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Still continuing to my professional life as an architect in a design firm in Ankara, I have completed my degree in ID with an explicitly thriving work with eminent designers of Turkey where I have had the chance of testing the design tool I developed. I keep trying to preserve an alternative attitude towards design and the designed world with a hope of one day being able to change a part of it.

ENHANCING CREATIVITY IN THE CONCEPT GENERATION PHASE: IMPLEMENTATION OF BLACK BOX AS A TOOL

Abstract. *In recent years, the field of design has met new grounds with the growing awareness among design researchers of the potential relationships between cognitive studies of creativity and computational modeling. The turn of the studies has given rise to the emergence of a new paradigm of modeling and understanding mental processes in creative design. This study tries to gain further insight into the creative occurrence by blending virtual experiences with designer actions in a model of creative thinking in concept generation phase based on the Geneplore Model by Finke et al. (1995) and supported by analogy construction incorporating the implementation of a computer based tool (Black Box) running on PC platform as a potential immanent part of the concept generation phase.*

The key ingredient of concept generation phase is taken as the design concept space; A space which entails all knowledge related to the design problem and also all knowledge of the designer's self; related to his/her background and experiences. In science fiction films such as Stanley Kubrick's 2001: A Space Odyssey (1968), we are also presented with another conception of space, not just infinite but also involving the space of the spaceship itself containing a whole minuscule world within its multiple spaces. The microcosmos that is tried to be implied with the spaceship is similar to basics of the construction of a design concept space. Designers are to construct the design concept space like a microcosmos of the design space as the concept is the designative key that holds together the subsequent processes of design. The construction of a microcosmos/space for each design concept is important as much as it is a problematic issue that designers are faced in designing.

Structured in a way similar to a microcosmos of design, Black Box is devised in such a way that the core of the constructive process of the analogy relies on the designer's expressional, perceptual and conceptual actions which are presented in the traditional methods of sketching and writing, whereas the change and expansion of the design space is realized through the virtual worlds the tool offers via the computer screen.

The research method is based on the development of Black Box tool and its subsequent implementation in a study with eight experienced design consultants, utilizing a procedure composed of preliminary interview, observational protocol analysis, questionnaire and retrospective interview. Through encoding actions of individual designers by means of their maps in the computational tool, the study yields significant results in revealing differing thinking maps of different designers which have been used to propose a general creative thinking map of concept generation in Black Box presented in a way to be adapted for further studies. Moreover, the study provided insight on the methods used to assist creativity in concept generation by different designers, on the selection of inspirational material and on the integration of analogies as knowledge transformers to evoke design concepts. Improvement of the quality of design processes can be facilitated by appropriate and useful support by computational tools. This research has implied the significance of enhancement of cognitive and perceptual interaction with a wide range of data of different domains through a virtual tool.

Keywords: *Concept Generation, Creativity, Creativity Methods, Analogical Reasoning, Computer Generated Virtual Spaces.*

1. Motivation for the Study: Special Relativity in Design

Special relativity proclaims that observers in relative motion will perceive distance and time in a dissimilar manner meaning that identical watches worn by individuals in relative motion will tick at different rates resulting different amount of times to pass for each of the individuals. After a century of Einstein's dramatic discovery, if we are to take the intuition of relativity into design grounds we may say that a theory of *spatial relativity* defined in terms of design space would proclaim that, individual designers acting in relative cognitive abilities will perceive and construct the design space in a different manner meaning that identical design problems worked by individual designers will evolve in a different rate and into different resulting designs.

The relative construction of the landscape of a design space is observed and realized through mapping, exploration and transformations (Boden, 1991) that concurrently occur during a design process and creativity is expected to be prompted through an agent that causes mapping, exploration and transformation of the knowledge base of the designer.

Localizing in the non-smooth landscape of the concept generation phase, this study tries to form an alternative theory of spatial relativity in design that accommodates a design space and a transformative agent for the landscape of the concept generation phase.

