HEADSPACE: THE STANFORD IMAGINARIUM

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Abstract: Creativity is a central component of successful design practice and design education. Prior research has shown that, in addition to individual ability, a person's moment-to-moment level of creativity can be influenced by mindset and environmental factors. A tool that allows researchers to change the experimental environment dynamically, as well as to deliberately affect participant mindsets, would therefore be of much use in creativity research. We present a design and prototype of such a system that accomplishes this effect through multimedia immersion in a geodesic dome for collaborative groups as large as 15. We discuss the objectives, functions and capabilities of the prototype, as well as initial findings from pilot testing regarding its effects on occupant creativity.

Keywords: Imaginarium, media immersion, visual thinking, geodesic dome

1. Introduction: creativity, mindset & environment

Creativity is a central component of successful design practice and design education. The Imaginary Lab at Stanford is focused on experimental research in creativity, and particularly how creative activity can be enhanced in individuals and collaborative teams (Kazerounian & Foley, 2007) (Sternberg, 1999). Prior research has shown that, in addition to individual ability, a person's moment-to-moment level of creativity can also be influenced by mindset and environmental factors (Hemlin et al., 2004) (Krampen, 1997) (Martens, 2008) (Vithayathawornwong, 2003). It has been suggested that creativity (or the generation of novel thoughts) is the result of everyday processes of the mind and body, processes which shift and adapt to an individual's current physical and mental state; this supports the possibility for influencing creativity in the short term (Smith et al., 1995) (McCoy & Evans, 2002). According to Csiksentmihalyi in *Creativity*, "Creating a harmonious, meaningful environment in space and time helps you to become personally creative" (1996). We seek to explore the particular mindsets and environmental elements that are most conducive to stimulating natural creativity. Through careful and deliberate control of the environment and by priming subjects' mindsets, we expect to be able to show significant differences in creative activity. To observe this difference it is required to design a functional space capable of changing dynamically to affect occupants in a known capacity. In this paper, we propose an initial prototype for such an environment. Its aim is to achieve the appropriate physical, mental and environmental conditions to maximize creativity in individuals and groups. Specifically, we focus on the following three aspects:

- Stimulating sensory imagination (such as visual thinking)
- Mental priming (such as guided relaxation)
- Environment (the Imaginarium, a geodesic media immersion dome)

Though there is no single measure for creativity or innovation, there are fundamental elements that comprise the practice and education of these processes. One such element is visual thinking, which has been shown to be an important aspect of problem-solivng and has a long history in the Stanford design program in particular (Arnheim, 1969) (McKim, 1972).
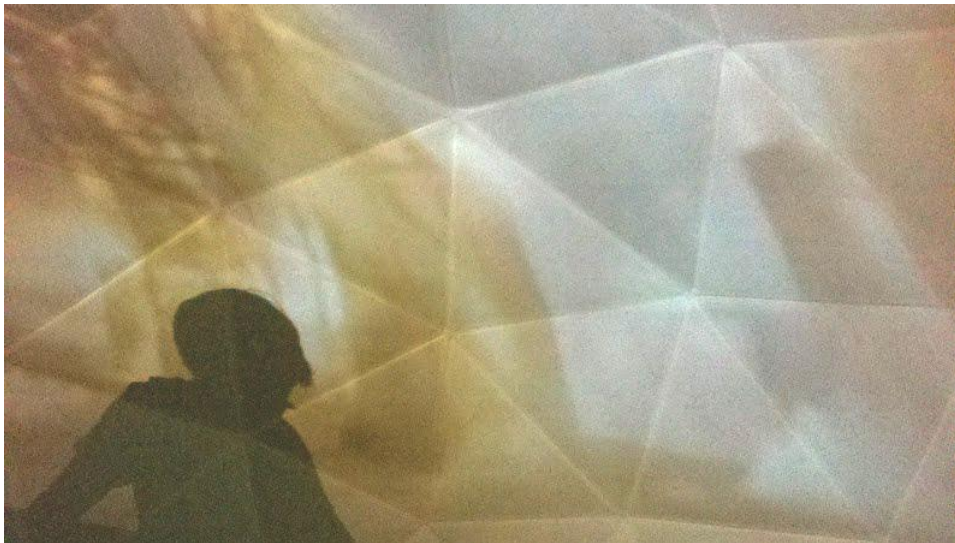

