

TOWARDS A NEW REPRESENTATIONAL ECOSYSTEM FOR THE DESIGN STUDIO

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Abstract. The collection of visual and physical simulation tools available to a design team constitutes what can be termed the *Representational Ecosystem* of the design studio. Current digital paradigm does not effectively support design discussions because it is limited to the *pictorial-frame* and *scaled* representations. We analyzed for the first time the link between the Interconnected Hybrid Ideation Space (HIS) and the representational ecosystem of a design studio as a case study. The *Hybrid Representational Ecosystem* is proposed to better achieve a comprehensive and closer view of the design solution because it is fully hybrid (analog/digital), it supports multiple kinds of representations, scales, and co-design. The epistemology and principles of the new paradigm are described.

Keywords. Co-design; Studio; Representation; Immersion; Ideation.

1. The need for a new representational ecosystem

In nature, all components of an ecosystem interact with each other and with their environment. New components or contextual changes disturb the dynamics of the ecosystem until a new equilibrium state is reached. The representational ecosystem of design studios has changed with the introduction of the computer; yet beyond the current digital representational paradigm, a better representational ecosystem could be envisioned.

The design studio houses a variety of media acting as a *Graphical Simulation System* through which design intentions are exteriorized (Lebahar, 1983). Together, these different media of representation are termed in this paper as the *Representational Ecosystem*, because of their inter-supportive nature. This ecosystem, which allows multiple forms of externalization, discussion and evaluation of design ideas, is the context within which the actors of the studio (students, professors and clients) reflexively engage in design

development, teaching and learning. However, the collective nature of the design studio, made possible through intuitive forms of depiction, has been hindered by the introduction of laptops. Digital design and representation software necessitate specialization and this seems to encumber the co-design process and knowledge transfer (Dorta et al., 2012). Computers do not allow the synchronization of reflexive design conversations with their related representations (externalization), or the utilization of abstract, inaccurate and ambiguous representations during ideation discussions.

Furthermore, both analog and digital representational paradigms inherently rely on the utilization of scale. In disciplines such as architecture or interior design, representations only simulate the proportional relations of the design solution but do not deliver a first-person experience. Life-size models or imagery are not commonly encountered. While scaled representations are important tools for design, being able to achieve a full-scale, embodied understanding of the design object could greatly facilitate the creative process and help make better collaborative design decisions. The lack of 1:1 representations is an obvious deficiency for these disciplines, however this is equally true for those dealing with smaller or larger scales, such as industrial design and urban planning.

In this paper, we describe the integration of a full-scale hybrid and immersive ideation environment, the Hybrid Ideation Space (HIS) (Dorta, 2007) into the representational ecosystem of a semester-long 3rd year industrial design studio. Using this studio as a demonstrative case study, we envision a new paradigm that augments the existing ecosystem with the benefits of a hybrid approach driven by the HIS, throughout the design process, namely: immersive life-size visualization, freehand sketching, and local and remote collaboration. We argue that the main goal of a well-functioning representational ecosystem should be to achieve a *comprehensive* and *closer view* of the design solution and describe the principles of such a representational ecosystem based on our observations on the case study where we used the Interconnected HIS with a variety of representations belonging of the traditional design studio all the way from early phases of design to final presentations.

2. A comprehensive view: The epistemological dimension

Widely accepted theoretical models suggest that design is a reflexive (Schön, 1992) and social process (Bucciarelli, 1988) in which multiple participants engage in a collaborative conversation with each other and with the representation (Schön, 1992). Designers reflexively converse with the problem at hand creating and interpreting different types of visual and physical repre-

sentations, and through this process emerging ideas are externalized. Complementing Schön's explanation of design as a graphical and verbal conversation, Lebahar (1983) theorized towards the necessity of a *Graphical Simulation System* (S) in the design process (Figure 1). The main goal of this system is to provide a testing ground on which ideas evolve and the design process moves forward. According to Lebahar's explanation, the design process sequentially progresses (t) towards the completion of an *object model* (O), which gets completed by the architect or designer (A) as the amount of *uncertainty* in the problem (shaded zones in P) decreases. This process alternates between synchronic states ($t_{0..n}$) and diachronic leaps (O to S').

