Digital Representational Tools Impact on the Design Decision Process

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ABSTRACT

This paper presents two pilot studies that explore the impact of virtual reality representations on the evaluative judgements of trained designers and design students. These projects are intended to explore several aspects of spatial perception as impacted by the representational media in an attempt to identify the potential impact of this media on the development of design solutions. The participants were exposed to different representational media and modes of representation or simulation: traditional "physical media" (plan, elevations, and model), physical place and projected computer generated media including flat screen animation and hemispherical corrected animation for display on the VisionDome. The 4-meter VisionDome is an immersive, multi-user, single projection virtual reality environment. The results of these efforts potentially indicate that when trained designers view a simulation of a space their perception of the space is, to some degree, affected by the representational media. The walk-through mode emphasized the perceptual differences between traditional and computer generated representations. A low level of detail in a computer-generated "walk-through" simulation provides perceptual elements, which allow the viewer to develop an understanding of the spatial relationships of the design.

1 INTRODUCTION

Design is a process involving creation, evaluation, and modification. As a designer develops and modifies a design this idea evolves and becomes clearer. The intent is to both understand the evolving idea and direct it to an appropriate solution. The means of representation of the design ideas supports the design and decision process. It is the contention of the authors that when the goal is to design a physical environment the means of representation used to depict the emerging solution can have a significant impact on the evaluative process and therefore the results of the design effort. Over the years the designers of the built environment used a variety of drawing types and physical models to develop and evaluate design ideas. Numerous texts have categorized and described various types of traditional simulations and the role of each in the design process (Laseau 1980, VanDyke 1990). Within the last ten years a new method of design simulation has emerged, the 3D-computer model presented in virtual reality simulations.

It has been suggested that this technique decreases the level of abstraction and ambiguity and therefore can change cognitive perception and design thinking (Chan 2000).

This paper presents two pilot projects that have been conducted at North Carolina State University, College of Design. These projects examined the impact of the evolving technology in digital modeling and simulation on the design decision process and therefore on the results of design efforts. The focus of these pilot projects were to investigate how changing the mode of simulation affected design perception and how varying the amount of detail in a digital simulation effects a designer's perception of the simulation as compared to their perception of the actual space. In addition, this paper outlines a research strategy that builds on the initial findings of the pilot projects.

1 PILOT PROJECT ONE

"A Comparison of Realities: Will emerging digital representational tools change our design judgements and results?" (Holmes, Tomlinson, Rice) 2001

These research project compared designers' perceptions of traditional simulations to designers' perceptions of computer generated simulations.

The goals of this project were:

1. Determine the significant differences in spatial perception related to the representational media. (Traditional and computer simulations)
2. Determine if there are significant differences in spatial perception related to the mode of representation. (Overview, walk-through, and panorama)

1.1. Experimental Design (Pilot Project One)

A design developed by the students was presented in two different representational media to panels of professionally trained landscape architects and architects. Each panel consisted of fifteen participants. One panel of experts viewed traditional representations, at a scale of one-inch equals twenty feet including a plan, section-elevations, perspective drawings and a one thirty second inch equals a foot scale chip-board model. The other panel of experts viewed computer generated virtual reality representations of the same design.

The participants evaluated the design using three different modes of representation: "overview", "walk-through", and "panorama". The "overview" was presented through traditional representation as an overall impression of the design resulting from the viewing of traditional drawings and the physical model. This overall impression was created through computer generated representations by a bird's-eye fly over and simulated ground level views. The "walk-through" was a view from a prominent path in the design. The path was indicated in the traditional media as a series

of arrows on the plan drawing (Figure 1). The participants were asked to mentally visualize the experience of walking along the indicated path. In the computer simulation of the walk-through the participants were shown a series of eye level views along the pathway (Figure 2). This series of views was presented at a consistent rate that simulated a rapid walking pace. The "panorama," a 360-degree view from a single point in the design, was indicated in the traditional representations as a viewpoint on the plan (Figure 3). In the computer representation a panoramic series of eye-level views were presented from the indicated point (Figure 4). Again, in the traditional representation participants were shown on the plan the viewing point of the panorama and asked to mentally visualize the experience of standing at that location.