2. The Virtual Expansion of Design Space

After half a century of surprises in terms of both technological and ideological advances, regarding the innovations in communication technology of the second half of the 20th century and new directions in design research, now it seems quite obvious that, in most if not all design domains, strict design methods based on well defined algorithms do not yield the expected improvement in design quality and that they just may not reflect what is actually taking place in today's design practices.

In as much as the new digital world -the net- represents the matrix of connectivity and a corridor of seemingly limitless freedom with VR standing for an enrichment of the world-space, the blind spot of the preceding design methodology remains with its limited and limiting conception of the design space. Indisputably, design methodology and the ways of conceiving design have to change to compensate for the delay that caused segregation between design methods and today's design. As a consequence, the new design space is to be perpetually verging on to the next "new" design space, by changing itself and opening itself up to a reconsideration of the promise of it holds for newness, otherness and divergence from what currently prevails.

2.2. Introduction to New ways of Conceiving the Design Space

Design has always been mentioned with an acceptance of a *space*. The decomposition of the radius within which design meets the world's grounds, reveals that it entails the defined problem, the designer, the designer's inner and outer radii and intruders of external media such as factual, actual, informal, experiential, procedural, tactile, auxiliary, auditory and fictional representations. Indeed, it is presumably accepted that better understanding of the structure of this space, the radii that design brings about, may allow further insight into the design process (Simon, 1973; Akin, 1986; Eastman, 2001)

Giedion (1941) mentions of a multi-faceted perspective of space.

“Space in the modern physics is conceived of as relative to a moving point of reference, not as the absolute and static entity of the Baroque system of Newton. And in Modern Art, for the first time since the Renaissance, a new conception of time leads to a self-conscious enlargement of our ways of perceiving space” (Giedion, 1941: 112).

Gideon’s account of perceptual enlargement is actually what Einstein calculated, Picasso painted. Having a cubist painting in front, one might say that vision is no longer subordinated to a single view of an external image which suggests that new ways of perceiving the visual surroundings have given way to new ways of perceiving the space. Crary (1994) emphasizes at this point the new status of the new observer through Turner’s work. Just as Turner’s works displayed a new way of perceiving light and *space through light* and just as a cubist portrait may show simultaneously the side and the front of a face, the space that VR offers, is a distinct multiplication of the constants that have defined our space so far. Papers, plans, elevations, sections and perspectives may have dominated our design space so far but the code of VR is to confront the core of design space by expanding it, bombing it with variables, elevating the nodes of the traditional cognitive mechanisms of seeing and perceiving.

To recapitulate, it can be said that the three main aspects that have been emphasized so far: *the new virtual space, the new variables in design and new conceptions of the space and design-space* have radically altered the ways we conceive design today.

3. Theoretical Framework of Black Box Study

Creative design, while being regarded important and valued is not much supported by computer programs that are used during design. As far as we are concerned for the post-CAD approaches to design, it might be said that computational studies to a degree, have tried to support the routine design process while not being able to transcend the role of just a representational tool for the creative design process (Akin, 1998). Still, there is agreement that unless computational tools are contemplated in a more innovative manner, including the contribution of the VR, the scene for creative design seems melancholic. In this respect we can paraphrase Walter Benjamin’s (1972) portrait of the *allegorist* to further indicate that a virtual corrective for a contingent design space can not be made unless the designers of the codes and variables of the system attribute an alternative meaning to it. Surrendered to a new understanding of codes and variables, computational tools can be used far beyond constructing the relationships between variables but also for introducing variables.

Nowadays, potential improvements for understanding creative design involve research in computational models and artificial intelligence. However, according to Gero and Maher (1991), research in computational processes for design has been mainly concerned with what they call ‘routine design’ and escaped providing further insight into ‘creative design’.

In order to provide further insight into the "Creative Design" that Gero and Maher have defined, Black Box study concentrates on the “Creative Occurrence” at the concept generation phase by blending virtual experiences with actual designer actions through the

implementation of a computer based tool which assists designer actions by expanding the creative design's design space.

