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Media Interaction and Design Process: Establishing a Knowledge Base

Integrating computers in architectural design means to negotiate between centuries-old analog design methods and the new digital systems of production. Analog systems of architectural production use tracing paper, vellum, graphite and ink, clipboard, clay, balsa wood, plastic, metal, etc. Analog systems have also been termed 'handmade', 'manual', 'material' or 'physical'. Digital systems of architectural production use scanning, image manipulation, visualization, solid modeling, computer aided drafting, animation, rendering, etc. Digital systems have also been called 'electronic', 'computer-aided', 'virtual', etc.

The difficulty lies in the underdeveloped state of the necessary methods, techniques, and theories to relate traditional and new media. Recent investigations on the use of multiple iterations between manual and electronic systems to advance architectural work show promising results. However, these experiments have not been sufficiently codified, cross-referenced and third party tested to conform a reliable knowledge base. This paper addresses this shortcoming by bringing together reported experiences from diverse researchers over the past decade. This summary is informed by more than three years of continuous investigation in the impacts of analog-digital conversations in the design process. The goal is to establish a state-of-the-art common foundation that permits instructors, researchers and practitioners to refer to, utilize, test, criticize and develop. An appendix is included providing support for the paper's arguments.

Interactions avec les médias et processus de design: Établissement d'une base de connaissances

L'intégration des ordinateurs dans le processus de conception architecturale nécessite un dialogue entre les anciennes méthodes analogues, utilisées depuis des siècles, et les méthodes digitales modernes. Les difficultés se situent au niveau de l'état sous-développé des méthodes et théories pour relier les nouvelleset les anciennes techniques. Des recherches récentes sur l'utilisation d'itérations multiples entre systèmes manuels et électroniques pour avancer le travail de l'architecte ont produit de résultats intéressants.

Cependant, ces résultats n'ont pas été suffisamment codifiés, référés, et testés pour former une base de connaissances fiable. Ce papier vise à combler ce manque en réunissant des témoignages sur diverses recherches effectuées au cours du décennie dernier. Ce reportage résulte de plus de trois ans d'investigations continuelles concernant l'impact du dialogue analogue-digital sur le processus de la conception architecturale. Le but est d'établir une base commune que les enseignants, les chercheurs et les étudiants peuvent utiliser, vérifier, critiquer et développer d'avantage. Une appendice contient les preuves à l'appui des arguments des auteurs.

introduction

The past five years have witnessed an astonishing shift in the way architecture is produced. Visiting any architectural firm reveals a working environment dominated by rows of desks filled up with computer workstations and printouts. Gone or pushed to hidden corners are the tables with drawing and modeling instruments. The old chaos of handmade production has been replaced by a highly pristine and hygienic productive territory. The noisy murmur of people interacting has been substituted by silent cyberspace communication and isolated machine–operator dialogues. The architectural studio has become a corporate office.

Academia has reacted to this trend by moving to the full integration of computers into their curricula. The results stand in sharp contrast with the path that offices have taken. Instead of doing away with the analog tools that have driven architectural production for centuries, schools continue to embrace a strategy of convivial and tolerance between old and new systems of architectural making. Walking through the studios of most schools today, one finds computers on the students' desks along with the traditional messy environment of handmade work. This productive environment allows a naturally fluid interface that foster unconstrained media iterations and dialogue.

The fact that academia has chosen this road largely out of financial limitations and not visionary zeal is to an extent irrelevant. Until very recently, most schools have been unable to put a computer on every student's desk or make it an educational requirement. What counts is that the resulting approach to media is, alas, highly promising.

Architecture is grounded, defined, born on materiality, tectonics, embodiment, and presence. This ontological character cannot be ultimately bypassed by electronic simulation in virtuality. In other words, no matter how evolved our digital tools and environments may become, and there is every reason to believe that they will be quite sophisticated, the physicality of architecture will always demand some direct reference to the analog world. Hence, it is not a reactionary statement to say that electronic media will never be able to replace / displace the representational power of analog media (see among others Bermudez 1997a; Cheng 1997; Herbert 1995, 1994; Smulevich 1997). Actually, the fact that fully digital, paperless practices suspiciously produce architecture that looks like it could have been developed without computers points at the impossibility of escaping materiality and the artificial tyranny of digital dogma.

For some time to come, however, we are bound to see an increased abandonment of analog tools in favor of the new, in fashion digital systems of production, touted as the ultimate productive business solution for all firms. And yet, once the dust of novelty and the mass hysteria of unreflective digital conversation dissipate the unmatchable and thus unreplaceable qualities of the analog medium will become obvious and inevitably call for its coming back into the office. In other words, the likely outcome of the competitive interaction between the two media is not the extinction of the analog in the hands of the digital but rather a coordinated and collaborative coexistence of both representational systems, each one highly evolved to do what it does best. The view that the digital will not displace the analog, but instead will help clarify its different strengths, force specialization and complementation is shared by other researchers.[2] This inclusive and symbiotic position is also the most reasonable to take when trying to prepare for an uncertain future. Evolutionary theory has taught us this loud and clear. The best resource against new challenges is diversity of resources, methodologies, skills, etc. So, and against what many believe, it is a diversified approach to the means of architectural production that holds most promise for the future of our discipline.

Hence, the challenge is not to rush to digitize all architectural work but instead to develop a productive space allowing representational-media interactions. At this stage, this challenge is methodological and paradigmatic rather than technical. Most architecture offices and schools already possess all the necessary technology to support this kind of work. That is multimedia computers and software, scanners, printers, intra and internet works, removable storage, and other media support (photocopy machines, camcorders, VCRs, TVs, telephones, etc.).[3]

What has been missing is the approach (methods) and theory to bridge the gap between analog and the digital media. Although we have known that there is a territory lying between them, we have not had the necessary maps to explore it systematically. This is a perfect job for academia. Lacking the market pressures of practice, schools are in a good situation to look at this problem and push the profession to a new level of competence.

This is already happening. Schools are great experimental grounds wherein the use of multiple iterations between digital and analog media are being tested daily in institutions across the U.S. These ongoing explorations of digital-analog dialogue are far more advanced than what we find in architecture offices.[4] However, and to be honest, this design edge that academia has over practice is by and large not the result of faculty or administrators' vision but rather a product of students' proactivity. Having grown up surrounded by computers and pressed by the real need to develop marketable skills for jobs, architecture students slowly began bringing their own computers into the studio. As a result, schools find themselves today in the odd situation of having a hybrid productive environment with little or no elaborated pedagogy and theory to deal with it.

In effect, there is little or no instruction of procedures or concepts about how to negotiate the interface between digital and analog media. Students are generally left alone to figure out these connections. This often produces superficial, wasteful and frustrating use and understanding of what otherwise could be a powerful productive environment.

This troublesome–but, at the same time, promising–situation has begun to be examined. Recent academic investigations on the use of multiple iterations between digital and analog media during the design process show promising techniques, methodologies and results. However, these experiences lack in one important aspect: they have not yet been sufficiently third-party tested, confirmed and codified to constitute knowledge. The developed strategies of teaching / practicing architecture via media iteration procedures requires compilation, verification and systematization. This shortcoming is not only holding back the application of a 'media interaction paradigm' in architectural practice and education but also causing a great deal of wasted time and efforts in the profession at large. We find ourselves having to start again and again without being able to advance the state of the art. Work on knowledge development is therefore of vital importance to move architectural thought, production and education to a new level of competence. This paper takes on this challenge. Given the magnitude of the task, we have humbly attempted to organize the series of findings that have been shown to possess some reliable consistency across many documented experiences and research programs.

developing a knowledge base

It is of vital importance to begin objectively collecting, relating and testing reported experiences on the interaction between digital and analog media during the design process. This cross-referencing work would move architectural thought, production and education to a new level of competence as such coordinated and verified knowledge base would provide the necessary foundation for more productive and insightful work.[5] The first necessary step in this process is to collect, compare, summarize, and organize the reported experiences in this area in the past decade or so.

