# Archville: A Distributed Virtual Reality System for Teaching Real-Time Design Collaboration

CHRISTOPHER PERI
YEHUDA KALAY
University of California, Berkeley

## INTRODUCTION

Architecture is a collaborative enterprise; virtually all building projects are the product of the contributions of many professionals, as well as public agencies and users. Design studios in most schools, however, ignore the social, political, and other collaborative dimensions of the problem, and instead promote the individual experience of each student. This abstraction is intended to equip the student with the basic proficiencies needed for design, a prerequisite to professional practice. Still, there should be room in every student's education for experiencing the social, collaborative dimensions of the problem. Lacking this experience, graduates are often shocked to discover that the "real" world of architectural design is very different from their academic experience; it is much "messier," both in terms of the number of individuals who are involved in the decision-making process, and in terms of the constraints their "creations" must meet. How can we, as educators, impart such a collaborative design experience to our students?

## THE CARDBOARD CITY EXERCISE

For a number of years, from the late seventies until 1987, a comprehensive design exercise was given to third year students. The exercise was intended to teach them, among other things, how to deal with the creation of spaces as a collaborative form-making effort, rather than as an individualized effort. The exercise involved the design and physical construction of a cardboard "city" on 3"x 3" plots in a pre-designed "urban landscape." In this so-called Cardboard City, students were assigned "city" plots through a lottery system, and instructed to design a "defined place for sitting."

Although the project was assigned as an individual design task, students were given the option to join with other students and build a larger structure collectively. Many students opted to work in groups, thus maximizing resources. As in real life, group work often entailed endless discussions and political power plays, which offset the time and resources saved. Students were also required to make an effort to conform their designs to the designs of their neighbors, or come to some common agreement on the vocabulary of form. This last requirement,
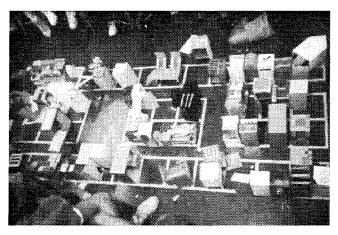


Fig. 1. View of Cardboard City.



Fig. 2. Scaled city layout.

together with group work effort, turned the Cardboard City project into an exercise in collaboration, as much as it was an exercise in physical design. Students learned the importance of politics in design, the destructive force of separatists, and the impact of decisions made by others on their own designs. It became the "right of passage" exercise to upper level studios, and a source of pride to the students who participated in it. But the creation of a full-scale urban cardboard city by 75 students

also inflicted so much damage on the design studio facilities, in terms of cardboard mess, gauged tables, floor tiles, and any other surface the students could use for cutting, that the exercise had to be discontinued.

## RESURRECTING THE CITY

The advent of computing technology, in particular the Internet, allows us now to resurrect the Cardboard City exercise, using computer visualization in lieu of cardboard. Archville, as the new exercise is called, is pedagogically similar to the Cardboard City exercise. Although computer visualizing cannot replicate many of the advantages of the physical exercise, like the ability to actually experience what 3' x 3' space feels like, or the impact of actually building something that can be inhabited, it gives us many other advantages over the original one. As with the Cardboard City exercise, each student is given a plot in an urban landscape. Instead of a physical space, where urban plots must be chalked on the ground, Archville uses a computer model of a hypothetical city. Instead of reduced-scale 3"x 3" plots, students are assigned "real life sized" virtual plots. Instead of designing a "defined place for sitting," students design houses or other structures. As in the Cardboard City exercise, students must design their houses for each plot in agreement (or disagreement) with their neighbors. Specifically, they are required to establish some common design elements with their nearest neighbors.

Archville allows students to walk through the "city" at anytime to experience their designs as well as those done by others in the class. The work of the other students is always up to date, thus eliminating the problem of making design decisions based on obsolete information. Students can interact with the model and query information from it. They can also see each other walking through the environment in the form of avatars, and communicate with fellow students.

Finally, work that has been done in previous semesters need not be "taken down" at the end of the exercise. Rather, buildings can be left where they are, creating a sense of history and a city that can grow and evolve over the semesters. If more space is needed, the instructor can simply create more landscaping within the computer model. Since we are working within a virtual environment, there is no limit to the size of Archville.

## METHOD

Archville is a distributed, Web-based VR system[1] that allows multiple users to interact with multiple models at the same time. Using a combination of HTML, Java and VRML[™], the system can display information, such as text and images, in a single dynamic environment. It does so by calling files from distributed sources, integrating those files, and then displaying the information.

