IGATY: an archetype-based interactive generative abstraction system focusing on museum interior archetypes

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IGATY: An archetype-based interactive generative abstraction system focusing on museum interior archetypes

by

Joori Suh

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Human Computer Interaction

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Iowa State University
Ames, Iowa
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ABSTRACT

Archetype in Greek means an original model that prevails in all later forms of variations, combinations, and transformations. In the field of design, types and archetypes have been used as an analytical tool; unfortunately, archetypes have not been perceived as promising prospects in the search for creative ideas, and the dynamic transformative quality embedded in archetypes has not been fully utilized among students and designers. Despite its inherent potential as sources of ideas for future invention, a number of scholars have criticized the typological approach to design for its exclusive nature primarily due to a misunderstanding of its fundamental structure. This dissertation aims at clarifying this misconception and explores a method that involves taking advantage of the malleable structure of archetypes.

In Part 1 of this dissertation, I redefine the malleable structure of archetypes as a dual structure in which two contrasting yet equally crucial elements coexist: a core signal and a set of peripherals. The study focuses on verification of this dual structure and identification of core signals and peripherals in the six selected museum interior archetypes as a test set. In Part 2 I explore the archetype’s transformative quality using the interactive genetic algorithm (IGA). The dual structure of museum interior archetypes defined in Part 1 was mapped into the genetic algorithms to design an archetype-based generative abstraction system integrated with the Unity game engine, named IGATY-beta. The focus was to develop a system that would serve as an interactive ideation partner, not as a single-solution-oriented optimization tool. In Part 3 a quasi-experiment was conducted to examine the proposed IGATY-beta system’s educational potential in enhancing creativity in the ideation process. Three teaching scenarios based on three
instructional materials were compared: (a) manual sketch-based archetypes exercise; (b) archetypes exercise using the IGATY-beta system displayed on a computer screen; and (c) archetypes exercise using the IGATY-beta system with an opportunity of viewing design in a virtual environment via a HMD. The results suggest the proposed archetype-based generative abstraction system’s positive educational potentials in enhancing creativity in the ideation process. Finally, the implications of the proposed generative abstraction system in the field of design are discussed.
CHAPTER I. INTRODUCTION

1.1. Background of the Study

Understanding and recognizing archetypes is fundamental to the field of design. With archetypes, a researcher can study and analyze design based on categories and deconstruct what is visible in a complex world into multiple, manageable, and comprehensible forms. The archetype is an efficient tool not only for effective recognition of the world but also for its reconstruction into the meaningful new. A number of theorists and scholars have claimed the benefits of understanding types and typological thinking in design: Schön states that types are “sources of leading ideas” (1988, p. 188); Symes (1994) claims the advantages of typological thinking in the solution of complex design problems. Type study in design, however, has also been a target of criticism (Bohigas, 1985; De Carlo, 1985; Gregotti, 1985) as a result of the misunderstanding of its structure. Some critics believe that type has a restricted and exclusive structure that implies designers only follow strict principles, resulting in misconception of standardization, imitation, repetition, and reproduction. In particular, according to Schneekloth and Frank (1994), the modernists assumed that “type is only one thing, . . . a static imprisoning thing” (p. 31). The confusion and misunderstanding of types obscure the benefit of understanding and using archetypes in the field of design.

Typology—the study of types—concerns “aspects of human production that can be grouped because of some inherent characteristics that make them similar” (Jennings, 2007, p. 48). I began my typology exploration when I studied interior design in the master’s program at Cornell University under the guidance of Jan Jennings. An awareness of typology and pattern recognition has been immensely influential in understanding contemporary design. The
typological approach to viewing contemporary design in its complex nature has allowed me to deconstruct components to grasp recognizable shared common traits, clarifying my comprehension of the design. When viewing a new design, I use the typological approach to initiate categorical thinking, which is helpful at the beginning of understanding complex design problems. Moreover, perceiving an archetype as a flexible structure is essential in understanding the fundamental quality of archetypes. I was also able to recognize that some archetypes are dynamically entwined with others creating multiple layers of different characteristics in their attributes. The flexible structure of the archetype has been argued by a number of scholars, including the influential architect Quatremère de Quincy (1775 - 1849), who initially developed the theory of types. Schneekloth and Franck (1994) argue that “type suggests, expands, grows beyond itself” (p. 20), and Jennings (2007) claims that a typology is “a flexible system” (p. 50). Symes (1994) states, “the flexibility of detailed development that they [types] allow is of considerable value to modern practice” (p. 167).

Delving into the flexible structure of archetypes, mainly based on Kubler’s (1962) idea of signals and mutants in his *The Shape of Time*, I realized that an archetype is not a single proposition but has an inherently dual structure: In the core of this structure, there is a set of principles (a *core signal*) that makes each archetype unique. However, because of a peripheral layer in the structure (a *peripheral*) that causes changes in appearance at different times and places, one is able to observe multiple, rich, and different alternatives of archetypes. Understanding the malleable dual structure of types can perhaps explain Arnheim’s (1969) idea of types as *generative abstractions*. In addition, it has the potential to guide the pre-logic stage (Root-Bernstein, 2002) of the ideation process through its richness of transformative imagery and sources of ideas. I believe that typological thinking based on a dual structure of an archetype
will encourage design students to develop comprehensive analytical research skills. Moreover, archetypes as generative abstractions may help the beginning stages of students’ ideation processes by providing sources of leading ideas and opportunities for transformation, alternatives, and invention. If implemented carefully in design education, understanding the dual structure of archetypes and typological thinking approach may enhance students’ creativity and creative confidence in the ideation process, which is one of the most crucial elements in creative achievement (Barron & Harrington, 1981).