Entering the design information into a three dimensional computer modeling application (Studio Max 3.0 R2), and rendering hemispherical corrected sequential images for display on the VisionDome, created the computer-generated images. The 4-meter VisionDome is an immersive, multi-user, single projection virtual reality environment that can accommodate one to ten users at a time. By combining computer generated 3-D models with advanced projection equipment, VisionDome users are immersed in a photo-realistic virtual environment.

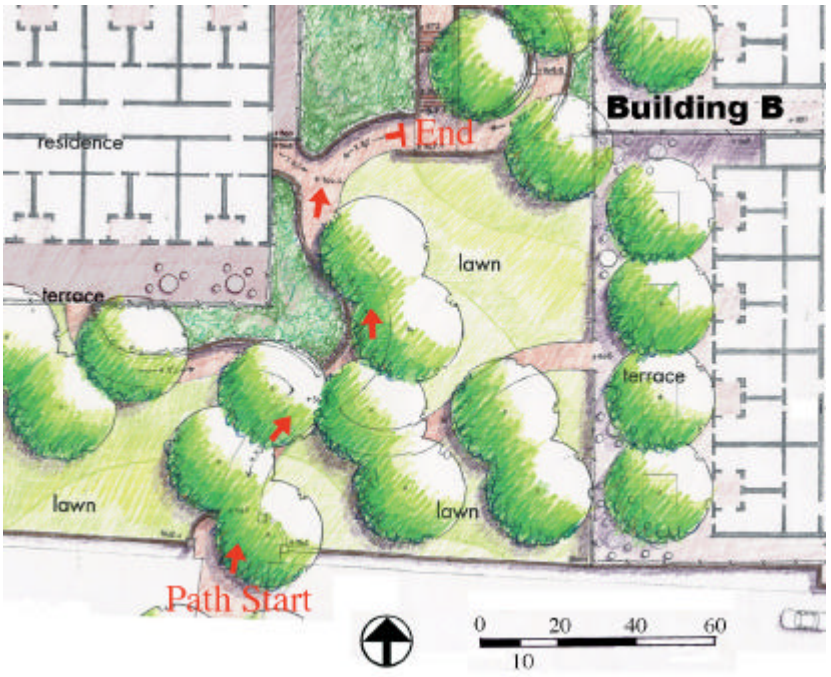

Figure 1: **Traditional Plan Media With Walk-Through Path**

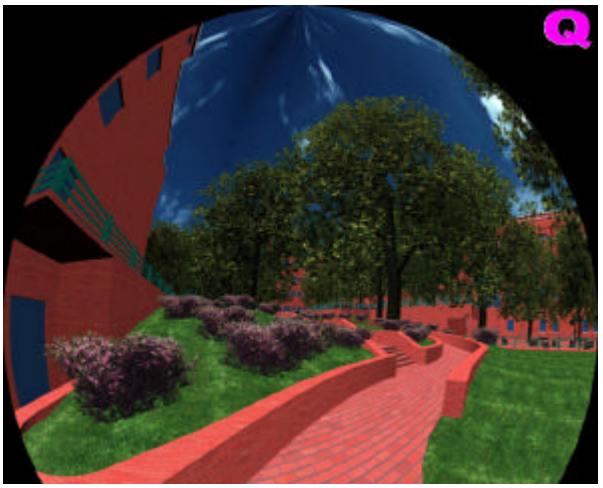

Figure 2: **Computer Generated Walk-through**

Figure 3: **Traditional Plan Media With Viewpoint**

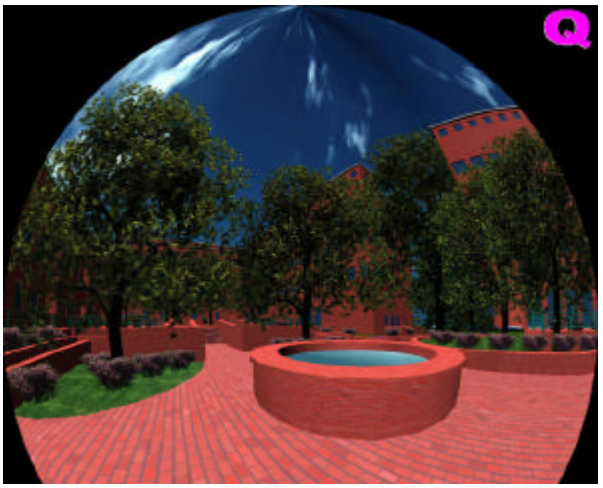

Figure 4: **Computer Generated Panoramic Viewpoint**

The 4 meter VisionDome hemispherical screen is designed to sit on the floor, providing a natural horizontal viewing angle. The bottom quarter of the screen is truncated to sit flat on the ground, freeing it from any type of external support structure (Figure 5). Special care was taken to ensure that information was consistent between the conventional representations and the 3D-computer representation and that no additional information was added in the building of the computer model.