The heart of the Archville system is a small file referred to as the "Address Book." This file contains the URL address of each student that is involved in the project. When a student, or anyone else, accesses the Archville Web site, he or she is presented with the streets and landscaping of Archville. As
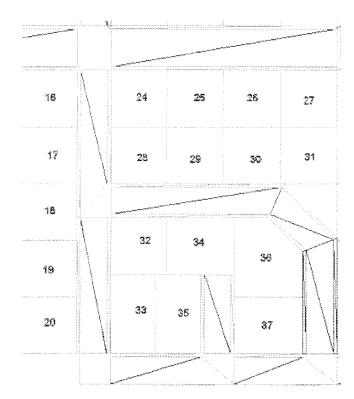


Fig. 3. Plan View of Archville within 3dsMax.

each file from the address book is loading from the Internet, the VRML viewer integrates its content into the scene. This continues until all the files have been loaded. If a file cannot be found, the visitor is alerted and the program then goes on to the next file.

The students create all the files, with exception to the landscaping and the urban layout, which is created by the instructors. A model of the urban layout is placed on the Web in the format of the 3D tool employed that semester. Students download the model to their computers. Students locate the site each is assigned: they erase all information except the site in which they design their own building. When the students are finished with their design, they "post" it by saving the file in a public directory on their own computer that is accessible by the Archville program through the Internet. The URL of their file is entered in the Address Book, so the file can be loaded into the combined scene. When the student accesses the Archville web site, his or her model is displayed on the plot they were assigned, along with all the other students buildings.

Once in the VRML viewer, the visitor can walk around the urban scene. If set up correctly, when a visitor enters a building, the VRML scene will reload with just the inside of that building, thus allowing higher levels of detail. If the designer of a structure added pre-defined viewpoints in their file, then the visitor can take a pre-set tour of the structure by moving from viewpoint to viewpoint. Although currently implemented in 3D Studio Max (3dsMax), the Archville system will work just as well using AutoCad, MicroCad, FormZ, or any other 3D-modeling program that supports the VRML format. There are

also many translator programs that can convert most 3D vector formats into VRML. 3dsMax was chosen because it supports some VRML nodes (programming) within the modeling program itself. Many of these nodes support attaching hyperlinks to 3D objects, for starting animations based on the viewer"s location or the clicking on an object. For example, the elevators in the office buildings are programmed to take the viewer to the floor selected on the elevator control panel. Once there, the VRML scene is reloaded with the interior of the selected floor. Another example is the sculpture in Archville"s central park. One student programmed the rings to move when the user presses a button at the base of the sculpture. The other button takes the viewer to that student"s web page. This student had no idea about VRML programming, this was all done in 3dsMax.

The viewer can control the content of the displayed scene. When Archville is launched, only the landscape (streets and sidewalks) appears in the 3D scene. Using a set of buttons located at the bottom of the browser window, the user can load selected files. Once loaded, that same button controls the visibility of those files. For example, the students can load only those files that were created by their classmates. Alternatively, they can load files created in former semesters. This facility helps avoid information overload, and the problems associated with displaying a large model on a relatively slow machine. If they use a powerful enough machine, all the files can be loaded: with over 90 students in the class, and with 1000 polygons per student, the VRML scene quickly approaches 100,000 polygons every semester, not including structures that were left behind from previous semesters. Also available to the viewer is a "chat box." A Java program, called Vnet, created by Stephen White displays a window below the VRML viewer that allows users to talk to other users who are logged onto the system. When Vnet first comes up, the users are asked to choose a name to login as, and then choose an avatar to represent them in the VRML scene. When encountering other users in Archville, they can see each other and talk to each other. Conversations can be logged for future examination to track the evolution of the design.

## PROCESS

The Archville exercise is currently a three-week exercise used in two classes. The first class is an introduction to computing course using 3dsMax or FormZ with an average student enrollment of 90. The second class is an introduction to 3D modeling course, using 3dsMax. This is a 7-week course given twice a semester with an average enrollment of 17 students per half semester.

After an introduction to using the selected 3D software, the length of which varies depending on the course, the students are assigned a site within an urban layout. The students in the first course are instructed to build a single-family house on that site. In the second course students have more freedom, and can design a house, a sculpture, or any other object, as long as it stays within their site. The only limitation is that their design must fit within their site and that the polygon count not exceed 1000.
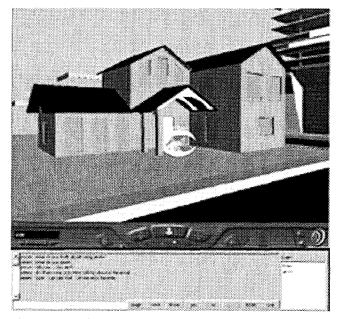


Fig 4. View of the Vnet Chat Box in the Archville System.