Although the choice of this time limit may appear somewhat arbitrary, reviewing the existing literature of the 1980's (largely ACADIA publications) reveals that by and large it is not before the middle 80's when digital media begins to be really employed with some degree of success in design process. It is by this time when the dialectic between analog and digital systems begins to be directly or indirectly addressed (e.g., Goldman 1987). Reported experiences remain somewhat steady until after 1994, when there is literally an explosion in research work in this area. This is perhaps related to the direct impact of Herbert's seminal paper "A Critical Analysis of Design Processes and Media: Applications for Computer-Aided Design" (1994), the delayed reaction to books on the subject (e.g., McCullough, Mitchell 1990; Mitchell 1991) in the community of academics specialized in digital media, or simply the natural confluence of many factors at the same time

(e.g., hardware cost, software power, etc.).

We focus our study on the use of digital media as a representation space for the design process. We have purposely avoided any reference to electronic environments as spaces for communication and/or collaborative work. This does not mean to underplay the importance of cyberspace communication and production, for it will surely revolutionize the way we think and make architecture as several researchers are beginning to demonstrate (Cheng 1995a, 1998; Mitchell 1995; Smulevich 1997; de Velasco 1997, 1998; Wojtowicz 1995). Rather, avoiding this topic allows us to concentrate our full attention to analog-digital media iterations and their impact in the design process. Following is a listing of 19 hypotheses that have found support from diverse lines of inquiry. As said, the list has been compiled by comparing and summarizing documented experiences over the past decade. The interpretation and organization of this material have been informed by our own research on media iterations during the last three years, both in design studios and in visits to several schools of architecture around the US and abroad.

We were tempted to include parts of our design studio investigations in this paper to provide further evidence to many of the hypotheses. After careful consideration, we desisted. We determined that it was more important to concentrate our efforts into codifying the reported experience rather than adding more information to the unstructured state of the art knowledge in this area. This decision proved correct as the compilation and analytical work this paper required took over a year of our time. We have included an Appendix at the end of the paper with relevant data related to our design studio investigations.

The constructed hypotheses are presented straight forwardly. The reader may refer to the originals for more detail as we have provided direct references to the published sources. The list does not attempt to be complete, prescriptive or even fully correct. This area of study is only in its beginning and these hypotheses are just that, hypotheses subject to provisory utilization, conscious testing, eventual change, and possible refutation.[6] These hypotheses are particularly strong because they summarize common and consistent findings reported by many researchers working independently and often unknowingly of each others' efforts.

We apologize in advance for possible misreading and miscategorization of researchers' findings. Conceptual boxes, clear cut definitions, and quotes out of context tend to be misleading but nonetheless necessary, even if only to criticize them. We hope that the reader will tolerate some of our shortcomings in light of the scope and goals of this project.

The first three hypotheses present fundamental premises and concepts of the media interaction process. Although these findings may be said to apply to all media iterations, we believe that the movement between digital and analog media increases the design impact of media shifts well beyond traditional iterations within the analog. Hypotheses 4-6 address the essential characteristics found in analog, digital and hybrid media. Hypotheses 7-9 present interfacial issues surrounding the media interaction process. Hypotheses 10-14 are concerned with findings in the area of architectural representation whereas Hypotheses 15-16 deal with the relationship between the media interaction process and architectural theory. Hypotheses 17-19 present pedagogic implications and issues that are necessary to consider and further test. Our research work agrees with almost all the presented hypotheses except in the case of contradictory evidence. In these cases, we have taken a position. In those parts where we make no reference to other people's work, the reader should assume our responsibility in the claim. We include three hypotheses that have not been documented by any other researcher yet but that we have found with enough validity in our own work as to grant documentation at this time (Hypotheses 8, 12 and 18). We have found contradicting evidences in Hypotheses 11 and 19. This does not necessarily mean that one of the positions should be wrong but instead, and most likely, that both may be responding to different situations (which again demonstrates the need for further investigation).

media interaction fundamentals

Hypothesis 1. Media and design process

methods associated with media have a direct and essential impact in the way architecture is conceived, developed and communicated. (Ataman 1997:4, 6; Herbert 1994:133-138). Rather than being "neutral, transparent and timeless" media and processes are "intentional, substantial and timely" (Herbert 1994:136). Analog and Digital representations are not just 'tools' for architectural thought and making but 'media', that is, they are environments wherein our minds and bodies fully engage the issues of architecture. (see for example DeLaura 1997: 76; Herbert 1994:133-135; McCullough 1996:62-64, Chapter 7; Smulevich 1997:148).

Hypothesis 2. Multiple iterations of analog-digital media interactions enhance the design process. The phenomena of transition (smooth or problematic) and re-interpretation required to move between media are of great importance as they enhance the design process in cognitive, qualitative, and productive terms. (Bermudez 1997a:522; Cheng 1995a:1, 4; Herbert 1995:30; Kellett 1996:38, 39; Matthews 1998:239; Novitski 1991; Parsons 1994:175; Smulevich 1997:149).

Hypothesis 3. The media interaction model encourages the idea and practice of process over product, doing over thinking, or better said, of doing as an extension of thinking and not a product of thinking. There is so much fluid movement that designers do not demonstrate particular attachment to a final product. After a while, the making takes over. As a result, the paradigm of operation tends to follow a pedagogy of experimentalism, play and constructivism (Ataman 1996:5; McCullough 1996:221-230; Neiman 1994; Neiman 1997:133).

media characteristics

Hypothesis 4. Analog representations are far more fluid and appropriate than digital media for initial and fast development of ideas, the stimulation of the imagination, free inquiry, the intentional and random cross-reference of diverse sources (Barreneche 1996, Cheng 1995b:1,2; DeLaura 1997:81; Goldman 1987:41; Kellett 1996:33, 38-39; Novitski 1991; Solomon 1995; Steigh 1996:183), the communication and evolution of tectonic/light studies, the manipulation and visualization of scale, the expression of emotional states, etc.

Hypothesis 5. Digital media are stronger for design development as they demand higher levels of geometrical definition and abstraction, and the elaboration and coordination of complexity and details (and delivering in kind) (Cheng 1995a:3; Cheng 1995b:1), allow the easy articulation and generation of multiple viewpoints (visualization), as well as access and manipulation of information (specially imagery), the storing of models and images (Kellett 1996:33), the generation of hyper-realistic rendering-simulations (although most of the researchers find the latter usually misguided). Many researchers agree with most of above. (Barreneche 1996; Bermudez 1997a; DeLaura 1997; Goldman 1987:47; Groh 1997; Kaiser 1993; Novitski 1991; Smulevich 1997; Solomon 1995).

Hypothesis 6. Combining the assets of each media during the iteration process creates hybrid media conditions that lower the "overhead and labor-intensive use of computer generated visualizations" (Smulevich 1997:149) or the effort of transforming and manipulating analog representations. The best hybrid methodologies and representations are found via play and personal interpretation (DeLaura 1997:76; Neiman 1997:132), that is, when designers fit media and technology to their process. As Smulevich says (1997:140-141): "The new processes involving high technology suggest a leaner, more ingenious use of resources leading to result-driven outcomes . . . Ingenious, individual enterprise, creativity and inventiveness stretched to the limit."