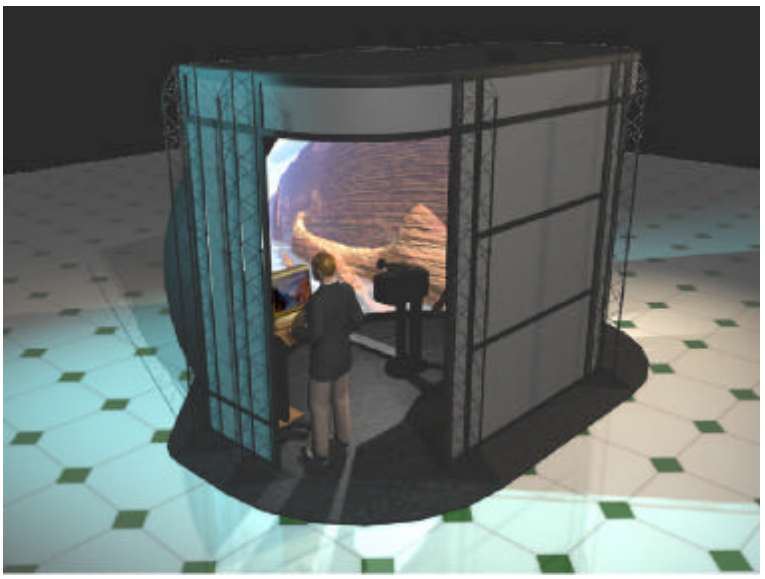

Figure 5: **Four Meter VisionDome System**

The mechanism for evaluating the design from all three modes was a questionnaire composed of four sections. Section one (Design Elements) required the participant to rate the importance of specific design elements to the character of the design on a scale of one to seven. Section two (Crowding Levels) asked participants to estimate the number of individuals that could be accommodated in the design to create specific levels of crowding. Section three (Paired Adjectives) required participants to evaluate the design based on ten paired adjectives. Finally, in section four, as a means to check the completeness of the structured part of the questionnaire in a open response format, participants were asked to describe the important characteristics of the design in their own words.

1.2. Results (Pilot Project One)

The data from the completed questionnaires were analyzed to identify significant areas of agreement and divergence between the panel that viewed conventional representations and the panel that viewed computer representations. Statistical comparisons were made to determine if a particular mode of representation had a greater degree of agreement or divergence between the two panels.

A T-Test was used to analyze section one (Design Elements) and section three (Paired Adjectives) of the questionnaire. This test determines if there are significant differences in the mean responses of two groups. In section one (Design Elements) significant findings occurred in two modes of representation, walk-through and panorama. In section three (paired adjectives) two modes of representation, overall and walk-through had adjective pairs that showed significant divergence in panel ratings. The results from sections one and three showed no design element or paired adjectives were significantly different in more than one mode of representation. This supports the idea that each mode of representation may reveal its content in a perceptually different way. In addition, it was noted that all of the design elements and paired adjectives that were perceived differently by the two groups were spatial or space defining in nature. In contrast, the two design elements that had significant agreement in response addressed design details (i.e., materials and colors). The Mann-Whitney Confidence Interval and Test (MWCIT) was used to identify significant differences in the medians of the responses in section two (crowding levels) of the questionnaire. The MWCIT was used instead of the T Test because in this section the data was not normally distributed. The section asked questions relating to the number of individuals that could be accommodated in the design to create specific levels of crowding. The walk-through was the mode of representation that produced responses that showed significant divergence. This divergence indicated that designers perceived that more people could be spatially accommodated in the computer simulation than in the conventional representations (Figure 6).