Apparently, a change or a new combination of "unusual" causing the expansion of the design space, calls for an agent or a knowledge transformer to make the change happen and to cause a sudden mental insight (Akin, 1996) which is to be followed by the creative occurrence. Such agents that can extend the design space have been defined by Gero (1996) as combination, transformation, analogy, emergence, and first principles. Furthermore, Sim and Dufy (1998) categorize knowledge transformers under: abstraction, associations, derivations, explanation, decomposition, generalization, etc. Black Box, aiming to assist creative occurrence during concept generation, makes use of analogies as the space extension and changing agent aiming to let the user make use of knowledge transformers as associations, and structural or surface derivations.

The transformative agent being analogies and knowledge transformers as associations and derivations that are used to construct analogies, it then it is time for the design space of Black Box (Boden, 1991) to be constructed. Based on the Genevieve Model of Finke *et al.* (1995), in this study, the design space is divided into two experiential subsequent phases which are adapted from the Genevieve model. The first one is the **Generative Phase** where the designer builds pre-inventive structures with the assistance of Black Box tool so as to promote creativity. The second phase that the designer is going to experience in the constructed design space is the **Exploratory Phase** where the designer is expected to search for emergent features in the pre-inventive structures which refer to concepts s/he produces.

3.3. Aim and Scope of Black Box Study

Black Box intervenes in the concept generation phase in order to enhance the creative ability of the designer and her/his performance with respect to pre-inventive structures s/he produces in the generative phase and develops into concepts in the exploratory phase of the study. As for analogy making provides a bridge between seeing and moving caused by recalling events and/or entities that have been at an unknown memory level as a consequence analogies are used as triggering agents to construct pre-inventive structures. Black Box offers to help find analogies that are going to be used to transfer data from one source to the target and a code that might set the designer free from the routine evaluation of still images, everyday images, surrounding images and animated contexts in a computer based virtual space.

3.4. Objectives of Black Box

Black Box as a tool has arisen out of the concepts of Boden (1994) that impossibilist creativity happens through exploration and change of the conceptual space of design and of the need of an agent to cause change as stated by Gero (2002) and of the possibilities of the moves that are to be produced by the designer as a result of the changes in the act of *seeing* (Schön, 1983). In short, Black Box expands the design space by attaching itself to it, changes the perceived data through analogies and aims at the creative occurrence by changing the way the designer sees and acts.

The tool is not a computational engine but rather a virtually organized set of windows that open to different perspectives after which the designer will form a concept in traditional media through sketching or writing. Thus the system's main focus is representation not computation.

The tool requires various types of knowledge which have been encoded procedurally. Below is a list of objectives that have been taken into consideration in the design of the tool.

- The tool should be simple and ergonomic in use but also unpredictable and multi-faceted at the system level so as to support creativity.
- Since rigid compositional order can be understimulating, unpredictability has been used as a driving force in the arrangement of visual and verbal knowledge represented within the tool.
- The tool is to use high level concepts in arranging low level graphical data which means that the segments of the tool, the worlds, have been based on singular concepts.
- The main focus of the implementation is to provide as much visual data as possible for the given problem definition and the amount of time.
- The rationale behind the selection of the knowledge base and the content is along with the existence of selection of content ranging from irrelevancy to relevancy for the design problem.
- The fact that the content of the tool is adequately varied is the consequence of the aim of coping with the different styles of the potential users and of course of divergent approach taken to support creativity.
- The tool does not require facility for the user to extend/modify the design base interactively.
- The tool is basically constructed on user manipulations such as stopping, playing and randomly picking.
- Themes and variations aim at expanding the conceptual space of design.
- The ways that have been used to introduce (non-random) variability are not based at the level of program codes nor through software definitions of an n-dimensional space but through employing lexicons of images variously modifying and combining them according to a set of rules analogous to the rules of morphology and syntax.

3.5. Black Box Architecture

Black Box is constructed via Macromedia Flash MX and common lisp where needed. At the level of program source code, Black Box is rather easy to define as it is not interactive software that responds to user actions. Unlike CAD software that makes even untrained individuals create shapes and drawings, Black Box is a system of experience, letting the user sketch in traditional ways later in the process; it is not a drawing medium. It is a surface-bound medium where all the interaction is based on the single point of contact of the mouse.