In fact, hybrid media procedures permits flexible and intuitive transformation of electronic technology into plastic media more suitable to the highly mutating nature of design inquiry. Media interface hardware (scanner, video cam, etc.) and software (video and image capture and manipulation–e.g., Photoshop, Premiere, etc.) are significantly more useful than CAD in advancing and supporting the design process, particularly during the beginning phases. (Bermudez 1998:522; Herbert 1995; Neiman 1994; Neiman 1997:136; Smulevich 1997:141). De-emphasizing CAD and directing students toward alternative use of digital media

may empower designers to assimilate media in their own terms, thus allowing for learners' faster adoption, retention and later utilization of the new techniques (DeLaura 1997:81; Herbert 1995; Neiman 1997:136; Smulevich 1997).

interfacial issues

Hypothesis 7. Media iterations help designers grasp the difference between media and therefore lead to the maximum exploitation of their capabilities as well as their synergistic potential in hybrid combinations. Moving between media discontinuities or interruptions also stimulates the development of rational and intuitive decision making causality. This in turn helps designers to:

1. "… grasp the way different media shape our habits of thought because we can see the progression, the change from one form to another" (Johnson 1997:4) (this is an outgrowth of Hypothesis 2);[7]

2. "progressively realize the relationship between different systems and thus understand their differences and strengths–this also develops bridges between the media;" (Bermudez 1997a:522)

3. "clarify, stimulate and develop what is being made." (Bermudez, ibid.); and

4. develop higher level of awareness of their own design process (Matthews 1998:239).

Hypothesis 8. Media iterations are completely dependent in interfacial events, that is, in situations, techniques and technologies unfolding between analog and digital media. The easier and the faster the input / output interfacial devices (converting analog to digital and vice versa) the better they support the media migratory movement and therefore the design process. The more these devices allow for reinterpretation (i.e., the more they frame and change what they mediated) the better their potential to enhance the interpretive process (to a point, of course) (refer to Hypothesis 2). In other words, the digital camera, the video camcorder, 2D printing and scanning work better than traditional photography, 3D printing and scanning, and plotting. This however may pass as new technologies develop (e.g., fast prototyping). The principle, however, would remain for any interfacial device allowing communication and movement between analog and digital media.

Hypothesis 9. There is considerably more digital manipulation of analog representations (e.g., scanned sketches, video-taped models, etc.) than an analog manipulation of digital representations (Herbert 1995:28). The problem here largely lies in the economical inaccessibility of technology to export electronic information out into the analog world (e.g., 3D printing) (Cheng 1995b:1; Scott 1997:152) except in the case of 2D printing. In both situations, moving between media invariably means to conduct work based on image and not data (Herbert 1995; Smulevich 1997). The arrival of reasonably priced and accurate 3D scanning will do a lot to change this (Cheng 1995b:3; Streich 1996:183, 189). Something similar will occur with 3D printing with CAD / CAM based physical manufacturing. (Streich 1996:183,189).

representation

Hypothesis 10. Media iterations facilitate unorthodox design methodologies and decision making because of the creative, often non-traditional use of software, hardware and ordinary representation systems (i.e., plan, elevation, section, perspective). For example, scanning a 3D physical model for developing elevations (Herbert 1995), digitally extruding a scanned manual sketch done from a video-captured 'plan-view' of a 3D physical model. As a result of these natural or other more conscious experimentations (e.g., Groh 1997:244-247; Neiman 1997:135-136; Pietrowski 1997:531-534), media iterations allow for new kinds of imagery and "representation fields" with a strong hybrid, strange yet familiar 'aura' conducive to metaphoric leaps assisting the design and communication processes. The resulting novel depictions begin to suggest ways of architectural representation beyond the traditional synchronic, unitary, and Euclidean boundaries of orthographic or perpectival constructs. Among the reported new potential qualities are representational shifting, simultaneity, multiplicity, temporality, speculation, assemblage, episodic fragmentation and typological hybridity. (e.g., DeLaura 1997:78-79; Herbert 1994:139, 142-143; Smulevich

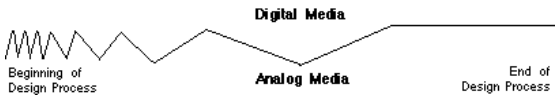
1997:149-151). Continued work on this area may lead to unprecedented ways of depicting or conceiving architecture.

Hypothesis 11. There are two positions (contradicting evidence):

1. "incorporating deliberate interactions between digital and manual media and manipulating the resulting images as sources for form does not necessarily displace the designer's traditional concerns for issues of program, physical and social context, and construction technology." (Herbert 1995:3; Herbert 1994:140).

2. the strong capability of digital media to display form and space in 4D (rendering, animation, interactivity) in conjunction with the use of analog representations aimed at developing tectonic and formal articulations is producing high levels of design development in all areas of design associated with form, space, technology, and materiality. The shortcoming is a decreasing attention to the social, contextual, and programmatic aspects of buildings. Put differently, the sensuality of digital depictions begins to bias the process towards an aesthetic formalism (i.e., the Form•Z look, the 3D Studio look, etc.).[9]

Hypothesis 12. There is a "breaking point" in the media iteration process where the designer "settles" on either analog or digital representations to complete the design. Media iterations are highest at the beginning of the design process and tend to slow down and eventually come to a stop at the end-phases of design development. At this latter stage, media interactions are rare and happen only as quick jumps from one media to the other, largely based on specific representation needs.



Hypothesis 13. There is a "comfort zone" where the designer tends to flee when faced with high performance expectations under stressful conditions. In these cases, the individual leans towards media (analog or digital) where they feel most comfortable so that they can concentrate on addressing the content of the challenge without having to add the practical and theoretical problems of the media (of course, this attitude misses the point that "the medium is the message" too). (the authors) This also tends to happen within working teams wherein different individuals are inclined to become expert at one media and thus develop a division of labor based on media expertise (Bermudez 1997a:522). The "comfort zone" phenomenon is also observed when a designer recently trained in iterative media procedures is put in a normal working environment that does not support such work. In these conditions, the designer reverts to old, traditional patterns of work (Ataman, 1996:3).

Hypothesis 14. Designers develop (and conservatively keep updating) a 'media / representation repertoire' that they manage during the design process. The incorporation of a media interaction paradigm to their available toolbox improves designers' capabilities since each representation tool has strengths to not only balance out the weaknesses of the other but also encourage the development of ideas in certain particular ways (Cheng 1995b:1, 2, 6; Herbert 1995:32; Kellett 1996:38-39; Parsons 1994:175). Ideally, a mature media interaction repertoire should allow for multiple representation iterations pursued in parallel-sequential-fluid order (Cheng 1995a:1-2; Herbert 1995:22; Kellett 1996:32) based on a heuristics of media fitness and economy (Cheng 1995a:3; Kellett 1996:32). The right tool at the right time for the right job means reducing representation redundancy and enhancing representation appropriateness in relation to the representation / design needs at hand (Bermudez 1997a:522; Steven Canter in Novitski 1991:99).

theory issues

Hypothesis 15. The theory behind pursuing an analog-digital media interaction process in architecture can be and perhaps should be related to the forces driving contemporary civilization and

profession. To do this, researchers attempt at creating theoretical bridges linking their procedures and approaches to a larger conceptual framework associated with rising information technologies, the post-industrial society, etc. (Bermudez 1997a:520-522; DeLaura 1997:76; Lange 1997:524-526; McCullough 1996; Neiman 1997:133; Smulevich 1997:140-141).

Hypothesis 16. The application of a media interaction paradigm helps if not demands the parallel development of architectural theory. Also, this paradigm brings attention to the ongoing theoretical challenges facing the profession (Bermudez 1997:522; Herbert 1994:133-135; Lange 1997:526; McCullough 1996; Matthews 1998:234-235; Raser 1998:2; Smulevich 1997:140-141).

pedagogy issues

Hypothesis 17. Students initially tend to resist the productive dialog between media and instead choose to work within one media or the other (Kellett 1996:36). Important pedagogic energy and will need to be placed to revert this situation. This is partially a result of the inability of media-inexperienced designers to perceive the eventual benefits of the new paradigm. It initially takes continuous instructional guidance to make students move back and forth between media. This effort decreases as students begin to get familiar with the process (Bermudez 1997a:522; Matthews 1998:239). Remarkable enough, students' evaluations generally warmly support the strength of this hybrid media approach and related pedagogy (Kellett 1996:40).