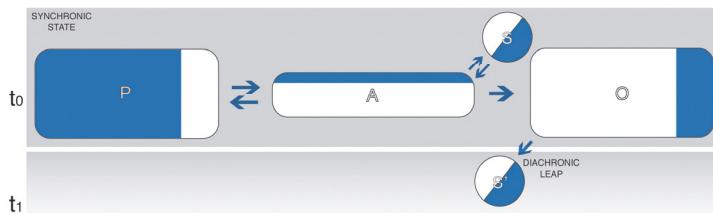


Figure 1. Lebahar's design process based on the Graphical Simulation System.

A good demonstration of this is the way designers and architects utilize sketches. In search of design solution, a designer may re-draw a sketch several times, sometimes drawing over and refining existing lines of sketch or using layers of tracing paper to make new ones, each time making gradual changes in the drawing. It has also been shown that the search towards a design solution through the use of graphical media necessitates the use of *re-representations* and *multiple representations* (Oxman, 1997). Designers also move back and forth between different views and scales of the same design object, switching between modes of representation as required by the questions arising as the design solution evolves. For example, an architect may switch between a physical model and sketch-perspectives to see how the 3D composition of a building will be perceived from different views. A designer can do a quick ergonomic evaluation by testing out various alternatives of a door handle, producing a mock-up model or a rapid-prototype, while refining the profile of the same handle in a sectional sketch. No single representational model can assess the design problem in a comprehensive manner. Designers use representational models to selectively navigate their attention from one design issue to another and apply the design skills specifically associated with the chosen medium.

The need for an array of representational modalities in design can be further justified since each representational medium is associated with intrinsic

knowledge structures (Oxman, 1997) and with characteristic affordances (Kvan 2006; Gero and Kannengiesser, 2012).

In Lebahar's *synchronic state*, the design activity takes place in a specific representational medium and aims to externalize the design task within the knowledge system and affordances of the simulation model in use. For example, at one moment of synchronicity, one may be considering the overall placement and orientation of a building, by sketching over a 1:1000 site plan; at another moment s/he may be experimenting the visual effect of different massing options on a physical model. In the closer view, the design activity takes place in any single representation medium that is most appropriate to the design question at hand. In the bigger picture, the designer shifts back and forth between these mediums and scales, and as the design solution gets completed, the model of simulation that is needed to communicate the design ideas becomes one that is less abstract and more rigid. This happens during the *diachronic leap* of design. The diachronic leap is like the upshifting of gears in a car as momentum increases and the vehicle is able to attain higher velocities with less force. It is simply impossible to start a car in the 5th gear. Similarly, it is not practical to initiate the process of design ideation on a representational medium where room for ambiguity is low and the expectations for realism and accuracy are high.

3. A closer view: Immersion and embodiment

Two of the most important premises of contemporary computational representation are visual realism and immersion. The former has found its place in the studio in the form of final 3D renders and animations. The latter, the potential impact of immersion in design, has also been explored mainly in experimental settings (Schnabel, 2011). There have also been experimentations to teach design in collaborative Virtual Environments (VE) such as ActiveWorlds™ and SecondLife™, and adaptations of multi-user game engines such as Torque Game Engine™ and Unity3D™. Even though the VE in question are not intended primarily for design purposes, it has been shown that they could facilitate local and long-distance collaboration (Maher and Simoff, 2004), in comparison to non-virtual, and offline collaboration scenarios. In these, immersion in the design environment is achieved through the proxy of on-screen avatars that inhabit the VE in lieu of designers themselves. These are not full-scale immersive environments since they carry the inherent representational limitations of the *picture-frame*. While it is important to use scaled representations for all phases of design, being able to have an immersive experience and interaction with the design object has several potential advantages.

