In 1994, students from Montana State University took part in a student exchange at the Eindhoven University of Technology in the Netherlands. The goal of this exchange was to investigate the pedagogical results of using Virtual Reality in the architectural design studio as a tool to create, understand, and describe three-dimensional space.

At the conclusion of this project, it was discovered that through VR the students were able to understand the spatial qualities of their own designs much more comprehensively than with three-dimensional computer models alone. It was also discovered that the understanding of peer students, design, and technical faculty was enhanced as well.

**Introduction**

During spring semester 1994, nineteen fourth-year students from the School of Architecture at Montana State University (MSU) participated in an eleven week European study tour. As a part of this school sponsored activity, two weeks were spent in Eindhoven, the Netherlands, at the Calibre Institute, part of the Eindhoven University of Technology (EUT). An exchange program had been arranged where MSU students would study Virtual Reality (VR) while in the Netherlands, and EUT students would study building codes and the architectural registration process while in the United States.

The specific purpose of the MSU student visit to EUT was to explore the possibilities of incorporating Virtual Reality (VR) into the architectural design studio, and to determine if VR could enhance the design process itself. The project used for the studio was the Bauhaus Competition sponsored by ACSA. The design challenge was to create a new architectural campus for the existing Bauhaus located in Weimar, Germany, by utilizing existing buildings and creating a new school facility. The students were divided into teams of two or three, and worked in these teams for the duration of the project. The majority of the project’s design was completed at MSU prior to beginning the studio at EUT. Work done at MSU was prepared in a six week time frame in the traditional design studio format; that is, a non-electronic studio where all drawings were created by hand using traditional tools such as parallel rulers and tracing paper. Students were aware that they would have the opportunity to transfer their designs into an electronic format once they arrived at EUT. Final submissions for the competition would be completed later in the semester during a three week stay at the Bauhaus in Dessau, and would be once again produced in a traditional studio format.

**The Process**

The work environment at EUT consisted of two studio spaces, each equipped with ten traditional drafting tables and five computer stations. Software available was AutoCAD 3D and 3D Studio. VR software was provided at a later time by selected EUT faculty. The MSU students had varying degrees of experience in working with computers. Approximately
half of the students had used AutoCAD previously, two
had used AutoCAD 3D, and one had used 3D Studio.
Two students had never taken a computer course.

As an introduction to the options available, the
students were given a short demonstration of AutoCAD
3D and 3D Studio. They were also allowed to
participate in a hands-on demonstration of Virtual
Reality, where they donned head-mounted display and
flying mouse and elrected their way through a
previously input office building. (It was noted at this
time that those who had Nintendo experience were
much more adept at maneuvering through virtual
space.)

All students were given the option of inputting
their projects into AutoCAD 3D or continuing to work
in a traditional format. Without exception, every team
chose to work electronically, although all teams also
continued to simultaneously develop their drawings at
the drafting table (Figure 1).

Figure 1: Traditional studio environment.

Only seven working days were devoted to studio work.
Because of this limited time frame, a short two-hour
tutorial on using AutoCAD 3D was given to expedite
the project. The students were then assigned to their
studios and asked to input their designs (Figure 2).
They were supported by their design professor from
MSU and rotating EUT faculty.

After spending approximately four days
working in AutoCAD 3D, the students were given an
additional short tutorial on 3D Studio. They spent the
next two days creating and applying texture maps to
their designs, in preparation for transferring their
projects into EUT’s VR system. Several groups also
created animations of their solutions.

Figure 2: Electronic design input.

The students were very excited, particularly
those with no or very limited computer experience, to
see their designs come to life on the computer screen.
The advantages to being able to look at their projects
from any point of view were obvious, and those who
had not worked on computers before were convinced
that this “new” technology had substantial merit.

The Presentation and Critique

A final presentation and critique was
scheduled at the completion of the project. Each team
was expected to demonstrate as much of its project as
possible using any media desired. Options included
traditional drawings and scale models, ink-jet prints,
laser prints, direct computer images, and animations
(Figure 3). All projects were then entered into EUT’s
VR system and a walkthrough of each building design
was presented by a respective team member. The
audience was EUT students, design faculty, technical
faculty, and staff.

Even though the students had experienced VR
on the original demonstration day and were enthralled
with its capabilities, there was no comparison to
anything the students had experienced prior to having
their own project loaded into EUT’s VR system.
Although the audience could only experience the
projects by viewing a computer screen which echoed
the view inside the head-mounted display, standing in
the same room and observing the presenter and
presentation process was nearly as exciting as
experiencing each project firsthand through VR.
Students experienced their projects in a way that had
not been possible through any other media. As they
described the spaces they had created, they were totally
immersed in the process (Figure 4). Their excitement
in actually moving through the building they had
designed was obvious through observation of their
animated descriptions of details present and imagined:
"Up here . . . " or "Let's go around this corner and look at
. . .". "This is a little bigger than I thought. We need to
size it down so it is in scale with . . . " On this side . . . ". They could experience size, proportion, and texture.
They also found much more to describe inside their
head-mounted display than when presenting in
traditional static two- and three-dimensional media.

Summary

We believe there is no question that the design
process was improved utilizing Virtual Reality.
Students were able to understand the spatial qualities of
their own designs much more comprehensively than
that provided by three-dimensional computer models of
the same projects. The critiquing process was also
enhanced because students were able to describe and
demonstrate their projects to their audience much more
effectively through VR.

Ultimately, the students found it difficult to
complete their competition submissions in Dessau
because computers were not available to support their
previous work. They frequently expressed their
disappointment with this situation.

After completing work on the project at EUT,
students and faculty discussed elements of the studio
that might be approached differently for a subsequent
project incorporating VR. The most important
conclusion was that the final presentation and critique
was very successful in terms of helping the students
understand their own designs. It was agreed that
intermediate VR presentations and critiques could only
enhance this understanding, because changes could then
be electronically incorporated throughout the
development of the design. It was also agreed that
more time to work on the electronic aspects of the
project would be desirable and would support these
intermediate presentations.

With a VR system such as EUT's, it is very
easy to load a design, move through it, understand its
spatial qualities, then go back to the drawing keyboard
and make revisions, all in a matter of minutes.
Unfortunately, very few schools of architecture at this
time can afford a system of this type. However, as this
technology becomes more affordable and continues to
improve, it will become a viable addition to the
electronic design studio.