Typically, a wide range of designs are created by the students, from common looking houses to interesting sculptures, to a tree house designed by one student.

After one week, students are told that they must adapt their design, and/or convince their neighbors to change theirs, such that there is an agreed-upon design element in common with each of local neighbor. Local neighbors are those students whose properties are directly across from, or adjacent to, the student"s property. This keeps the number of collaborators in check. After another week has passed, the third part of the assignment is given. Each student must now design a walkway that connects to his or her neighbors" properties. This forces the students to react to geometries that are not under their control. So far, we have not implemented the third part of the exercise because of time constraints, but this issue is being addressed.

The end result is an urban setting that is populated almost overnight with 90+ buildings. Since each student can see what his/her neighbor has done as soon as it is posted, comments can be made immediately. For example, a student may be working on some element in his or her design that is intended to match the neighbor"s design. If the neighboring student is online, he can look at the proposed design and make suggestions. The first student can immediately make the change in the modeling program and re-post the model. When both students refresh their web browsers the change is displayed, and they can continue to deliberate its desirability. Alternatively, if the neighbor is not online, the proposed changes will be waiting when he or she logs in.

## CONCLUSIONS

Other than the pedagogical benefits discussed earlier, the greatest advantage of using Archville as a teaching tool is the immediate feedback students get from their work. Creating a
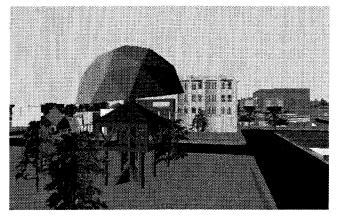
Fig. 5. Image of Tree House.

large virtual environment takes quite a bit of work. By sharing the task, a virtual world can be created in a week. This is an example of different professionals working together to create something that is too large and diverse for one person to create alone. Although in our case each student is creating the same thing (a building), this idea is not hard to expand into different specialties (Engineers, HVAC, etc.) working on the same building. The Archville system also shows students the power of the Internet for sharing up-to-date information. Many students were able to work from home and still interact with other students in the labs.

For many students these classes are the first exposure they have ever had to 3D modeling, or to being able to walk through a model on the computer. By providing an alternative view to drawings and scale models, the students begin to deal with issues of multiple views, of movement within an urban context, and with issues of how other students interact with their designs.

The Archville exercise has been offered successfully for the last three semesters. Students seem to be very excited about building models that can be walked through and interacted with on the computer. Some more ambitious students have even dabbled in animations and simple programming. The level of student interchange has been limited due to time constraints - both the time it takes students to become comfortable with the software and the time available to complete the exercises themselves. It is quite clear that Archville needs to be more than a three-week exercise. We are currently exploring the possibility of extending it into a semester-long design studio. In this studio, students will not only create VR models, but also create the data behind those models.

The Archville system allows instructors to create different types of environments that can be populated by students. Although we have been working with an urban layout, there is no reason that an exercise could not be developed for the construction of a single building, with the students assuming different specialties, such as architecture, structure, HVAC, interior design, etc. There are problems however, the biggest of which is time. Learning how to use a 3D modeling program is

hard enough, but to also understand the principles of low-polygon modeling is an extra learning step. This also goes for the teaching assistants, most of whom only have a functional understanding of the software, much less are trained in low-polygon modeling.

So far the experiences of the students in collaboration has been mixed. Because the students are still struggling to learn the software, resolution of design conflicts have been minimal although there have been examples of students employing the Archville environment to resolve problems when a student is unable to attend class. Typically students use a combination of Archville, marked up screen shots and the actual exchange of files to resolve design conflicts. The next phase of the development of Archville will be to include a whiteboard for the students.

Archville is now viewable over the Internet at any time. We are also beginning to invite other universities to participate. Since all files are accessed over the Internet, including the original source files, anyone can participate in using the system. The computer power required to run Archville has become quite accessible to most institutions. Currently we are using PentiumII 450 with OpenGL graphics cards.

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## FOOTNOTES

[i] The idea behind distributed VR is very simple: a simulated world is stored not on one computer system, but on several. The computers are connected over a network (typically the global Internet) and people using those computers are able to interact in real time, sharing the same data in the same virtual world.

[ii] The Virtual Reality Modeling Language (VRML) is a language for describing multi-user interactive simulations—virtual worlds networked via the global Internet and hyperlinked within the World Wide Web. VRML is to 3D what HTML is to 2D. Rather than describing the location of 2D text and images on a page, VRML files describe the location of objects in a 3D space. As with HTML, VRML objects may be links to other objects, URLs, inline images, movies and sounds. In addition to the properties of HTML, VRML objects may be animated and interact with other objects and the user.