Figure 1. A student watches a rocket launch in the Imaginarium

An individuals's mindset (including outlook and mood) can also have a significant impact on creative endeavors and has been shown to influence group performance. In many cases, the impact on creativity is negative (e.g. when an individual is tired, stressed, or even overly excited); on the contrary, a mental state of relaxation has been shown to be conducive to creativity. A state of mental relaxation (which is closely coupled with physical relaxation) allows the unconscious mind to create combinations and recombinations of all a person's thoughts and stored knowledge, in the best case ultimately resulting in novel thoughts appearing to the conscious mind. This is otherwise explained as creating "motivational-emotional states (i.e. personal preconditions) that are a prerequisite for the optimal realization of one's own creative abilities." (Krampen, 1997) Designers in a relaxed mindset will be both composed and spontaneous, and will be more successful in memory retention and concentration.

The physical environment is also a crucial element of creative cognition, and this topic has been covered extensively in the literature (Hemlin et al., 2004) (Martens, 2008) (Parkin et al., 2011) (Vithayathawornwong, 2003). For example, a space with unusual furniture, unique visual and physical representations of work can stimulate the mental process of creativity. The degree to which participants are engaged in collaborative work, and the methods in which they interact, is also influenced by the characteristics of the environment, particularly in terms of the available technology (Fruchter, 2008) (de Souza Fleith, 2000) (McCoy, 2005). An environment that has the technical capability to produce unique representations of work can facilitate visual thinking (Hori, 1997); if this environment is also designed to promote a state of relaxation and aid in collaboration, then it can offer a substantial benefit to creative design work, and would be a powerful tool for creativity research.

2. Imaginarium background

At the founding of the Stanford design program in 1958, there was an emphasis on the influence of sensory experience on creativity. Professor Bob McKim created the course ME101: Visual Thinking to introduce methods of exploring one's sensory imagination; this remains a required course in the design curriculum to this day. To aid in the course, McKim and his students designed and built a 16' diameter geodesic cardboard "Imaginarium," equipped with a 16mm slide projector, tape deck and spray bottles of scents. A typical Visual Thinking class would take multiple trips to the Imaginarium for "progressive relaxation" exercises, audio/visual sensory stimulation and "imagination games." The

dome itself served as "a metaphor for your sensory imagination," such that it represented an externalization of creative thought that could be experienced as a group (McKim, 1975).
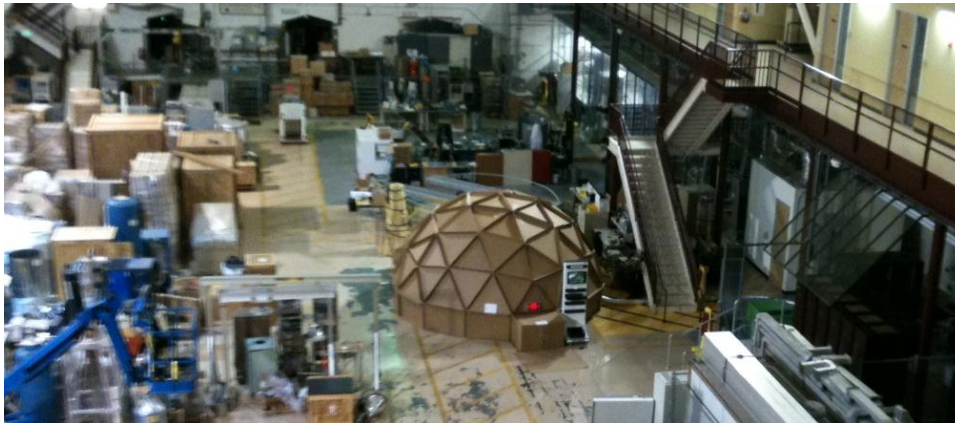

Figure 2. The Imaginarium is currently located in the Hansen Experimental Physics Lab (HEPL)

We were inspired to reenvision and recreate this space as an experimental research platform for the Center for Design Research. With modern media and interaction technology, the Imaginarium has the potential to be a far more powerful tool than its original incarnation. A richer, more immersive media experience will allow for deeper dynamic control of subjects' sensory experiences, and should create stronger effects as a result. At a high level, the project spans generations as it seeks to incorporate futuristic media interaction with the original pedagogical goals and methods of the Stanford design program.

