Measuring the Difference:
Tectonic Effects of Media on Architectural Design

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INTRODUCTION

In architecture, media is defined as apparatus for selecting, gathering, organizing, storing, and conveying knowledge in representational forms. From a theoretical viewpoint, media can be regarded as an important and influential factor in the design process. Consequently, the potential for a relationship between media and architectural design can be seen when the interaction between cognitive processes and characteristics of the environment is considered (Salomon, Perkins, and Globerson 1991; Salomon 1993; Kozma 1993) Given this, it would be appropriate to assert that the nature and power of the available media facilitates what is conceived and accomplished. In the generation of new ideas, the media can be regarded as a tool of primary importance. Conversely, limitations in the design can result from the limitations of the media. In this respect, media can be thought of as cognitive tools that serve constructive thinking, transcend cognitive limitations, and engage in cognitive operations not capable otherwise (Pea 1985).

The general agreement among architects, architectural educators, and researchers is that new technologies, -digital media in particular- will play a critical role in the future of the profession. But, a debate rages about how architects should be trained to interact with these media. We do not have a clear answer to this issue. The problem is that there is not even an established relationship between media and architectural design. The primary reason is not the lack of this relationship but the lack of empirical studies. As a result, our understanding of media is fuzzy and unclear. Perhaps, this is partly due to the lack of adequate systematic research, and partly due to difficulties in formulating essential questions. Moreover, existing arguments are often based on implicit conjectures, and these may block the formulation of productive research questions. Consequently, there have been many speculative claims that students or junior architects, who cannot draw freely and thus design only within the limits of their power of representation, are the victims of analog take-over (Heath 1984). Hence, media is a constraint on design thinking. In fact, many authors have made assertions and predictions that the capabilities and limitations of the media have a direct effect on the outcome of the design. In order to test these claims and to provide a framework for their potential contributions to architectural education, this study aims to study media and its' effects on architectural design, particularly architectonics. It focuses on a specific level of architectural education, two types of media and the ways they relate to major aspects of design, such as space-making and form-building. It provides an opportunity to compare the effects of different media and consequently to establish a link between media and design.

BACKGROUND AND RELATED STUDIES

In architecture, there are scattered studies that attempt to address the issue that media effect design process. Even though, these studies are valuable and contribute to the accumulation of knowledge in this field, they are not able to establish a relationship between digital media and design. There are several reasons for this failure. Most of these studies were done without comparing their results with traditional media, such as Akin (Akin 1990), Eastman and Lang (Eastman and Lang 1991). The results they concluded are only reinforcements of their claims, especially in the studies of Danahy (Danahy 1990; Danahy 1991) and Saggio (Saggio 1992). The second reason is that the sample size of existing studies was too small to be considered as valid systematic research, such as Walters (Walters 1985), and Smulevich (Smulevich 1993). Another reason is that the reliability of these studies. Most of them did not use explicit methods that would have allowed the repetition of the study by other researchers. Still another reason is that these studies are more impressionistic than empirical, personal observation is used as the main method, such as Cigolle and Coleman (Cigolle, Mark, and Coleman 1990; Cigolle and Coleman 1990), Parsons (Parsons 1994). Finally, some of them remain only at a normative level, such as Herbert (Herbert

1994, 1992) and (Mitchell and McCullough 1991). That is they may be theoretically useful but do not contribute strongly to the empirical body of knowledge.

RESEARCH DESIGN AND INSTRUMENTATION

During 1997-2001, a total of 145 students who were enrolled in a first year design studio at three schools (Georgia Tech, University of Utah and Temple University), participated this study. Some of these same students were simultaneously enrolled in an introduction to computing class. The experimental group consisted of the students who took the design studio and computer course together (Group 1). The control group consisted of design studio students not enrolled in the computer class (Group 2). Both groups worked on the same design project. Group 1 used digital media while Group 2 used manual media. Because of factors influencing the sample and other experimental conditions, a quasi-experimental research design was used. The independent variable and the dependent variable of this study were "media" (both digital and manual) and "design" respectively.

Because of factors influencing the sample and other experimental conditions, a quasi-experimental research design was used. The independent variable and the dependent variable of this study were "media" (both digital and manual) and "design" respectively. Since architectural design is still considered partially as an art and is generally evaluated on subjective grounds with few quantitative measures, the following procedures were developed in order to assess the differences between the two media and the effects on the dependent variable (design).

