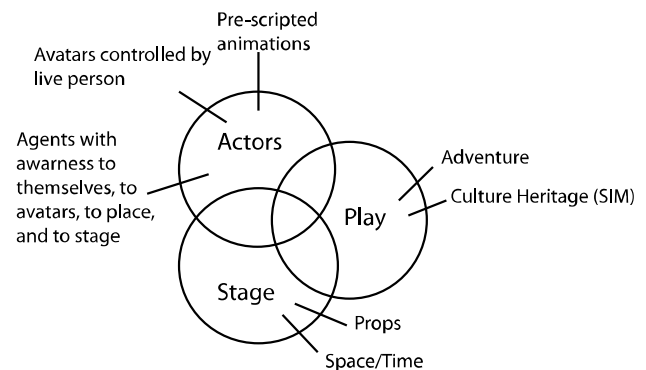


Fig. 4 Diagram of the Stage Play metaphor.

The interactions between these components are what make Sambor Prei Kuk a ‘place’: the avatars, which are the representations of the visitors, can ‘see’ other avatars—as well as the other components of the game—and be ‘seen’ by them. Likewise, the NPCs can be seen by the visitors, and they can react to their presence. This reaction both conveys some of the essence of the cultural heritage (they can perform actions related to the history of the place), and adds to the authenticity

and 'sense of place' of the experience. And of course the context (buildings, marketplace, etc.) help locate the experience, both spatially and temporally.

#### a. The Stage

The first problem facing digital reconstruction of a cultural heritage site is finding the appropriate documentation that describes the built environment and the 'props' for the period being reconstructed. In many cases the buildings still exist and they can be photographed, measured, or digitally scanned, providing a basis for the reconstruction. In the case of Sambor Prei Kuk, as discussed above, we used a combination of existing structures and archaeological data to reconstruct the temple complex.

#### b. The Actors

The second main challenge in reconstructing Sambor Prei Kuk was modeling the people who inhabited the site. The physical challenge has been mostly technical: modeling human beings is difficult because we are so accustomed to seeing them in real life that any discrepancy is immediately, and jarringly, obvious. Yet, to render high fidelity models of people would slow down the interaction due to hardware limitations. We needed to develop a wide range of characters, both avatars for the player characters and 'bots' for the non-player characters (the NPCs), who would resemble some of the real people who inhabited Sambor Prei Kuk in the seventh-eighth century CE. We relied on carvings in various temples, including Angkor Wat, and on literary sources that described the people of the region. In the end, we chose to sacrifice some quality in order to gain speed.

#### c. The Play

Finally, the component that brings everything together is the activity or narrative. What does the visitor do in the virtual world environment, and how are all those actions and interactions tied together in the larger experience of the virtual world and the story it tells? In the case of Sambor Prei Kuk, we tried to do this by creating both small, localized activities, centered on various rituals (such as the market, the fire sacrifices, the ceremonial pool, and the *linga* ceremony in the central shrine), and the larger, overall narrative, which takes the visitor from outside the temple at the market all the way into the central shrine.

To maintain the 'sense of place,' visitors must choose an avatar (a representation of themselves) that fits the place. Hence, the avatars appear in the scene in the form of one of the people who inhabited the site. Their activity is limited to observing the ongoing activities; they cannot partake in them. But they can chat with one another via the chat mechanism provided in the game. It is this aspect of the MUVE that further projects will improve upon greatly.

## 5. THE SAMBOR PREI KUK MUVE

The Sambor experience starts with choosing avatars. As mentioned, both the avatars and NPCs resemble some of the people who might have inhabited Sambor Prei Kuk in the seventh-eighth century CE. They all have Cambodian features: their hair styles, outfits and decorations are similar to those found from inscriptions and carvings. Players can customize the color of their outfit to differentiate themselves from other visitors.