Hypothesis 18. Carrying on a successful analog-digital dialogue demands the designer's skills in both media. Designers that are unskilled in either analog or digital media naturally migrate to and stay with the media where they are most knowledgeable. Students with low skills in digital media (and also lower confidence) or who had a low desire to explore that medium, exhibit low levels of application of the interactive media process. This means that teaching this process requires previous digital background or pedagogical introduction and guidance.

This gives some support to Herbert (1995) (see Hypothesis 19, position (1) but could also be addressed by (1) clear structured instruction (Goldman 1987; Neiman 1994) or (2) a pedagogy of collaboration, hence enabling the use of media iterations early in the architecture career (see Hypothesis 20, position 2). In fact, we have found that successful team work permits the acceleration of the design process and the learning curve associated with the media interaction process.

Hypothesis 19. The iterative media process (conflicting evidence):

1. is better taught to and applied by mature design students and professionals given their larger cognitive and skill repertoire (Herbert 1995:32). This suggests that teaching the hybrid media paradigm should occur in graduate school or after graduation.
2. should be taught right from the very beginning of a designer's education in an organized and guided manner (Cheng 1995; Kellett 1996).

This means that it is necessary to develop a pedagogy of progressive acquisition of knowledge based on the teaching of technique and then content, and moving from sequential to parallel to fluid uses of media (Cheng 1995a:9). It may also imply to work in teams or collaborative types of pedagogies (the authors). Both positions agree, however, that "working in multiple media requires more skill building, but can yield more insight" (Cheng 1995b:6). Content-independent learning has been proven pedagogically inappropriate for higher-cognitive and skill learning.

conclusion

> "In the early sixties, McLuhan famously remarked that living with electric and mechanical technologies at the same time was 'the peculiar drama of the twentieth century'. The great drama of the next few decades will unfold under the crossed stars of the analog and the digital." (Johnson 1997:40-41)

Today's state of productive and cultural liminality calls for a dynamic equilibrium between the digital and the analog systems of architectural

representation. We need both media as each one opens different praxial territories that are inaccessible by the other. And what is even more important, their interaction generates synergistic opportunities that transcend by far their own individual strengths. The diversity of tools and approaches offer not only more choice but also liminal conditions wherein the new breakthroughs lie. Awaiting . . .

The ongoing studies on the relationship between digital and analog media during the design process are beginning to help us develop in this direction. However, much remains to be done. By bringing together the hitherto disperse body of research efforts and findings in this area, this paper provides for the first time a common framework we can all use. This structure will hopefully allow us to engage in a more organized and fruitful utilization, discussion and inquiry regarding media interactions during the design process. Although this will mean different things for different people, we can foresee at least four clear directions in the utilization of the proposed knowledge base:

1. to assist practitioners and instructors in their ordinary work both as reference and guidance;
2. to develop research programs that verify, extend or disprove any of the 19 hypotheses;
3. to generate critical reactions that further the cause of media inquiry in architecture;
4. to point at the unexplored territories left uncovered by the constructed hypotheses.

In addition, there are many questions that still beg more systematic study and response regarding the media interaction process. For instance:

1. does higher productivity result from a more seamless transition between idea generation and design development allowed by analog-digital methodologies?
2. do the levels of creativity and exploratory attitude increase?
3. do students expand their theoretical breath and critical awareness of the contemporary challenges facing the profession regarding digital representation?
4. do designers reach higher degrees of design development than using either analog or digital media alone ?
5. do designers learning the media interaction process change their perception of the computer towards perceiving it as a potentially design-friendly tool / environment?

Design and research work in media interactions is providing solid evidences that offices will have to bring back the analog tools into their productive environments, albeit transformed by a new understanding of their strength and use. The result will be future architectural practices based on hybrid, multiple, and diverse media technologies (Cheng 1997; DeLaura 1997; Kellett 1996; Lange 1997). It is this kind of approach that will provide the discipline with the necessary foundation to address the challenges of the future. As Bermudez says (1997b:59), "the architectural practice and education of tomorrow is not ahead in the digital but between the analog and the digital; and not in one medium / approach but in many media / approaches." This inclusivist assertion has a strong ideological stand consistent with a humanistic understanding and ethics of architecture. Such a position:

> "involves the use of all available resources and combining them creatively to push the envelope of what we already know in the hope that what we find as a result will make a difference . . . It is a hybrid and complex state, accelerated and defiant of preexistent norms. This notion of becoming inventive with relatively modest means is suggestive of what it means to be an architect of the end of the millennium. We are . . . redefining what it means to be an architect in a world where old truths are now suspect and where the notion of Information has become just another buzz word for selling goods" (Smulevich 1997:141).

The path will not be easy. For we are not moving towards a simpler and easier future world but instead to a hybrid, messy, and complex reality. A world that, as Lange (1997) put it,[10] is closer to the images of Star Wars (or Blade Runner) than the hygienic, pristine, and modern scenario of 2001. And yet, the eruption of digital media into

the traditional fabric of architecture offers us the opportunity to revisit the premises and ways underlying contemporary architectural education and practice and ponder how we can make them better. This is a great time to be in academia. As this paper has pointed out, what is happening on campus is far more advanced and promising regarding the assimilation of the digital into architecture than what we find in the 'real world'. In this sense, research on media interaction theory, methodology and pedagogy can play a leading role in guiding our discipline into the future.

endnotes

[1] Analog systems of architectural production use tracing paper, vellum, graphite and ink, clipboard, clay, balsa wood, plastic, metal, etc. Analog systems have also been termed 'handmade', 'manual', 'material' or 'physical'. Digital systems of architectural production use scanning, image manipulation, visualization, solid modeling, computer aided drafting, animation, rendering, etc. Digital systems have also been called 'electronic', 'computer-aided', 'virtual', etc.

[2] See for instance Herbert (1995); Kellett (1996:31,32); Neiman (1994).

[3] Herbert (1995) and Smulevich (1997) also argue along this line. For instance Smulevich says: "Most of the valuable pedagogical (and we could add professional) contributions that high-end visualization technologies can make in the design realm are also achievable with very low-end (consumer-grade) technology." (1997:152).

[4] We would argue that this is one of the facts that makes Rafael Moneo state that" . . . it is not the architectural schools that follow the trends set by the professional firms, but now it is the professional firms that follow the trends set by the architectural schools." (quoted in Tschumi 1994:8).

[5] The need for this systematic study is reflected by other researchers. See for example Kellett 1996:41.

[6] One of the characteristics of scientific inquiry is the impossibility of reaching final truth. It is this refutability and falsifiability of scientific hypotheses that gives science social respect and trust and encourages its evolution. In this subject refer to Karl Popper (1965).

[7] The understanding of media bias provides ground for important insights. As Johnson puts it: "The explosion of media types in the twentieth century makes it possible for the first time to grasp the relationship of form to content, medium to message, engineering to artistry." (1997:3-4).

[8] A good example of this shifting is reported by Herbert (1994:139): "He (the student) excerpted and rotated parts of the plans, reinterpreted them as sections and then developed them further. Similarly, he returned to the developed floor plan, and reinterpreted and refined it as a perspective."

[9] This point was discussed in one of the Digital Media Sessions at the 1997 ACSA Annual Meeting in Dallas. Faculty from several schools reported concerns about this matter. Our own experience supports this concern. Glenn Goldman recognized this problem as early as 1987 (Goldman, 1987:41).

[10] This clear image was provided by Lange in her paper presentation at the 1997 ACSA Annual Meeting in Dallas, TX.