PROCEDURE AND MEASUREMENTS

Relevant conceptual and operational definitions of the first year architectonic design issues related to this study are identified. Since the assessment of architectural design is difficult, a set of quantitative measures is developed in order to lay out the procedures that provide criteria for the evaluation of students' projects and allow for a quantitative assessment of the differences between the two samples to be made. Two levels of measurements were taken in this study: Quantitative and Qualitative. Quantitative measures intended to measure aspects such as categories, numbers, degrees, proportions, size, location, etc., and qualitative measures intended to measure as designers' subjective evaluations of a project based on several survey questions. In terms of statistical data types, both categorical and continuous data types were used for quantifiable aspects of design, and numerical types for the qualitative aspects of design.

RESULTS AND ANALYSES

Four major design issues were measured and reported. These are:

1. Concept development
2. Space making
3. Form building
4. Design Quality

In concept development, it was found that unclear conceptualizations were more likely to appear in the manual media group regardless of the sequence of the concepts they employed (Figure 1). Another important finding of the concept development analysis that would appear to be affected by the media was the variation of the samples. The manual media group seemed to produce some easy-to-build concepts and created fewer categories. Furthermore, the resulting conceptual implementations by this group tended to be less complex and more ambiguous and displayed fewer features than the digital media group. The digital media group appeared to overcome this problem. These results indicated that from the manual media users' point of view, there was simply not enough flexibility and/or sufficient time to develop and explore a wide range of alternatives and refinements. This kind of exploration and efficient conceptual representation of content is essential for effective concept development. Moreover, it seemed that certain conceptual issues were related to some specific capabilities of a particular media. These results suggest that the employment and utilization of digital media gave students enough flexibility to study, to execute and to maintain desired or expected concepts. The relatively more homogeneous distribution of design concepts in all concept categories and the clarity and readability of these concepts in the digital media group's projects were supported with the consistency of the sequential concept developments.

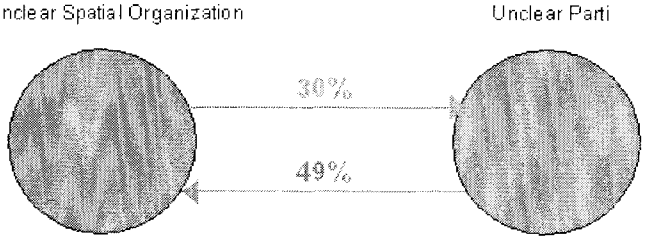
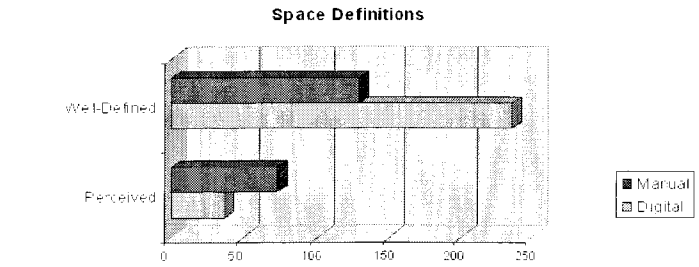


Fig. 1. Statistical correlation between the different parts of a design process.

In Space-making, digital media group appeared to be more actively involved than the other group. In comparison, the digital media group produced significantly different results on most measures related to architectonic space making and these differences suggested a relationship between media and measured architectonic design issues.

The first and one of the significant differences between the two groups was the definition of the spaces. According to the results, students who used digital media developed designs that suggested more understanding of architectonic space and clear distinctions between the conceptual and perceptual spaces. The proportional differences between the groups (well-defined vs. perceived) implied that certain attributes of media made a notable difference in space definitions. In comparison to the other group, the digital media group created significantly more well-defined spaces and qualitative analysis later suggested a strong correlation between the well-defined spaces and better design quality (see Figure 2).



	Perceived	Well-Defined
Manual	73	128
Digital	37	238

Fig. 2. Space definitions of both groups.

These definitional results were related to the results of the shape of the spaces. The digital media group created 62% more orthogonal spaces than the manual media group and since the qualitative analysis showed a considerable correlation between these issues, this difference was also reflected in better design quality. The geometrical shape was one of the important characteristics of spaces and, since the spatial volume depended partially on the edge definitions, it was related to the spatial definition of spaces. In the formation of space construction, the shape served as the key element in the vocabulary of the architectonic definition. The orthogonality of spaces did not only support these definitions but also articulated the spatial continuity.

These issues were further supported with additional findings. Space construction results indicated that the digital media group relied more heavily on the primary wall planes to create their spaces whereas the manual media group used mostly horizontal and secondary planes for space creation. The manual media group's reliance on other planes, especially on horizontal planes indicated that their efforts were not focused on considering the spatial composition. Simply, they could not solve the spaces, their organization, and their relationship as successfully as the digital media group. Almost all of the other space-related findings, especially roof/space ratio support this explanation ($p = 0.58$).