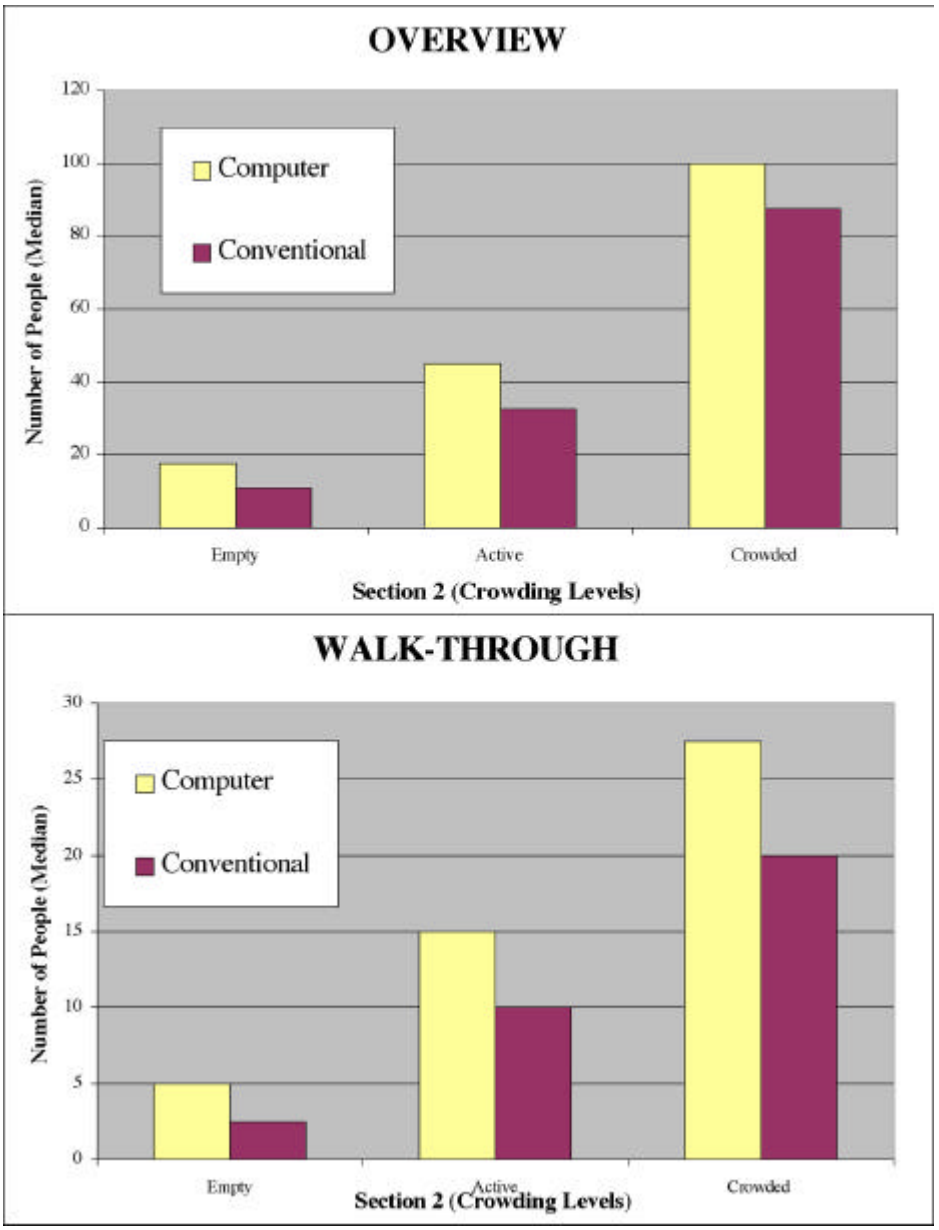

Figure 6: **Median Responses of Perception of Crowding**

2 PILOT PROJECT TWO

"How Real is Real? The potential impact of virtual reality on the development of spatial visualization skills." (Holmes, Rice, Tomlinson, Hasenmyer) Unpublished

This research project focused on the impact of the level of detail in virtual reality simulations on the ability of design students to construct an accurate mental image of a space. The two hypotheses that drove this project were:

3. That even with a minimum level of detail in a virtual reality simulation, students will be able to construct an accurate mental image of a space
4. That by adding more detail to a virtual reality simulation, the accuracy a students of mental image of the space will improve.