3. Imaginarium objectives

Much like the original Imaginarium, our modern recreation is a space that is designed to create a physical and mental separation from the outside world, and can be a used for relaxation and visualization. Our goal is to create a space that can be transformed by media to stimulate the sensory imagination, promote a state of mental relaxation and encourage creativity in a collaborative context. The occupants' perception of a physical and mental separation from the outside world helps to promote open-minded thinking, and the unconventional environment and means of visualization can offer new ways of looking at problems and solutions. By completely immersing the user into the space with sounds, visuals and other lighting effects, the dome can recreate a wide variety of different environments, moods and contexts, making it a flexible and powerful tool for research, education and collaborative work.

The Imaginarium encloses a largely unobstructed hemispherical space within, capable of containing 15 people comfortably. In total, there is approximately 500 square feet of projection area and 200 square feet of useful floorspace inside.

4. Dome features & development

The Imaginarium was designed with three primary functions in mind:

- To create an enclosed space that provides physical and psychological separation from the outside world, while providing maximum usefulness/flexibility for the occupants;
- To allow for video projection on as much of the interior surface as possible, with as little occlusion as possible, to ensure full field-of-vision viewing from any location within the dome.
- To create a rich audio landscape for quality listening at any location within the dome.

Simplicity and modularity contribute to its usefulness with low cost of operation, ease of repairs and modifications, mobility, and low impact at end-of-life.

Figure 3. The platform assembled (note the office chair for scale) and disassembled into modular components. The flooring is removed to reveal the structure

The space itself is comprised of an 18' diameter 3V geodesic hemisphere resting atop a 2¼' high cylindrical base. The dome is made from regular, single-ply cardboard that has been painted white on the inward-facing side; the platform is made from wood. The structure can be disassembled and relocated by a small team in a matter of hours with no special tools or expertise. When it is no longer needed, the dome can be completely recycled and the wood reused. Over time, we have made other improvements to the functionality of the space such as adding a vent for air conditioning, covering gaps in the dome wall (projection surface) with fabric tape, and installing smooth, user-friendly flooring.
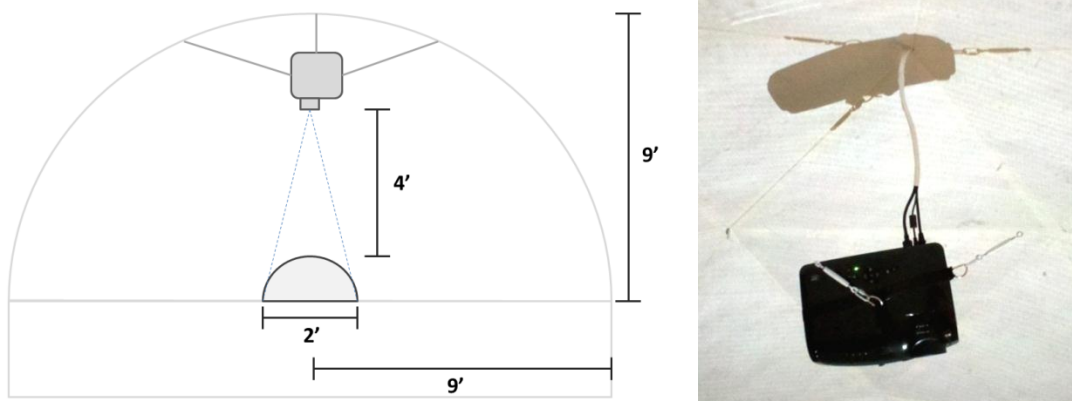

Figure 4. A single projector is suspended above a convex mirror to achieve hemispherical projection. Shown here is the schematic and the actual installation; note the minimal occlusion.