The kernel of the generated tool is that it is case-based and the types of data structures are defined accordingly. For another hypothetical design scenario, type of data has to be defined again. As for this study, data structures are organized according to the integration of themes related with *time* considering the fact that a *clock concept* is going to be designed. Additionally, in order to provide ease of use, the tool has been reformulated through the HTML code and presented in an arrangement of a web-page.

Black Box is a compilation of virtually designed worlds which are loaded with images, words and animations or a combination of those. The content is to be changed, redesigned and extended according to the design problem at hand or the hopes are towards the tool's improvement to such a degree that the content can also be extended with the user's own intervention.

3.6. The User Interface

Black Box provides the user with a shape based interface. Navigational actions are executed through buttons marked with the name of related point of the navigational map (Figure 3.1).

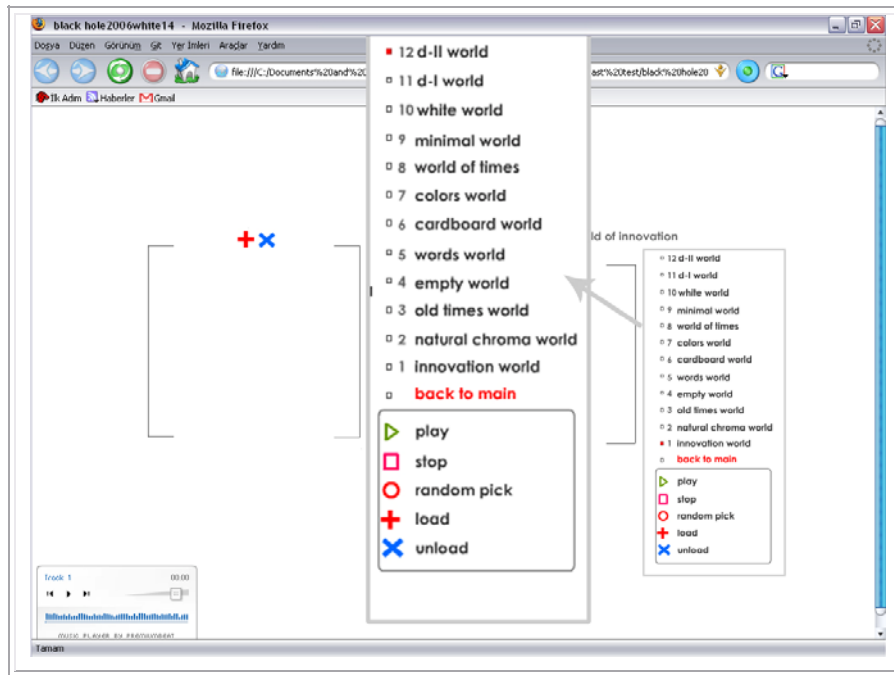


Figure 3.1 Main Interface of Black Box

As the interface stays static, the set-up of each point of the navigational map (by point, a specific world of the tool is meant) shows a deviating design. So, the differing set-ups of the worlds have followed intuitional self-organization rather than a hierarchical one, designed by the author through selection of differing graphical computing.

- Part Two: Generative Phase; Real-Time Observational Protocol Study (Attributed time: 15-20 minutes)

Designer behaviors during generative phase have been categorized into three action levels. The main idea behind the coding scheme for the real-time observational protocol analysis has been first established by Suwa and Tversky (1997) and afterwards developed by Suwa, Gero and Purcell (1998). The coding scheme explores the concept design process by focusing on expressional designer actions like drafting, gestures and verbal expressions as well as the perceptual actions like navigating and thinking during generative and exploratory phases. Basically, it is a content-oriented coding scheme where *expressional*, *perceptual* and *conceptual* design behaviors of designers have been sorted into five categories: *drafting*, *verbal*, *cognitive*, *perceptual* and *mapping*.