2.1. Experimental Design (Pilot Project Two)

Two 3D-computer models were constructed of the College of Textiles courtyard on the NC State campus. The first model contained a low level of detail with respect to geometry, color, and lighting. This model used simplified geometric forms, four colors and only one light source with no shadow casting. This model took only five hours to construct. The second model used more complex geometric forms, unlimited colors; two light sources with shadow casting and took twelve hours to construct. The two models were used to develop computer simulations along an animated path. Three groups of student participants were used to assess differences in perception of the two computer generated simulations and the actual courtyard space. Each student answered a questionnaire based on their impressions of the place after visiting the site or viewing one of the two computer simulations. The "walk-through" mode of representation was only one tested in this experiment. The computer simulations were projected on a flat screen in a classroom for viewing. The participants that visited the actual site walked along the same path as represented in the computer simulations.

The three groups of participants were comprised primarily of Landscape Architecture and Architecture students. Group A consisted of 30 participants who viewed the actual site; Group B consisted of 35 participants who viewed the low level of detail simulation; Group C consisted of 18 participants who viewed the simulation with more detail. (Figure7.) A questionnaire was used to record the participants' general perceptions of the site. The questionnaire contained 35 paired adjectives, which required approximately 5 minutes to fill out. This questionnaire was a simplified and refined version of the questionnaire used in the first pilot study.

2.2. Results (Pilot Project Two)

The data from the completed questionnaires were analyzed to identify significant areas of agreement and divergence between responses generated from the real space and each of the two computer simulations. Statistical comparisons were made to determine how the

responses generated by each computer simulation varied from those generated from the real site. (Figure8)

A Kruskal Wallis test was used to analyze the paired adjectives. The student responses were in line with what was expected. For example, both computer simulations were perceived to be harder and more barren then the actual site. However, the low-level simulation did result in students developing an equivalent spatial understanding of the site when compared to those viewing the more detailed simulation.

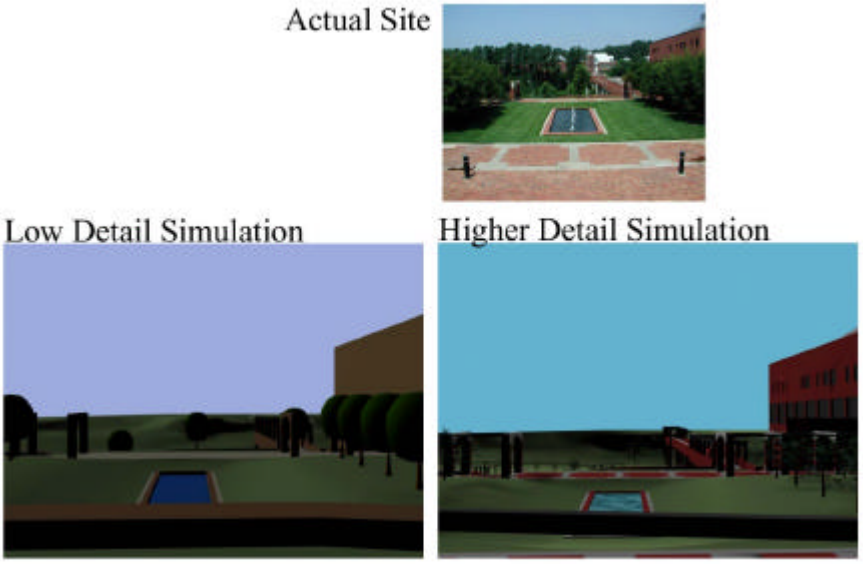

Figure 7: **Actual Site and Computer Generated Simulations**

In both cases 24 out of 35 of the paired adjectives showed similar medium responses to those generated by the real space however, there was variation in which pairs were similar. Both simulations performed equivalently in the perception of scale and spatial structure but did not perform well in issues related to texture and color.

The more detailed simulation showed stronger similarities to the actual site in pairs related to lighting and shading where the less detailed simulation showed stronger similarities to the actual site in pairs related to exposure and enclosure.