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appendix

We have chosen two examples to present evidence supporting Hypotheses 8, 12 and 18. As explained in the main body of the paper, these examples only attempt to offer initial arguments as more work is necessary to arrive at more final conclusions. This appendix is therefore intended to bring provisory support for our claims and the validity of many of the nineteen hypotheses.

The two examples are from two studios conducted at two different schools of architecture (one in the US and the other one abroad) in Winter 1996 and Summer 1997. They were selected because they:

1. summarize common issues regarding media iterations;
2. complement each other in students' background (with similar and different media skills) and length and complexity of design project (ten vs. three weeks, and 30,000sf commercial building vs. a 3,000sf dwelling), thus providing a wide spectrum for analysis;
3. belong to different cultural milieu (although they respond and generate situations that appear to be universal); and
4. both had students with no previous knowledge in media interaction procedures but that had at least two years of architectural design studio experience. In both cases, the teams of students were self-selected.

example 1

The student team was composed of three senior undergraduates and one graduate student. All were very skillful in CAD and manual sketching but with poor or no experience with non-CAD software and physical sketch modeling. The project was conducted at the Universidad Nacional del Litoral, Argentina in Summer, 1997. This example includes the collaborative work of four students, Martin Calabrese, Guillermo Mantaras, Guillermo Weiskal, and Gustavo Weiskal. The three-week long project was a house with contradictory needs easily framed within the contemporary clash between material and media cultures.

Phase 1. Students start with an analog sketch model of several planes articulated by a hinge. Many manual sketches are made trying to conceptually summarize the architectural ideas present in the physical model. (Figure 1). It is hard for students to engage the process. They cannot initially understand the need for analog 'stuff' in a 'digital / media' studio. Considerable pedagogical work and personal reassurance are needed to get them to accept the process with an open-minded attitude (Hypothesis 17). The flexibility of analog media allowed the team to start without having an idea. The very act of model making created the design space for discovering architectural concepts which were extracted largely through manual sketches (Figure 1) (Hypotheses 3-4).

Phase 2. Based on findings from the first model and sketches, the team builds a second analog model (Figure 2 left). At this stage, the students assign planes the meaning of 'real' and the penetrating lines the meaning of 'virtual' (in our civilization, the material is held together by media– the virtual). The model is then video-taped, pre-viewed on the computer and several images are selected

and digitized. The chosen images are then 'cleaned up' to communicate the conceptual scheme behind the image (Figure 2 center and right). The team decides to take on the idea of "layer" as its guiding design metaphor.

From this point on, both design process and media iteration are sped up and directed by the discoveries made in each medium. A quick digital model is built to explore the concepts of line and plane (Figure 3, left). From here, two parallel lines of inquiry emerge. Two models, one analog (Figure 3, right) and one digital (Figure 4) are constructed, both pushing the idea of "layer" through interactions between plane and line toward the formal limit. After making an animation to study the temporal / experiential implication of their scheme, the team decides to extract the visual elements of the previous exploration and produce an "image of synthesis" (Figure 5). The team expends considerable amount of time in digital media, obviously, trying to impress the instructor and because, finally, they can work in CAD (Hypothesis 18).

The medial iterations (analog modeling, video taping with biased viewpoints, digitalization of selected video frames and electronic 'clean-up') allowed a process of continuous 'architecturalization' of the idea, each media 'jump' requiring some formal / spatial emphasis or exaggeration in order to clarify and define the inprogress scheme (Figures 2-5). CAD enters as another media in the process of design elaboration with the implication of a geometric definition that had been unnecessary until then (Figure 4) (Hypothesis 5).

The CAD interpretation robbed the ongoing process of its tectonic significance. A hybrid image (Figure 5) is digitally built to consciously bring back materiality into the design iterations with relative success (digitally pre-captured material textures are incorporated as background) (Hypotheses 6 and 10).

Phase 3. The instructor reviews the design recommending the team to begin to concretize the basic scheme through a series of analog models, particularly focusing in the tectonic nature of planes and lines. The students are told of their lack of consideration of material issues in their digital phase

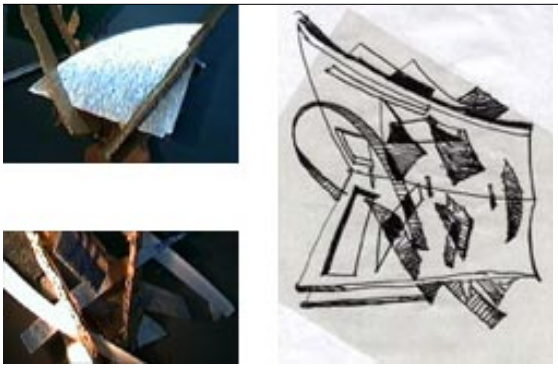
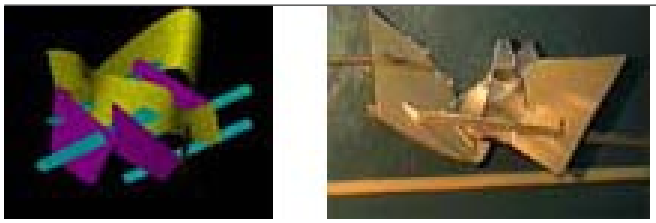


Figure 1

Figure 2



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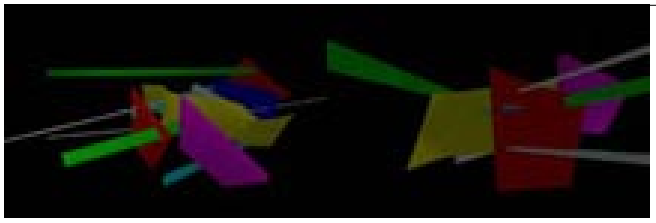

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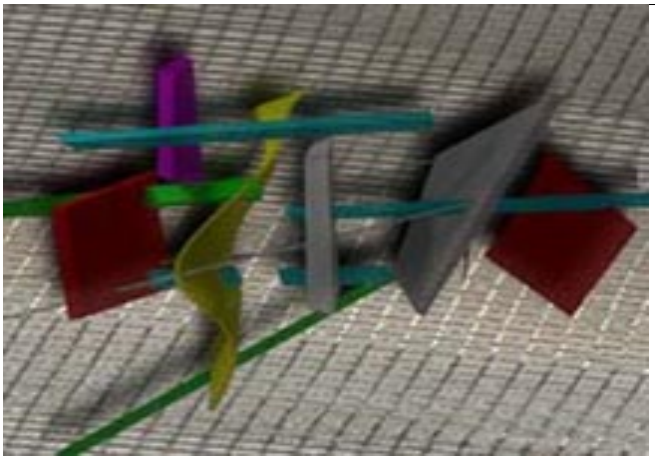
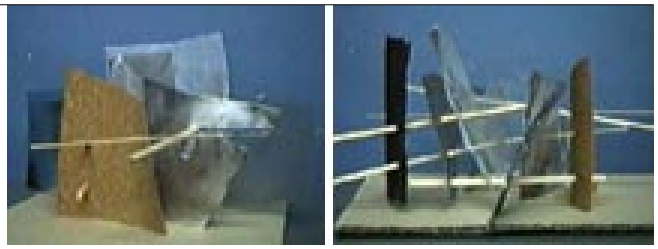


Figure 5

Figure 6



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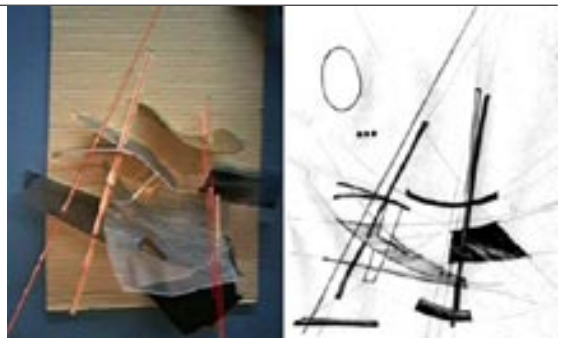


Figure 8

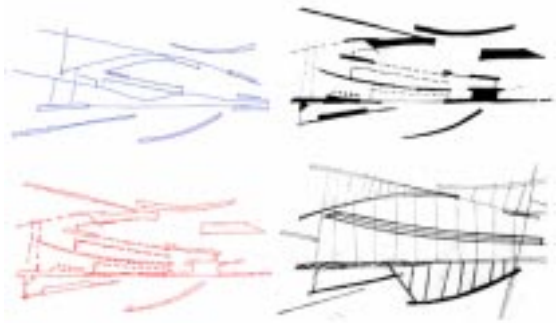


Figure 9

and the need to return to media iterations.