First, full-scale immersion allows the immediate understanding of real-life proportions of the design solution. Designers can think outside the picture-frame and understand the life-size impact of the project.

Second, in an immersive design and visualization environment, fully embodied interaction is made possible. Designers can have a more intuitive relationship to the design solution and interact with natural hand-eye-body coordination. This allows designers to make quick and intuitive decisions, as well as represent and evaluate them in real time.

Finally, a shared sense of immersion may enhance collaboration in a co-design setting. When designers are co-located in the same simulation space, either physically or virtually, they are able to directly experience the same viewpoint. Co-presence has been shown to enhance collaboration (Dorta et al., 2011).

4. Case Study: The Augmented Design Studio

The Augmented Design Studio was carried in Fall 2012 at the *Université de Montréal* (Quebec, Canada), in collaboration with two international partners from the industry, an American automotive company (*Name withheld*), and a design office (*Design Innovation, Milan, Italy*). We also collaborated with two academic partners: *Université de Lorraine*, at Metz and Nancy (France), where 4 graduate architectural students participated as structural *consultants*. The project subject was: *Lightweight structures offsetting impacts in automobiles*. 14 students were asked to work in teams of two, each one doing their own project. They were asked to collaborate with their teammates in developing their projects. Each team met the instructor in the HIS once a week for a one-hour co-design session where proposals from both students were developed. They worked in the traditional studio for the remaining hours. Occasionally, a remote collaborator/critic from the automotive company or the consultant-students from Université de Lorraine joined the sessions using two interconnected HIS (one in Milan, at Design Innovation and one at Université de Lorraine). The co-design sessions were observed and recorded using a remote station located at a different building at the Université de Montréal.

4.1. THE INTERCONNECTED HIS

The Hybrid Ideation Space (HIS) (Figure 2) used in the Augmented Design Studio, is a design environment that allows digital and analog representations to enhance each other. The HIS immersive projection system consists of a 5m diameter, 360° semi-spherical display for immersive visualization, and dedicated software that allows for intuitive manipulation by immersive

sketching and model making. This environment was created mainly with the design ideation process in mind. In the HIS, users can create and make annotations by sketching on a Wacom Cintiq™ pen-tablet placed on a special rotating device. Users can interact with the panoramic canvas simply by rotating the pen-display in the direction they wish to focus. They can sketch on and interact with a variety of sources including panoramic images, pre-rendered realistic 3D backgrounds, and real-time views from a scaled (approximately 1:20) physical model through a panoramic video camera. The system can also display panoramic videos.



Figure 2. Hybrid Ideation Space partially opened for student presentations in this project.

The Interconnected HIS consists of multiple interlinked HIS units allowing for real-time and immersive co-design between remotely located participants. The sessions are linked over the Internet and the parties can interact with each other's designs and drawings by sketching in real-time. In addition, audio and video information is exchanged to allow for verbal and gestural interaction between participants.

4.2. REPRESENTATIONAL MEDIA IN THE HIS

In the co-design sessions carried out in the HIS, students were given the option to develop their designs using any combination of the following representational channels: 2D images, orthographic and perspectival sketching, 3D CAD models, physical models and 360° immersive video or stop-motion animations. Freehand sketching and verbal exteriorization of design ideas were encouraged throughout the workshop, while other means of representation were gradually utilized to accommodate the evolution of the design process. As the representational requirements changed from abstract to rigid, CAD models replaced rudimentary 3D sketches, and more detailed, sometimes 3D printed models took the place of earlier draft mock-ups. However, in each phase of development, sketching was used as the primary channel of communication, for formalizing new design propositions and making annotations on existing ones.

Figure 3 shows the evolution of the design communication and representation in the HIS. Through the semester, the students were able to go back and forth between the traditional studio and the HIS. In both environments, they were allowed to utilize digital tools and analog methods to develop their designs.