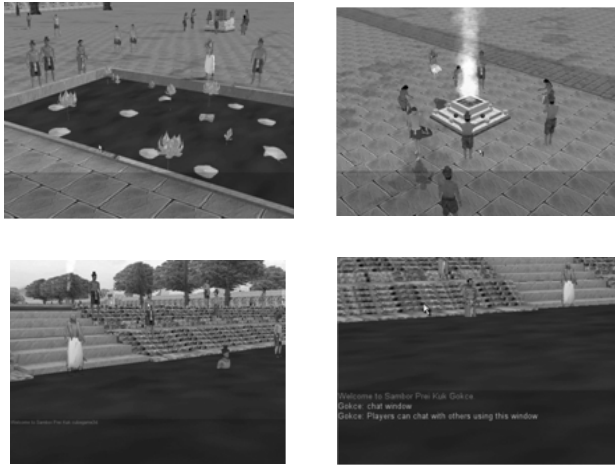
Players start their journey(s) from the market outside the temple (Fig. 5). They would be able to experience the festive side of daily life such as trades, shows, and colorful products for sale. This can then be contrasted to the solemn religious activities experienced later. To enhance the experience, the market journey is accompanied by acoustic effects: the sounds of crowds and animals permeate the scene.



Fig. 5 View of the market.

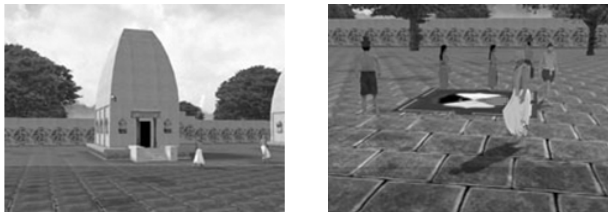
However, whether there was market outside the temple complex is unknown. The choice of re-creating a market right outside the temple walls is mainly to introduce more cultural heritage other than religious practices. The descriptions of the market for the model were taken from the text of early fourteenth century Chinese traveler Zhou Daguan. See Zhou, *A Record of Cambodia*. It is important to note that we *absolutely* recognize the problems of applying a fourteenth century description to a seventh century temple complex. However, we chose to do this with our eyes open, and we think it serves the purpose to give an idea of what the market would look like in the absence of other records.

Entering the outer courtyard, players can join other NPCs for ritual blessing at the lotus pond, participate in a fire sacrifice, and go for a ritual bath. They can just participate in the services, but not interfere with their progress. If the players are visiting virtual Sambor in a group mode (via internet connection), they are able to see and communicate with other visitors who might have logged into the virtual world at the same time (Fig. 6).



**Figure 6** (Upper left) Lotus pond blessing; (upper right) fire sacrifice; (lower left) ritual bathing; (lower right) chat window.

As the player moves inward towards the centre of the temple complex, the level of solemnity of the rituals increases. Upon entering the inner courtyard via the second *gopura*, players are able to see the main shrine ( $C_1$ ) and the two ancillary shrines (Fig. 7, left). For the ancillary shrines, as we have no surviving structures but only archaeological evidence for their foundations, we were more conservative in our modeling here. Using both inscriptional and sculptural evidence from both the northern and southern groups, we can confidently posit that they contained ancillary forms of Shiva. Yet, we have no idea what those forms might have been. Therefore, we chose not to recreate the interior of these shrines. The visitor can see the outside of the shrines and witness devotees at the entrances, but the visitor cannot enter them.



**Fig. 7** Ancillary shrine (left) and *mandala* initiation (right).

We have also modeled the ritual of a *mandala* initiation (Fig. 7, right). This would be a ceremony only for those who wished to enter the highest levels of Shaivite initiation, and therefore it would be performed by very few. This is a clear case where the needs of experimental modeling overcame historical accuracy, as even if some kind of initiation was performed, it would not have been inside the temple complex. In this case, the digital modelers made a very good argument: they needed to see how modeling non-player characters with specific movements in multiple locations would effect the overall flow of the MUVE. In the end, after much debate, the decision was to include this ritual in a non-historically accurate location. Such is the nature of cross-disciplinary collaboration. However, in future versions of the MUVE, with more funding and more time, we could easily expand the model and move these rituals outside the

boundary walls. Or, we could eliminate the *mandala* initiation altogether as this initiation is not indigenous to the Khmers.