The fourth physical model loses track of the 'layer' concept because, among other things, it suggests volumes rather than spaces between the planes (layers) (Figure 6). However, it brings the students back to tectonic considerations. A fifth analog model is built with careful awareness to materiality to avoid the problems found in the previous iteration. Students sketch before making the model to further clarify their intentions (not shown). In this process, the students reconsider the idea of "layer" and create a 'semantics' of materials (e.g., translucent materials represent virtuality and perhaps related activities). Another physical model is built (Figure 7). This model is video-taped and images are digitally captured. At this point, video takes a phenomenal power in informing the design process as it delivers uncountable images suitable for analysis, selection, change and design development. Studies of these images in relation to the actual analog model permit to reduce the density of the layers, change the planes proportions, and look at the spatial situations of betweenness.

Phase 4. One image (top view) is selected as a 'plan' (this same event happens with one image that is defined as 'section', not shown in this series of images, and based on Figure 7 right). The progressive and subtle distillation and transformation of the 'plan' is clear and related to the nature of each media. The video-taped image of the analog model is traced rapidly in free-hand (allowing flexibility at exploring different interpretations of the same information–the one shown is the end of a series of many sketches made, Figure 8 right). More careful free-hand tracing and scanning follows looking at the material nature of the layers (walls), the spaces between them (Figure 9, both on top) and structural considerations (Figure 9 bottom right). As this takes place, section studies (not shown) are being developed in parallel. Hand drawings and non-CAD software are used to think and develop architectural ideas without stiffing the life and looseness of the analog model.

The digitized video image that appears as 'plan' is digitally analyzed in Photoshop, printed, and manually traced / re-interpreted in a very lose

free hand sketch (Figure 9 top left). Concepts and relationships related to lines and planes are manually synthesized first, second scanned, and third imported and developed in CAD. This procedure is clearly documented in the evolution of floor plans (Figures 9-10). The new insights from this media iteration are transferred to a new digital model (Figure 11).

The scanning and digital development of the analog sketch (Figure 10 top) do not substantially change anything except that the manual drawing information in plan and section are now available in 3D and modified accordingly. Once the students arrived to this point of design development (second part of phase 3, Figure 10 on) they continued in the digital realm until the end, giving strong evidence of media iteration *breaking point* (Hypothesis 12).

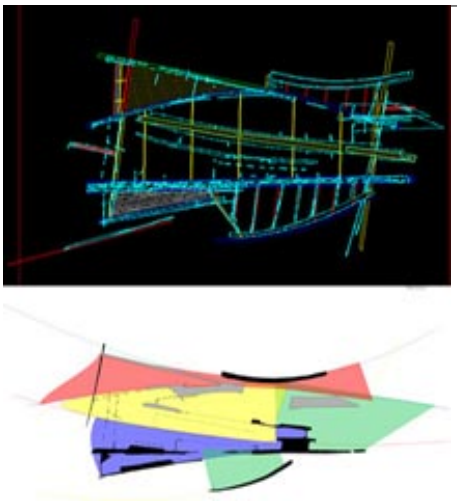


Figure 10

The team does diverse 'extrusions' and animations trying to model the intermediate spaces (Figure 11 top). They proceed to assign activities to these spaces in the floor plan (Figures 10 bottom). The final presentation includes diverse still images, animations and VRML. This set of representations in addition to the rough analog model provides a high degree of development and sophistication for the short period of time devoted to this design exercise (Figures 11 bottom and 12). Given the concept of "layer" that the team was pursuing, the design development in section was an essential aspect of the process and final presentation (Figure 11).

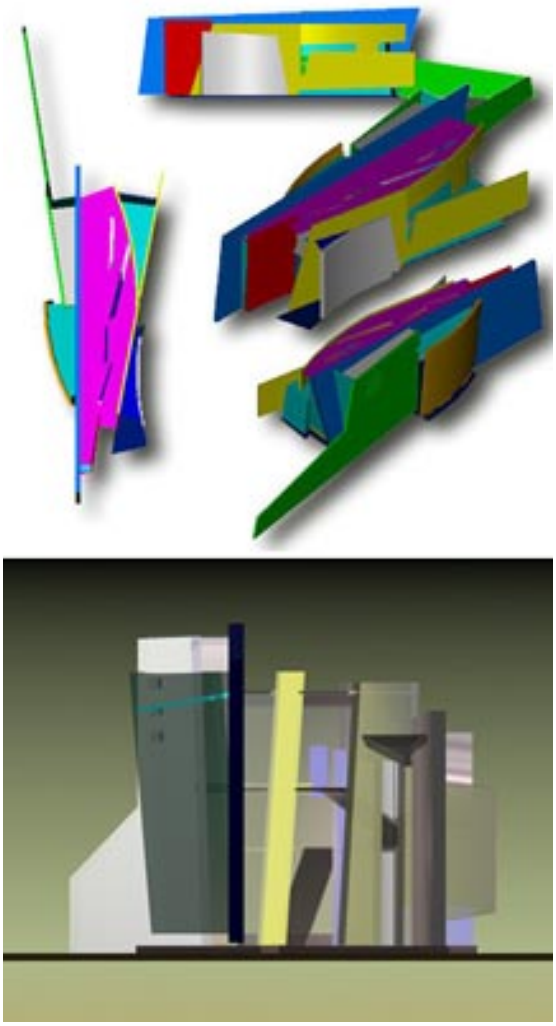


Figure 11

general comments

During Phase 1, the team resisted the media iteration paradigm and had high levels of stress, largely due to their lack of experience in analog sketch modeling, their education background rooted in functionalism, strict precedents and geometric logic, as well as their expectations of what a CAD studio ought to be. As they began to let go of preconceptions and feel at ease with physical modeling, the situation started to change. The breakthrough occurred during Phase 2, while trying to interpret the digital model (Figure 3 left) into material and electronic media (Figure 3 right and 4). After experiencing the positive results of fully engaging the media interaction process, students

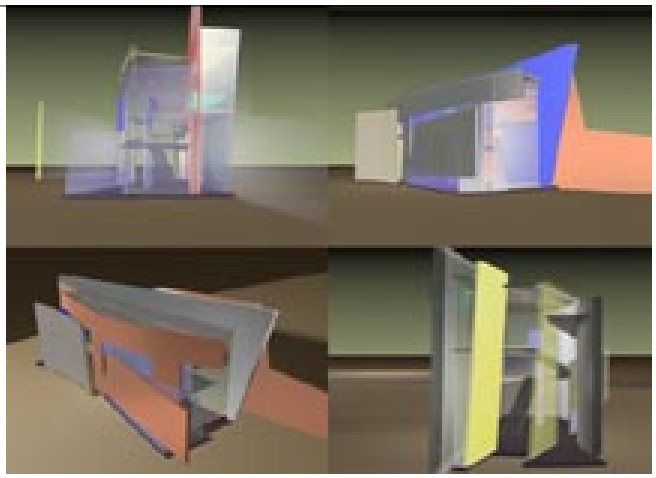
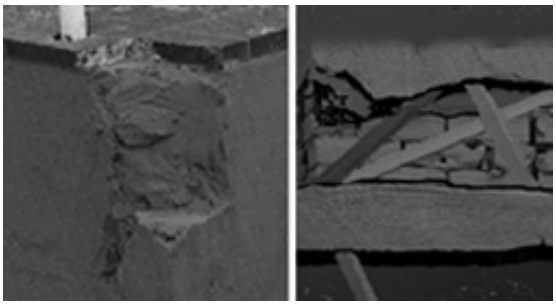


Figure 12

finally gave in and accepted this procedure as a natural and helpful design methodology. After this event, the team's production improved dramatically as did their design results. Non-CAD software in relation to analog sketch models appeared to have given students the necessary freedom and good design results to allow them to abandon some of their preconceptions.