The requirements for the projection system were to achieve full coverage of the interior surface of the dome with as little occlusion of the image or obstruction of the space as possible. We experimented with several means of projection. Commercially available divergent lenses capable of achieving full 180° divergence cost upwards of $6000 each, and will only work with a limited number of projectors. Ultimately we arrived at a system that uses a single elevated projector in the interior of the dome, projecting downwards onto a floor-mounted hemispherical mirror. In total, five adjustable connections extend to a homemade harness that wraps around the projector, allowing for simple fine-tuning of the projector orientation and having less than 2lbs. tension in any one line. It satisfies the requirement for total coverage of the dome interior, as well as the requirement for minimal occlusion; in total less than 2% of the image area is occluded (by the shadow of the projector itself).

Images that are projected onto the mirror are naturally warped and inverted, and only a circular section from the center of the image is actually mapped onto the dome wall. This distortion can be corrected in software, either in post-processing or in real-time; additionally, media could be created or captured using hardware that is already in a "direct-to-dome" format (e.g. shooting video in a hemispherical mirror). High-quality surround sound accompanies the projection; speakers installed around the platform edge (just out of sight) and a sub-woofer beneath the platform provide 5.1 standard surround sound.

The dome offers a number of additional modalities, some of which are still under development. One recent addition is a simple removable table that can be set in place over the central mirror. When in place, the projected image appears on the black matte surface of the table as a normal, two-dimensional rectangular image. This modality could be very useful for detail-oriented collaborative work where concrete visualization is more applicable than the more abstract spatial representation. Were the table to be enabled with an interactive device such as eBeam, it could serve as a fully interactive digital surface for collaborative work or control of dome functionalities. Installing minimalist, removable furniture will further extend the comfort and usefulness of the dome without seriously disrupting the space or projection. Further potential improvements and enhancements are discussed in Section 7.

5. Pilot test

5.1 Pilot test procedure

We conducted a pilot test to try find early indications that users feel more creative in the Imaginarium. The preliminary test was comprised of a creative doodling exercise (Kelley and Littman, 2001), followed by a guided media relaxation, and then a second round of the creative doodling exercise. Each phase lasted approximately nine minutes, with the whole trial lasting approximately 40 min. The trial included two groups of three participants each. One group experienced the first doodling round in a conference room, and then relocated to the Imaginarium for the guided media relaxation and second doodling round. The other (control) group relocated to a different but otherwise typical conference room instead to experience the media on a small, flat television. We expected to see an increase in creative output for both groups after the relaxation session, with a larger increase for the group inside the Imaginarium.

The doodling exercise we used is called "Popcorn People." In this exercise, participants see a page full of amorphous shapes that look vaguely like popcorn. Their task is to turn each piece of "popcorn" into something that resembles a person, while making as few changes to the shape as possible. The output of this exercise can be assessed for creativity by subjective self-assessment or by subjective assessment by objective raters. See Figure 7 (Heye, 2006) (Risser et al., 2010) for an example of a "popcorn" shape as presented to the participants, and two sample outputs.

Figure 5. Sample input and two outputs of the "popcorn people" exercise

The relaxation exercise included abstract video imagery of moving colors, ambient background music and a narrated routine of breathing and muscle tense-and-release exercises. Participants were instructed to follow along with the narrated routine. After the relaxation session, participants were given the popcorn people exercise a second time, but with a new set of shapes to fill in. At the end of all rounds, we had the participants self-rate each sketch for creativity (definition not given) on a 1-10 scale. These scores were than averaged by participant for each round to determine an increase or

decrease in self-rated creativity between rounds. Our hypothesis was that both groups would experience an increase in creativity as a result of the relaxation exercise, with the Imaginarium group showing a greater increase due to a more immersive relaxation experience and the novel environment.

5.2 Pilot test results

We did not see an across-the-board increase in creativity as we had expected; in fact, only half of the participants showed an increase in self-rated creativity, whereas one exhibited no change and the remaining two showed a decrease. Whether a participant experienced an increase or decrease did not appear to depend on the Imaginarium, as both cases occurred in both groups. This does not support our hypothesis, and furthermore indicates that there are structural flaws with our experimental trial. Participants reported that the task was not challenging enough to be suitably engaging or "taken seriously," and also that the relaxation was too short (or too quiet) to be effective. However, most participants when asked did report feeling more relaxed as a result of the relaxation session, though to varying degrees. Pending analysis of the creative output by objective raters will offer more insight into whether or not the Imaginarium had an observable effect.