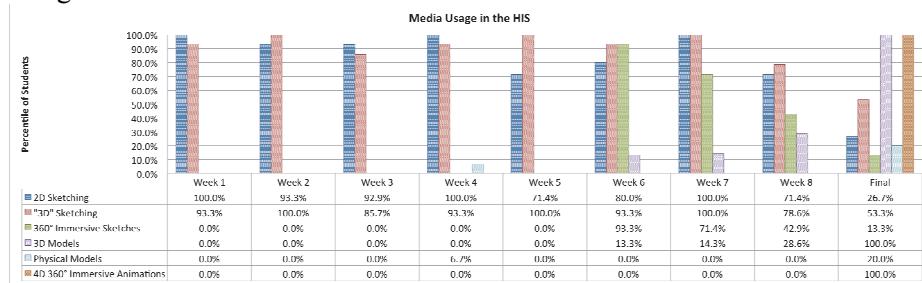


Figure 3. Comparative utilization of different media in the HIS during the design studio.

Figure 4 shows the development of a student project in the successive phases of design. 2D and perspectival sketches were actively utilized for all sessions throughout the semester. In the beginning the blackboard (the 2D window of the HIS used to display non-immersive images) was more commonly utilized than the immersive 1:1 display; as the project progressed, there was an increase in the use of perspectival sketching. These were initially made on top of a background with a ground grid and a skeleton model of a car, provided as a workspace template. As students were able to produce their own 3D models, these replaced workspace templates. These models were displayed in the HIS as 360° renders. Students not proficient in 3D modeling used analog (scanned) or digital freehand sketches in the form of 360° spherical panoramas, using a geometric template for the spherical deformation. For the final presentation, the students produced an animation to communicate the functionality of their solution. These were made by rendering the 3D models by placing a special panoramic camera in the digital scene. Two students worked with stop motion animation technique using physical models and a panoramic camera (Sony bloggie™) (Figure 5).

5. Principles of the Hybrid Representational Ecosystem

We expand Lebahar's model to allow for the existence of multiple collaborators (Figure 6). The co-design process also alternates between synchronic states and diachronic leaps. The amount of uncertainty associated with the Design Problem (P) is reduced as the Object Model (O) gets completed. Each co-design participant also has his/her individual levels of *uncertainty* (?) about the project.

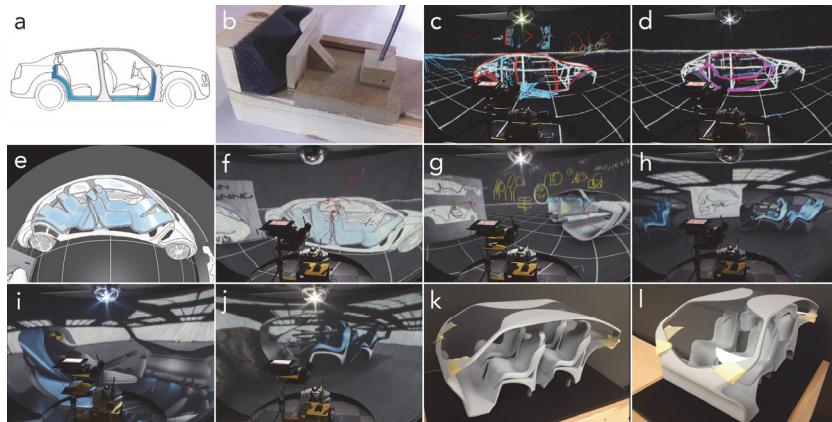


Figure 4. Development of one of 14 student projects: (a, b): pre-HIS concept studies. (c, d): 2D and 3D sketch-explorations in the HIS. (e, f): Anamorphic sketches. (g, h): Panoramic 3D renders and sketches. (i, j): Immersive animation, (k, l): RP final model.