The speed and ease at jumping between media was essential to keep students interested and focused in what they were designing. In other words, the technological know how did not get in the way of the design process, hence allowing the designers to concentrate in the business of architectural decision making. Little technical friction was also appreciated by the students and received with great appreciation in comments during studio evaluation afterwards. This provides evidence supporting Hypothesis 8.

This team was highly productive at all levels. Their major difficulty was to engage the analog freely without trying to jump too fast to CAD. Imaging software was an essential tool for them to allow a transition and interpretive phase that they often utilized best through printing and manual sketching (Hypothesis 6). It was clear from this experience that the repetitive practice of media iterations generates a growth in the students' critical attitude as well as a familiarization with their own design process, and the association of media and decision making. This was particularly true when



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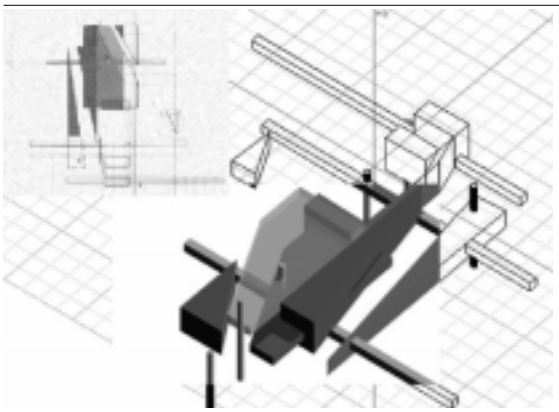

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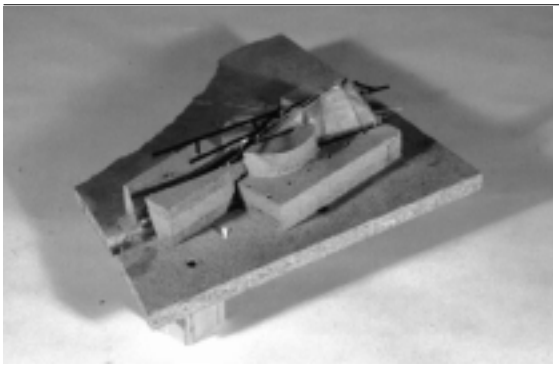

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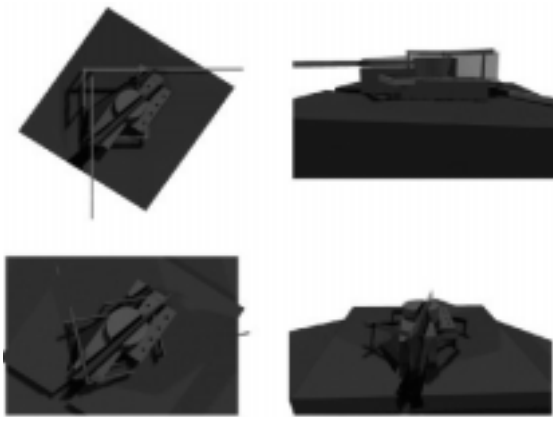


Figure 16

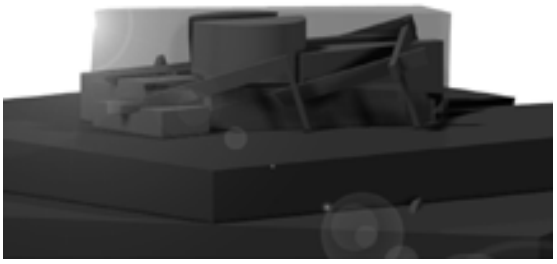
the architectural inquiry in one media had been exhausted and a media 'jump' was necessary.

At these points of media articulation and translations, the team had to figure out (i.e., critique) the whys and whats of their design and decide when and how to move to the next media. It was also clear that media interactions enormously encourage students to develop metacognitive skills beyond traditional media conditions (Hypothesis 7). The continuous moving back and forth between media also permitted the students to realize the nature of media in theoretical terms. This realization in addition to the ongoing critical discussion encouraged by media translations, helped to instill an environment fostering the discussions of contemporary architectural theory on media, culture and technology. Theoretical development was therefore a natural outcome of doing media iterations during the design process, thus supporting Hypotheses 15 and 16.

example 2

The student team was composed of three graduate students with very different backgrounds and media skills. One of them quite conversant with CAD, another with very good sketching skills, and the third student with extraordinary abilities in physical model making. All of them were comfortable at sketch modeling. The project, conducted during Winter 1996 at the University of Utah, was a ten-week long architectural problem addressing a seeming contradictory program (officing services and a bath house) that represent the issues of the information age: its call for disembodiment on one hand and its obsession for the body on the other hand.

This studio example includes the work of three students, Troy McOmber, Chris Webb, and Robert Hansen, who worked as a team. However, some portions of the project were divided up by tasks and completed individually. The project was a bath house and business officing building. The project was split up into two main segments. The first was to come up with three schemes and present them as a group. The second was to select the strongest of the three and develop it as a design project. At the initial phase, they split up and worked individually to each one up with a parti. They met



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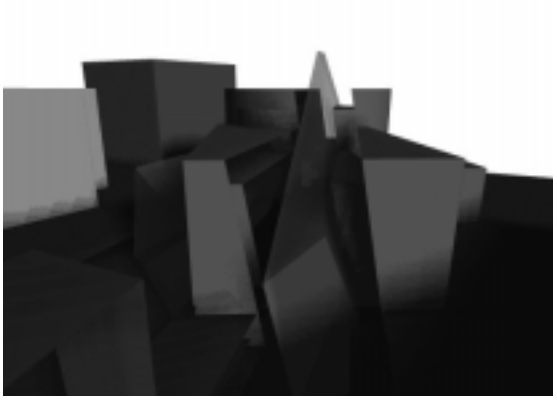

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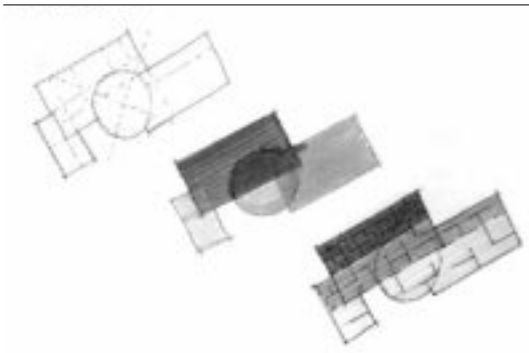

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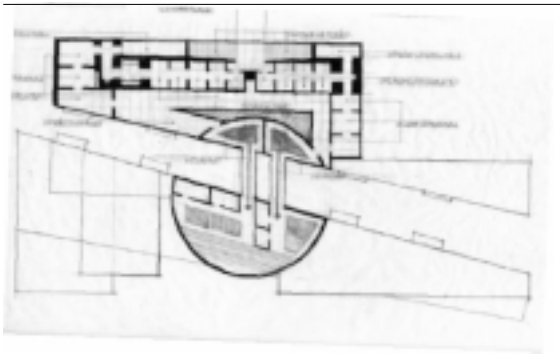