- Part Three: Exploratory Phase; Concept Generation and Sketching/Writing (Time left to the designer)
- Part Four: Retrospective Report of the Exploratory Phase (Attributed time: 5-10 minutes)
- Part Five: Post-assessment Questionnaire (Attributed time: 10 minutes)

The general idea is to capture the construction of the totality of ideas and relations of the designer while he uses the tool. These ideas and relations are formed in the mind of the designer, but also partially made explicit in multiple representations. To a certain extent, the designer will have to use the tool in a way to create nodes and links, according to which his/her ideas and relations are going to be interpreted.

4. Conclusions and General Discussions

Assisting creative processes of design is a great area of inquiry of today's design world and one of the ways of this was assisting creativity through the expansion of design space which was the first assumption of this study. As for *spatial relativity*, it might be said that, certain features of the space that is inhabited are conceived of in different manners by different individuals. Phrased in this manner, space appears to be a rather mundane concept. However, when it comes to a time related inspection of space as this study focused, an explication of the *experimental dimension of the design space* is set into light. Considering the fact that space is related with our notions of motion which in designing is based on our behavioral actions, it becomes inevitable that the definition of a *design space should plausibly fit the designer behaviors* which also change the space itself.

Such a definition of space has been adapted and presented in this study by means of *a virtual design space as an expansion to the concept design space* through which a study of creativity in concept generation, guided by the principles of *a situated nature of design* has been carried out. The constructed virtual space has helped managing, arranging and storing abundant visual data for a possible triggering of creative occurrence through agents that formalize and conceptualize the retrieved data through the visual bombardment.

In order to promote designer actions during the concept generation in this virtual space, *analogies have been used as the agents/knowledge transformers* that canalize design behaviors. Analogy making has made it possible for a mutually reinforcing relationship to exist between the *focus on creative occurrence and the experience of a synthesis of various elements into a design concept*.

It was indicated that the meaning associated with the design concept was of crucial importance which held a close connection with the nature of the creative concept generation phase. That is why the study was based on *phenomenological interviews* with eight design consultants to understand their attitude towards the “concept” and the subsequent *concept generation phases in the proposed design space* Black Box. As a consequence, a qualitative analysis of the interviews in relation with the exploration of the actions in the concept design space yielded a multifaceted explication of the experience of the creative process as it unfolds through time and *eight different thinking paths have been traced*.

Tracing of the thinking paths was realized through decomposition of the spatial experience of the designers. As was anticipated through the spatial relativity, that designers construct their surrounding space of formal and informal deviations in a subjectively relative manner, the thinking paths also displayed different focalizations and scatterednesses according to a convergent or divergent approach the designer has taken.

It has been shown how translated into design developed first in then sketched. The from the abstract to the through multiple paths and visual concept were revealed studies and interviews and thinking path. This represented the attempts at material at hand transformation, representation and the thinking process in a

In addition to the the study, the attitude the effects of media on creativity commonality where all on the use of visual inspirational source. the designers alleged much time for an most of the design client's time why a tool that has into a collection of of great use for for different concepts contains.

A virtual tool in this designer performance through the following been observed through and results of the

- A virtual tool concentrated and unknown experience and preventing disturbances of mental processes with the implementation of suitable scenarios can place the user in a state of relaxation which encourages creativity during concept generation phase. This state can be changed by variation of the virtual environment and be directed into an arousing series of visual stimuli to let the designer think in ways s/he is not used to.