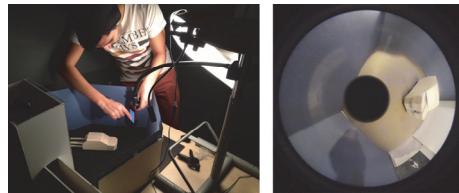


Figure 5. Preparing the stop-motion 360° immersive animation.

Through communication and collaborative decision-making those levels of uncertainty also influence each other, and gradually decrease. At the end of an *ideal* design process, the uncertainty of participants and design problem should reach zero and there should be a complete and shared knowledge of the design object that all the participants fully agree upon. In real-life design processes, this state is approximated or *satisficed* (Simon, 1973) but never fully achieved.

In the *epistemological dimension* (O, P, ?), the process of co-design aims at reaching the shared knowledge and understanding of what the design object ought to be. However, design interactions are made solely within the *representational dimension* which includes externalizing and exchanging of such knowledge states through verbal communication and representational simulations (S', S'', S''', ...). In each *synchronic state* only one representational medium may be used. In the *diachronic leap* (when designers move between modes of representation) design decisions are actually consolidated.

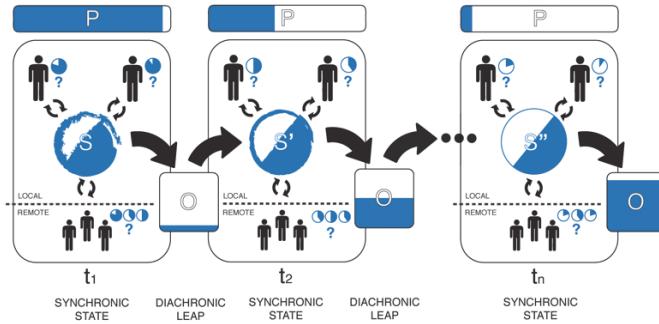


Figure 6. Diagram illustrating and the evolution of a design project in a co-design setting.

In other words, the ideas carried from a section to a plan, or from a perspective to a model are traces of design decisions being made. The completeness of the Object Model (O) stands for the confidence of the designers in the final form of the design object (a shared consensus on the design solution) and this in turn corresponds to the ability to produce construction drawings and make final specifications for the physical realization of the design object. Differing from Lebahar's original model, the representational simulation in our case benefits from being an immersive environment that actually becomes a fostering context for collaborative design.

The principles of the proposed paradigm for the new representational ecosystem, as exemplified by our observations of our case study, are:

- (a) To be *fully hybrid* (analog and digital) allowing back and forth between different skills and different realms, not only in one direction (through the digital);
- (b) To allow *multiple kinds of representations*, from graphical, physical to time-based such as animations;
- (c) To allow the use of *multiple scales* including one-to-one immersion, giving the opportunity to better understand the proposed design solution;
- (d) To allow *active and intuitive co-design*, permitting rich design exchange and knowledge transfer, without becoming only a passive presentation tool for the later steps of the process.

6. Conclusion

The current digital paradigm of the design studios, arbitrarily combining conventional computing and traditional representations, does not support design discussions, and is based on the *pictorial-frame* of 2D/3D renderings requiring scaled representations. Updating Lebahar's *Graphical Simulation System* to reflect current design practice involving digital media and collabo-

ration, we analyzed for the first time the relationship of the Interconnected HIS with the representational ecosystem of a design studio. We argued that the *Hybrid Representational Ecosystem* achieves a more *comprehensive* design process and a *closer view* of the design solution.

In this case study we demonstrated that the HIS was useful for development and presentation phases of a design studio in addition to the ideation phase. The observations of this case study helped us formulate the principles for a new representational ecosystem for the studio regardless of the actual technology utilized: to be *fully hybrid*, to support *multiple kinds of representations*, to use *multiple scales* and to allow *active and intuitive co-design*.

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