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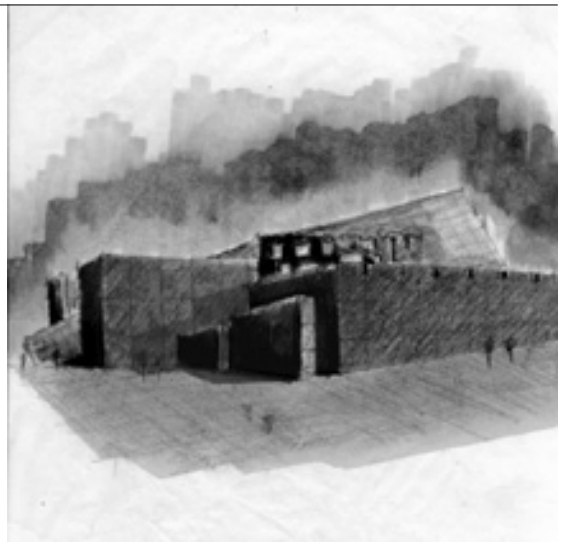

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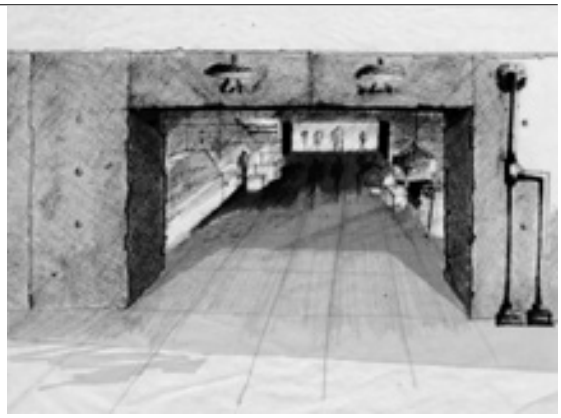

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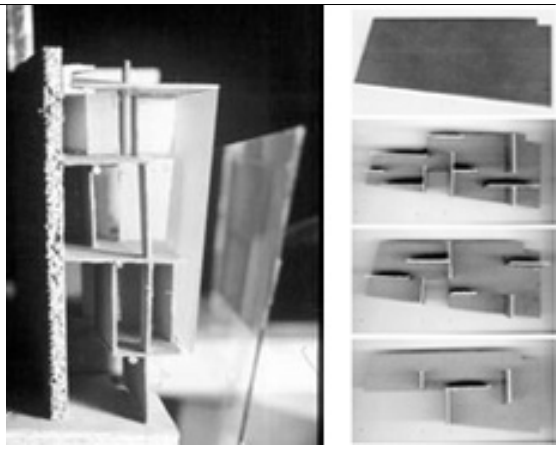

Figure 23

together to determine a direction and philosophy and then felt it was more productive to work individually to develop three distinct partis. Troy's scheme was the one selected by the group to develop further and therefore his individual work is presented here for the initial design. The work of the entire group is shown for the design development (Phase 4).

Phase1. Troy began working with an image his grouped developed during one of the warm up exercises. Along with this image, he worked with video images that the entire group had filmed while performing a preliminary site analysis. These im ages concentrated on close up shots of fracturing details and connections of dissimilar materials (Figure 13, left).

Phase 2. Troy then rapidly moved between digital manipulation of the images and quick analog study models. In working with the images, he eventually developed and combined the video capture with images of one of the models (Figure 13, right). This all lead to exploration and playing with a digital model. Troy was still looking for a parti or design concept. He was still looking at fractures and dissimilar materials. While working on digital models, he happened upon what was at first a mistake, but ended up as his scheme. He rendered a view and part of the object didn't show up (Figure 14). This was due to a color he had used that was practically invisible. This notion of the visible and yet invisible (represented as solid and void) became the basis for his further studies and the eventual design. He eventually termed his idea as "void."

Phase 3. Now that Troy had a concept to work with, he began to work feverishly between analog and digital media. He worked so quickly between analog and digital media that it became almost impossible to track his initial media iteration process. In fact, he also found it impossible to trace and distinguish all of his steps. This was due to his comfort level with both analog (models) and digital media (image manipulation and 3D modeling) (Hypothesis 18). The moves became transparent to him as he sought different representations for further development. (Hypotheses 2, 3, 7, 8,14).

Each model transition from analog to digital and back again was not about manipulating but rather about making what was done in the previous and discovering new opportunities (Figures 15-18). The design was worked on from a formalistic view with each model (analog and digital) concentrating on the exterior form and ignoring function until after the form was completed (Hypothesis 11). The resulting form has characteristics developed from both media. Each media iteration informed the design of the project's form. Without both analog and digital media for instance, the "void" would not have been separated in structure from the solid portion with double sloping walls (Figure 11).

Little manipulation took place except for digital manipulation of images (generally video captured). Most of the work simply informed the moves from the analog to the digital (Hypothesis 9).

Phase 4. The group reconvened to develop Troy's parti. He had only superficially forced a program into his form (Figure 19 for proposed function at time of parti presentation) and so a major task was to now maintain his strong concept of void and make the functions of bath house and officing building work while developing the project tectonically and contextually. Here the group did little work together. They did enough to refine the design and work out most of the programmatic issues. They then separated and divided up the tasks for completing the design and presenting the finished project. This came about as a result of trying to complete the required presentation elements (digital model, animation, physical model, etc.). They each had different strengths (Robert, physical model; Chris, sketching; and Troy, digital model and animation) and they divided up the tasks accordingly for production purposes (Hypothesis 13). Here there was little interaction between them as they worked on their individual areas of focus except for occasional interaction between Robert and Chris.

The major moves between analog and digital media were now much slower and more a result of presentation requirements than the need for design development. This shows the near breaking point where there is no real further iteration development (Hypothesis 12). See Figures 20-22 for Chris' floor plans and sketches, Figures 23-24 for Robert's analog model, and Figures 23-24 for Troy's digital model. The sketches were done by hand, scanned, and digitally manipulated for effects and shadowed (Hypothesis 9).

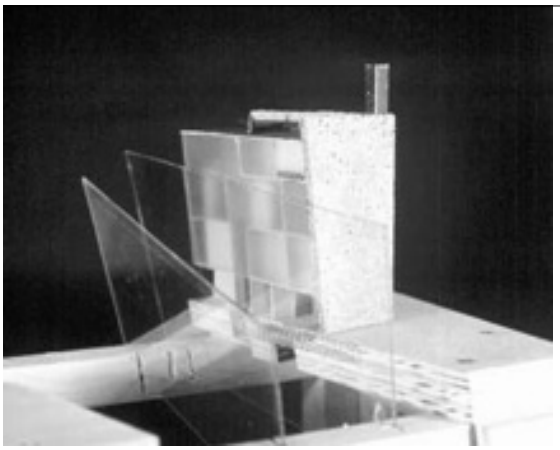

Figure 24

Figure 25

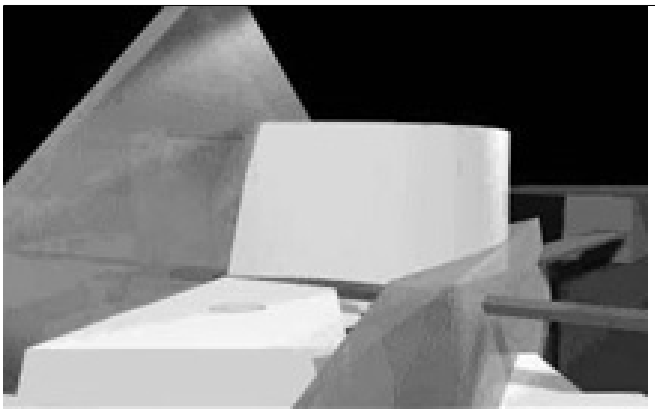

Figure 26