Finally, players would reach the main shrine to attend the ritual which was to be reserved for the royal family (Fig. 8). There is no clear evidence concerning the details of the ritual performed in the central sanctuary. There is no doubt, however, that a Shiva *linga* atop a pedestal was installed at the centre of shrine  $C_1$ . The size of the shrine suggests that any rituals done here would be private, as perhaps ten to fifteen people could fit into the shrine itself at one time, and the circumambulation of the *linga* would be difficult with even this many bodies present. But, again, there are no inscriptions or documents describing the rituals that were performed there. Therefore, in reconstructing the intangible heritage of the site we had to use imperfect evidence.



**Fig. 8** Entry to the main shrine (left); worship of the *linga* inside the main shrine (right).

## 6. METHODOLOGICAL AND PEDAGOGICAL ISSUES ENCOUNTERED

In the course of the Sambor Prei Kuk project, we encountered two issues, one methodological and one pedagogical, that need serious consideration.

### a. Virtual Reality and ‘Reality’

MUVE technology is relatively new, with a short history, devoid of a comprehensive theory, and short on useful precedents to guide the development of virtual cultural heritage experiences. It certainly is a technology of illusion, creating an intangible reality. It freely borrows architectural principles, but can only be experienced through the proxy of avatars. Most importantly, and perhaps disturbingly, it requires the creators to fill in the missing details—architectural, social, ritualistic, and others—to create a ‘complete’ experience. Many of these details are based on conjecture and interpretation informed by thorough research. But when experienced by a user, a MUVE often convinces viewers that what they see is ‘true reality’. In other words, the finished product *hides* the thousands of decisions, often extrapolated from the incomplete evidence at our disposal, that go into making it. So, how do we expose the relationship between the modeler and the data? How do we convey that this is one truth among many possible truths, rather the ‘*the truth*’?

There are two potential solutions to this problem. One, we can embed meta-data into the physical structures of the model itself. Thus, when users chooses a wall, or an artifact, or even an avatar, the data used to create that feature can be displayed. This secondary information can be a short paragraph detailing the strengths and weaknesses of the sources used, or longer pieces written by the modelers and domain experts, detailing the

decisions they made in choosing from a variety of options. But this can destroy the ‘genius loci’—the sense of place—we try to create, because it diverts the visitor’s attention away from the immersive environment and towards a text-based one.

The other solution to the problem of presenting a ‘true reality’ is to include a mechanism to identify how certain we are of a particular feature. One method is to use a ‘fuzzy threshold’ in the model itself.<sup>8</sup> A fuzzy threshold would display features we are less certain about more fuzzily and features we are more certain about more sharply. Thus, as users move through the model, they can readily see how much speculation went into its creation. However, a model that is partially fuzzy might negatively impact users’ experience. The other possible mechanism is a tool that presents a level of certainty on a sliding scale. This tool could be activated and seen in the toolbar (scholars would be very interested in this), or it could be deactivated for a more integrated experience (as student visitors might desire).

### **b1. Educational Goals: Learning History**

The rush to create digital models that render the original features as accurately as possible has obscured a fundamental question: what do we want the user to remember about the experience? How does virtual reality function as a cognitive technology?

One advantage of virtual worlds is that it encourages participatory learning. Participatory learning engages students’ imaginations. It draws their interests with powerful narratives and nudges them with puzzles they feel compelled to solve. Students’ hunger for challenge is evidenced in their fascination with video games. In the virtual world we are creating, learners are given scripts, called quests, which introduce them to the social and historic issues of the day: art, entertainment, labor, religion, and education. These quests offer learners a variety of entry points that allow them to consider questions that resonate with them. As they role play, interacting with fellow learners as well as non-playing characters, they create a reciprocal feedback loop that enhances their imaginations and contributes to the development of a community of practice which comes to embody certain beliefs and behaviors. As the newcomer moves from the periphery of this community to its centre, she becomes more active and engaged within the culture and gradually assumes the role of expert. Resources and tools available to learners in the game offer them the opportunity of contextualizing their in-world experience with historical data that enlarges the meaning of their experiences. Learners come to know the lives of the characters they meet, their beliefs, values, and struggles. As learners share their understanding through presentations they participate not only in directing their study but in building collective understandings of the history they encounter.<sup>9</sup>

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<sup>8</sup> For more on ‘fuzzy logic’ and ‘fuzzy thresholds’ in 3D reconstructions, see Hermon and Niccolucci, “La Logica Fuzzy e le sue Applicazioni alla Ricerca Archeologica” (2003) and Hermon, Nikodem, and Perlingieri, “Deconstructing the VR - Data Transparency, Quantified Uncertainty and Reliability of 3D Models” (2006).