The Form-building results indicated that media influenced the typology of design by effecting certain elements of form that contributed to the development of form building. Overall, digital media group articulated their planes, emphasized the penetration and continuity of its surfaces, handled the openings to visually organize the volumes, utilized their object elements and formed more balanced compositions than the other group. An important finding was the compositional differences between the two groups. The results indicated that media made a significant difference on formal compositions in student designs. The digital media group created more balanced compositions than the other group (see Figure 3). Therefore, in comparison, their designs were clearer, more consistent and were assessed of having better design quality than the manual media group.

The overall Design-quality results showed considerable differences between the two groups. In a randomly selected sample, all design issues and projects (with one exception) were evaluated favorably for the digital media projects. According to the results, certain design issues were correlated more than others. For example, "donut" and "nine-square" partis, "grid" organizations, "datum" and "repetition" ordering systems in design concepts category seemed to be related to better design quality. All of these conceptual types were found overwhelmingly more often in the digital media group's projects. Other design issues, such as planes' porosity, spatial definitions, orthogonality, balanced compositions were significantly different in the digital media group's projects and these differences were correlated with better design quality. For example, The more porous the primary walls, the higher the design quality became ($r = 0.65$, $p = <0.0001$) (see Figure 4).

One interesting finding was the combined effect of these issues on design quality. The multiple regression results showed that these issues made individual impacts on the overall design quality in varying degrees but this impact was increased when they were used all together. Another interesting finding was the one-sided, independent effects of some issues. For example, the accessibility of the openings correlated significantly with higher design quality scores, whereas non-accessibility did not seem to make any qualitative difference. In other words, when a design included both accessible and non-accessible openings, the number of accessible ones made a positive difference even though there was no effect for non-accessible openings.

Overall, these findings suggested that media not only created quantitative differences in design projects but also affected the quality of the projects. The effects of digital media on basic design properties seemed to have a direct and essential impact in the way architectural design was produced. Students appeared to develop a better understanding on the nature of the design project and made better design decisions.

Descriptive Statistics

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing	Range
Digital - Spatial Design/ Composition/ Balance	-1.000	1.552	.231	45	-5.000	0.000	0	5.000
Manual - Spatial Design/ Composition/ Balance	-2.511	2.149	.320	45	-6.000	3.000	0	8.000

Fig. 3. Descriptive statistics of balance in both groups.

LIMITATIONS

There are certain limitations of this study. First limitation is the theoretical framework (media theory) that this study is based on. According to this theory, different media have causal mechanisms by which cognitive and social processes are influenced as students interact with the media's capabilities. However, there are some shortcomings of this work. The relationship the authors try to make is causal which is very difficult to establish if not impossible. In terms of coverage, there are some limitations. Even though this study investigates the relationship between media and architectural design, the scope of both areas is very narrow. In terms of media, only the representational parameters of both media (digital and traditional) are investigated and their boundaries are limited to architectural design. In terms of architectural design, only first-year, first-year design studio students' projects were analyzed and compared. Furthermore, the definition of design is limited to formal aesthetics, namely architectonics. Other areas of architectural design and education are neither covered nor addressed. Another limitation pertains to some of the methodological issues used in this study. First, certain student demographics information such as race, age, cultural orientation, etc. is ignored because of the impossibility to control these issues. Moreover, because of the nature of this study, the students are not assigned randomly to experimental conditions, and therefore, the equality between the two groups cannot be guaranteed.

Finally, due to the nature of architectural design, the design evaluations created additional limitations. Since architectural design cannot be self-evident and few quantifiable measures are available, the evaluations of the design projects rely on subjective interpretation of the assessors. Therefore, maximum care is taken for identification and operationalization of the design issues and additional assessors are included for verification. Still, the results require further testing.

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Regression Summary
Design Quality vs. Planes/Primary/Porosity

Count	90
Num. Missing	0
R	.655
R Squared	.429
Adjusted R Squared	.423
RMS Residual	.721

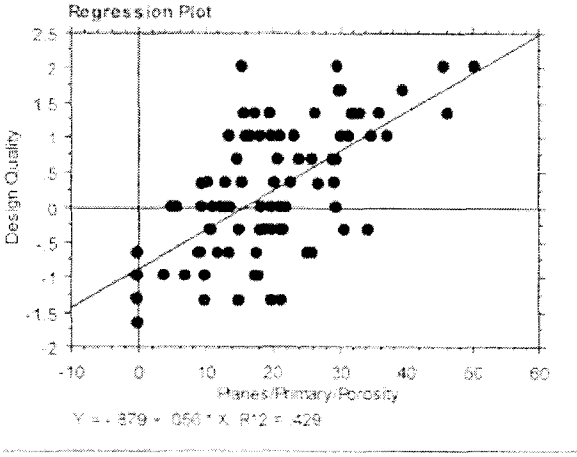

Fig. 4. Correlation between the porosity level of primary planes and design quality.

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