6. Conclusions & discussion

In order to explore the relationship between creativity, mindset and environment, we have created a media immersion facility that allows us to conduct creative activities while having a certain degree of control over the mental priming and sensory stimulation of the participants. The student-led construction and development of the dome (made entirely of single-ply cardboard and wood for the base) has been very successful.

Our first pilot test encountered several limitations that prevent us from drawing any firm conclusions. Though participants reported feeling relaxed for the most part by the relaxation exercise, they did not show a commensurate increase in self-rated creativity. Future trials could be conducted with larger sample sizes, more engaging activities (perhaps styled as a competition) and longer duration (to enhance the effect of relaxation). Additionally, the unexpected outcome of the second round suggests that the "popcorn people" exercise may not be well-suited for being repeated twice in a short time interval, likely because it is too simple, and constraints were not enforced rigidly enough. It would perhaps still be useful for one of the two rounds, if an alternative (but functionally equivalent) challenge were offered for the other round. However, just as with the relaxation session, it is likely to elicit more engagement from the participant if it is more challenging and broader in scope and duration.

In addition to pilot testing, the Imaginarium has been host to a number of class sessions (from Product Design to Video Arts) and many diverse groups of visitors, and has been used as a prototyping testbed for graduate students in design engineering, virtual reality, and fine arts. Most first-time visitors report an immediate positive change to their state of mind, with one exclaiming "I haven't felt this relaxed in months!" Several students have expressed their immediate intention to build one for personal use. As a general rule, occupants find the dome to be a peaceful environment that promotes relaxation (with or without media immersion). There is also a considerable "wow" factor; first-time audiences will often break out in spontaneous applause at the conclusion of a demonstration. We believe that the dome does have a positive impact on mindset, and particularly relaxation; thus, we believe that it will stimulate creativity regardless of the pilot test results.

As a prototyping platform, the dome offers several unique advantages that we are only beginning to explore. Hemispherical projection means that an occupant's full field of view is saturated with media at any one time, no matter their location or orientation within the dome, and no matter how many occupants there are. Therefore, the dome could be used to create (or recreate) immersive environments that are representative of real-world places, or even entirely virtual. A group could be "transported" by means of multimedia from Death Valley to the streets of Mumbai, for example, or they could interact with avatars online. Designers could use this feature to immerse themselves in a relevant problem context; anthropologists could immerse themselves in life in faraway villages; physicists could take extended journeys through the outer reaches of the universe. More abstract

representations can help to visualize data, provide information augmentation, or even to deliberately influence occupants' mood and mental states.

Of particular interest is the potential for interactivity, and we are considering several potential pathways to implement this capability. One would be to use piezoelectric transducers mounted to the exterior surface of the dome, acting as contact microphones; these could turn the dome walls into a crude touch-sensitive matrix to use as a source of input. Coupling the projection with the location of these inputs, virtual buttons could appear on the walls with tap input functionality. Other interaction devices such as the eBeam Edge and Microsoft Kinect would expand the input modalities beyond tapping to include gestures, handwriting, etc. Without interactivity, the dome is essentially a fancy "home theater;" being able to interact meaningfully with the technology, and have it respond intelligently to occupant activity, would be of tremendous benefit for the Imaginarium as a creative tool.

7. Future work

We will continue to pursue improvements to the Imaginarium equipment and capabilities, focusing primarily on visual immersion and interactivity. To enhance the effect of visual immersion, we intend to build a software solution (from open-source components) that can correct for the distortion of projected imagery for pre-existing video, as well as a hardware solution that can capture in a "direct-to-dome" format.

Interactivity will be explored first in low-resolution using piezoelectric transducers on the dome exterior as contact microphones to detect taps from inside. Arranged in a matrix, the amplitude of the signal received by each transducer could be compared (and perhaps triangulated) to determine the location of each tap. This would essentially make the walls touch-sensitive, which is the single most frequently requested mode of interaction by visitors. More advanced equipment such as the eBeam Edge and Microsoft Kinect will also be used to explore pen-type and gestural input modes.