This test determined that eleven out of thirty five pairs had a significant difference in the median responses to the actual site when compared to median responses to the low detail simulation. When the more detailed simulation was compared to the responses to the actual space it was also found that eleven out of thirty five pairs showed significant difference. Therefore when it came to understanding scale and spatial structure the level of detail in the simulation did not have an effect.

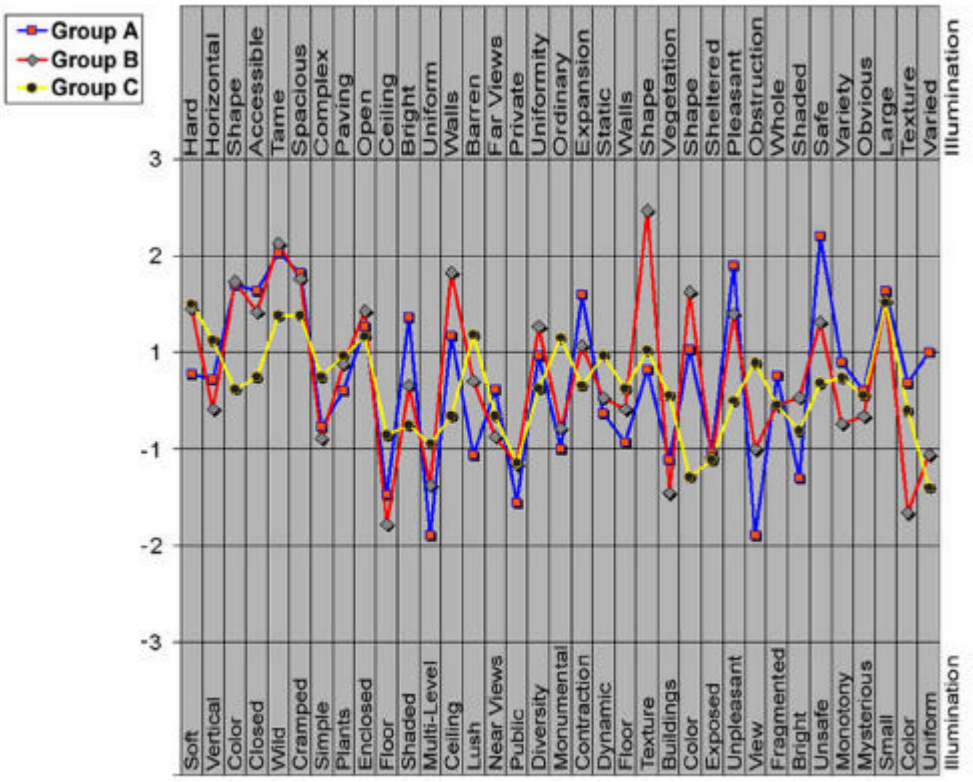

Figure 8: **Statistical Comparisons of Paired Adjectives**

3 CONCLUSIONS FROM BOTH PROJECTS

The first pilot study showed that the "walk-through" mode had the greatest number of responses that were significantly different between the two panels, as much as the other two modes combined. In addition, the "walk-through" mode provided three of the four strongest "p values". This would suggest that the walk-through mode emphasized the perceptual differences between conventional and computer generated representations. The second pilot study indicated that a low level of detail in a computer generated "walk-through" simulation provided enough perceptual elements to allow the viewer to develop an understanding of the spatial relationships of the design.

4 FUTURE EFFORTS

This research effort is just a first step in determining how our new digital tools affect the environments we create. Based on these initial findings there is a need to expand the effort to begin to address questions related to specific designer, design and representational characteristics. It will be necessary to develop better assessment tools to survey the perceptions of designers and the general public. It is important to know how years of experience and familiarity with digital media affects the understanding of images. Will the perception of space through computer generated representation change as designers become more familiar with this new tool? Will some representational modes convey certain design characteristics more effectively than others? Are these findings transferable to other designs or are they idiosyncratic in nature? However, even if we answer all these questions there is still one key aspect that needs to be explored. Which representations best model reality? We need to know how the perception of space conveyed by our representational media corresponds to our perceptions of the real thing. As designers of space our representations are not our goal but rather a means to an end. In shaping the physical environment it is important that we drive our tools to achieve our intent and are not transported by our tools to unknown destinations.

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