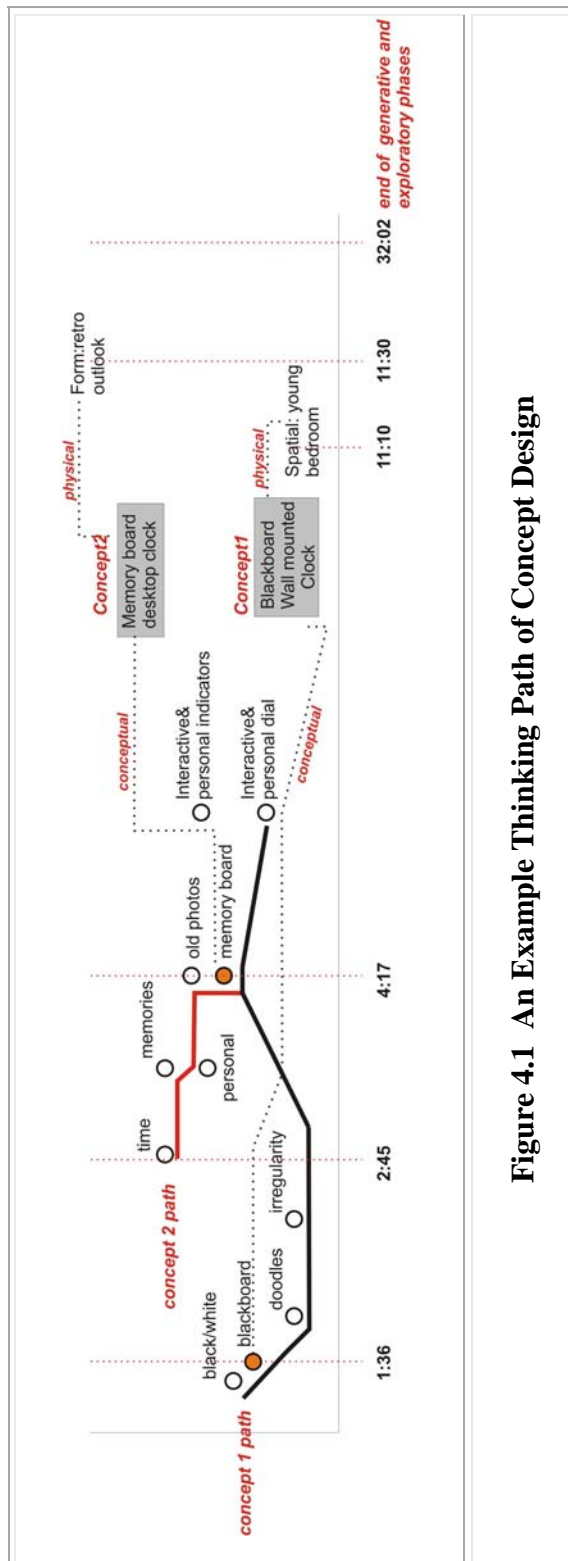


Figure 4.1 An Example Thinking Path of Concept Design

keywords, images are concepts and generally verbal manner and designers' progresses more concrete level including conceptual characteristics of a through protocol retrospective represented in the model of thinking path designers' various manipulating the through association and re-construction of their concept design.

overall indications of towards the scope of externally provided displayed a the designers agreed media as an Furthermore, most of that there might not be extensive search in projects caused by the limitations. That's been already formed external data might be designers, a Black Box varying in the data it

respect can enhance in divergent thinking aspects which have the implementation Black Box study.

providing a

- A virtual tool providing immense amount of data in terms of visual references can act as a visual-virtual library for designers that will provide a new search space for the designer which is developed and expanded for diverging ideas.
- A virtual tool that permits information to be presented visually, acoustically and, in the future, haptically can help use of multimodal stimuli to trigger unusual associations in the knowledge memory and cause a divergent thinking.

4.1. Implications for Design Support

Improvement of the quality of design processes can be facilitated by appropriate and useful support by computational tools. From the gathered feedback, it can be concluded that the operability of the Black Box tool facilitates thinking about a variety of relations, multiple associations, exploration of visual metaphors and abstractions triggering creativity in a positive manner. Being an alternative to systematic approaches of supporting creativity, this study and the implemented tool can be used in the early design phase for supporting concept generation where the interaction with the designer can be formed in giving him/her feedback on the actions s/he has executed showing how s/he shifted between ideas or parts of the one idea which will result in a more effective use of the tool in supporting creativity in early phases of design.

4.2. Suggestions for further Study

A further investigation into perception and its consequences in similarity based reasoning, on the methods of relaxation of different individualities and on context dependent design problems can be used in simulating and constructing new virtual spaces for designers but with a more three dimensional quality. The virtual three dimensional space can be used as a tool and also a medium which is capable of imparting complex entities where the high immersion of user is achieved through influencing his/her perception and thus cause variations in the types of associations and retrievals.

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