Future dome iterations could pursue the notion of modularity even further, to the degree that these domes could be largely pre-fabricated as consumer products, able to be shipped and quickly constructed in any location, for any purpose. They are particularly well-suited to temporary applications because of their ease of setup, cheap materials and recyclability. Schools could use an Imaginarium as a classroom annex, scientists as a data visualization tool, and health professionals as a relaxation therapy aid. Modular, mass-produced components would lower the cost of the structure drastically, and in the case where users could provide their own media equipment, it would be of incremental cost to implement.

As was clear from the severe limitations of the "popcorn people" experiment, it will be necessary to perform further investigations in to the affects of the Imaginarium on designers' mindsets. A future dome experiment could be a longer, longitudinal study across the course of a year. It would be necessary to observe many design groups, perhaps groups from graduate classes, using both the Imaginarium and typical workspaces to work on projects. We could analyze self-reported satisfaction in using the Imaginarium as well as analyze the success of the creative projects, and therefore quantify the Imaginarium's affect on creativity.

References

Arnheim, R. (1969). *Visual thinking*. Berkeley: University of California Press.

Csikszentmihalyi, M. (1996). *Creativity, NY*. HarperCollins.

de Souza Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review*, *22*(3), 148–153.

Fruchter, R. (2008). Degrees of engagement in interactive workspaces. In Gill, S. (ed.) *Cognition, Communication and Interaction* (Human-Computer Interaction Series): Springer London, 56-69.

Hemlin, S., Allwood, C. M., Martin, B.R. (2004). *Creative Knowledge Environments: The Influences on Creativity in Research and Innovation.* Northampton: Edward Elgar Publishing

Heye, D. (2006). Creativity and innovation Two key characteristics of the successful 21st century information professional. *Business information review*, *23*(4), 252–257.

Hori, K. (1997). Concept space connected to knowledge processing for supporting creative design. *Knowledge-Based Systems*, *10*(1), 29–35.

Kazerounian, K., Foley, S. (2007). Barriers to Creativity in Engineering Education: A Study of Instructors and Student Perceptions. *Journal of Mechanical Design*, 129, 761-768.

Kelley, T., & Littman, J. (2001). *The art of innovation: lessons in creativity from IDEO, America's leading design firm* (Vol. 10). Crown Business. Krampen, G. (1997). Promotion of Creativity (divergent Productions) and Convergent Productions by Systematic-relaxation Exercises: Empirical Evidence from Five Experimental Studies with Children, Young Adults, and Elderly. *European Journal of Personality*, 11, 83-99. Martens, Y. (2008). *Unlocking Creativity with the Physical Workplace*. Paper presented at the CIB W070 Conference in Facilities Management and Maintanenance, Edinburgh, Scotland.

McCoy, J. M. (2005). Linking the physical work environment to creative context. *The Journal of Creative Behavior*, *39*(3), 169–191.

McCoy, J. M., & Evans, G. W. (2002). The potential role of the physical environment in fostering creativity. *Creativity Research Journal*, *14*(3-4), 409–426. McKim, R. H. (1972). *Experiences in visual thinking*. Monterey, Calif.: Brooks/Cole Pub. Co. McKim, R. H. (ca. 1975) "Imaginarium One/Script." Unpublished manuscript annotated by students.

Risser, E., Han, C., Dahyot, R., & Grinspun, E. (2010). Synthesizing structured image hybrids. *ACM Transactions on Graphics (TOG)*, *29*(4), 85. Smith, S. M., Ward, T. B., & Finke, R. A. (1995). *The creative cognition approach*. Cambridge, Mass.: MIT Press. Sternberg, R. J. (1999). *Handbook of creativity*. Cambridge, U.K.: Cambridge University Press.

Vithayathawornwong, S., Danko, S., & Tolbert, P. (2003). The Role of the Physical Environment in Supporting Organizational Creativity. *Journal Of Interior Design*, 29(1/2), 1-16.