<sup>9</sup> The Sambor Prei Kuk MUVE is still in development, so we have not yet been able to create “quests” for the model. However, an earlier project created by the Digital Design Research Group, “Remembering 7<sup>th</sup> Street: Virtual Oakland

A visitor might, for example, meet and talk with a character who describes a particular spiritual practice. The visitor is directed to a place of worship where she meets and talks with others. She decides that she wants to learn more about the historical roots of the practice and they partners with two classmates in an investigation. Together they consult the project’s homepage where they link to resources that include blogs, readings, films, artwork, artifacts and websites that deepen their understanding of the practice. The students make a film demonstrating their new knowledge and share it in-world to an audience of interested learners. Other presentations may include a group who has studied the trade routes between eighth century Southeast Asia and India, or a group that dramatizes a myth that may have been significant to the inhabitants. These groups then present their findings in a PowerPoint presentation which is linked within the actual model. As the virtual world exists online, it can be freely accessed by learners from anywhere on the globe. University scholars might visit the site, and at the same time two classes of high school students, one in the US and the other in Cambodia, can log on as well. The virtual world, then, becomes a meeting place where learning becomes a social activity that brings life to history and history to life.

### **b2. Educational Goals: Beyond “Mere” History**

The use of MUVEs goes beyond the “mere” learning of another’s history. Rather, such learning, we argue, will have a profound impact on how students engage with the learning process itself. Once this aspect of the model is further developed, we argue that it will bring together Lave’s Situated Learning methodology (Lave, 1991; Lave and Chaiklin, 1993; Wenger, 1998), and digital media (Gee, 2004). This approach situates the student at the center of the learning activity, as an actor who actively performs given learning tasks, rather than passively observing others perform them. This approach builds upon Vygotsky’s constructivist learning theory, a process of participation in a set of practices that take place in a socio-cultural context or community of practice. Thus learning is engaged as part of real social practices in the lived-in world. Our model extends this approach to learning into the virtual world, and thereby takes advantage of the following principles that are uniquely enabled by digital media (Gee, 2004):

1. Certain aspects of learning in our MUVE will be designed to facilitate “active” and “critical” rather than passive learning. In part this approach encourages the learner to develop an “inquiry” learning process based on “probing” the designed environment. This allows the learner to reflect on and more deeply understand issues, problems, or challenges presented, and ultimately to create strategies or approaches to address or ameliorate them.

2. Incorporating the “identity” principle in which the learner takes on virtual identities and roles through which the game narrative allows for real choices that have various consequences. Ideally, the learning activities are sequenced so that there is an incremental increase in learning and skill development in the model environment. Learning situations are ordered, so they build on “intuitive knowledge” such that the earlier experiences lead to understandings that are fruitful for addressing more complex situations and challenges in the development of the narrative of the game. The identity principle

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Jazz and Blues,” does include such quests. That model can be accessed at <http://7thstreet.org/>.

also connects the player to the larger community of practice or affinity group(s) leveraged through the game's narrative(s) and design.

3. Learning within this model involves developing increasing levels of mastery of "semiotic domains" as complex systems – the interrelations and interdependence of meanings within and across multiple sign systems (words, images, actions, symbols, sounds, animations, artifacts, etc.).

We have developed these principles and experimented with them in another virtual heritage reconstruction and learning environment, called "Oakland Blues," which told the story of the 1950s jazz and blues scene in Oakland California (Kalay and Grabowicz 2007).

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The virtual Sambor Prei Kuk MUVE is hosted on the UC Berkeley Digital Design Research Group's website and can be downloaded and installed on local computers for use at the following address:

<http://steel.ced.berkeley.edu/research/sambor/>

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