In this study I examine the intrinsic and conceptual attributes of archetypes and their structure focusing on museum exhibition design and display aesthetics, and I also explore the possibility of implementing an interactive genetic algorithm (IGA) into the dual structure of museum interior archetypes I propose. The current application of GenerativeComponents™ (GC) in architectural design is useful in exploring multiple alternative forms by manually changing individual design parameters; however, only a limited number of design alternatives are usually explored because the user has to set detailed rules and parameters for each alternative solution (Wu & Katta, 2009). Maintaining the initial rules and principles that the user sets, genetic algorithms generate a large group of alternative options for the user to see and evaluate. The implementation of IGAs in this study may illustrate the conceptual understanding of the transformative quality embedded in the dual structure of museum interior archetypes.

In order to examine the basic dual structure of archetypes, six museum interior archetypes were selected for this study from my previous museum typology thesis. The selection was based on the objects’ relationship with their physical context (whether the objects are displayed free of a spatial context, a spatial context itself, or combined with a spatial context), the physicality of
objects (whether the displayed objects are material or non physical elements such as light or projected images), and the dependency of display aesthetics (whether the display aesthetics appear only with certain other archetypes). To investigate the dual structure of the selected museum interior archetypes and define core signals and peripherals in each archetype, a qualitative content analysis and case study methods were used. The set of core signals and peripherals found in each archetype were used to map the dual structure of archetypes into the genetic algorithm. This research proposes the Interactive Generative Abstraction system for the archeTYpe-based ideation process (IGATY), which provides visualization of the dynamic transformative quality of archetypes as generative abstractions that can also be viewed in a virtual environment via a head mounted display. The proposed system operates as an interactive partner and allows user interaction in the selection and evaluation process. Emphasis was placed on the use of interactive genetic algorithms in the “pre-logical” (Root-Bernstein, 2002) stages of the ideation process where divergent thinking (Gomez, 2007) and synthetic thinking (Fauconnier and Turner, 2002; Johansson, 2004; Johnson, 2010; Root-Bernstein & Root-Bernstein, 1999) are crucial.

A quasi-experimental design was used in the validation process of the educational potentials of the proposed IGATY system to evaluate the effects of three different methods of teaching archetypes on the ideation process: a manual sketch-based archetypes teaching method, a 2D screen display-based archetypes generative abstraction system (IGATY-S), and a 2D screen display-based archetypes generative abstraction system integrated with an opportunity of viewing the design in a virtual environment via a head mounted display (IGATY-VE). Students’ creativity and creative confidence in an exhibit design project were measured. The Consensual Assessment Technique (CAT) was used for evaluating participants’ creative projects. In addition,
in order to understand participants’ attitude towards archetypes, typological approach, and IGATY system, survey questionnaires and mini focus groups were included.

1.2. Rationale for the Study

1.2.1. Limited Future and Innovation

The conceptual framework for this study derived from a philosophical understanding of Kubler’s (1962) idea of the “finite world” (p. 114). Kubler challenges the conception of the novelty of things by setting an invisible boundary upon the perception of originality and innovation. For him, nothing is genuinely novel if novelty is defined as “new and not resembling something formerly known or used” (Merriam Webster’s Online Dictionary, n. d.). He believes that all human products carry certain defined or undefined signals in various forms, and those various forms sometimes appear novel despite their shared essence in certain categories. Kubler believes that types that carry the signals can be used as strategies for profitable inventions for the future. Kubler argues:

We would be seen to inhabit a finite world of limited possibilities, still largely unexplored, yet still open to adventure and discovery. Instead of regarding the past as a microscopic annex to a future of astronomical magnitudes, we would have to envisage a future with limited room for changes, and these of types to which the past already yields the key. The history of things would then assume an importance now assigned only to the strategy of profitable inventions (p. 115).

In describing types in architecture and design, Scheneekloth and Franck (1994) also argue their belief in a limited future: “Humans do not occupy, image, or create an infinite variety of particular, idiosyncratic places. Instead we structure environments by creating and using a
multitude of categories of places and spaces, often called types” (p. 9). Their conceptual foundation not only implies that designers and artists deal with a limited world but also that creativity and innovation rely on an understanding and employment of a multitude of categories, patterns, or types, regardless of the ways these are called.

In *Sparks of Genius: The 13 Thinking Tools of the World’s Most Creative People*, Root-Bernstein and Root-Bernstein (1999) also claim the importance of recognizing patterns. They argue that creative people require the ability to recognize patterns because “discovery occurs when something about our observations and experiences forces us to make another pattern” (p. 94). The network model and conceptual blending theory proposed by Fauconnier and Turner (2002) also suggest that the recognition of identity, sameness and difference of what people see provides a “natural beginning place for form approaches” (p. 6).

The ultimate goal of this research is to find a way to facilitate innovation in design. The starting point, however, is not a search for an unlimited world of novelty defined by a current dictionary; instead it is a search for a discovery of an innovative way to employ types for future invention. Thus, the first rationale of this study is based on the agreement with Kubler’s notion of types as strategies for the future exploration in a finite world.

1.2.2. Archetypes as Sources for Abstract Thinking in the Pre-Logic Stage

In search of design ideas before a concrete communicative idea is formed, designers and students go through a pre-logical stage of abstract and conceptual thinking where aesthetic sensibility, intuition, and impression play an important role. Root-Bernstein (2002) defines aesthetic cognition as “pre-logical, emotion-laden, and intuition-based feeling of understanding” (p. 62). He argues that intellectual exploration often begins with aesthetic cognition and there is a
fundamental distinction between the aesthetic cognition and “its translation into” (p. 73) formal logic or a concrete concept.

In design education such aesthetic cognition starts in various ways, including brainstorming and the early stage of ideation. Most importantly, as Root-Bernstein states, “pictorial images” or “sense images” (p. 70) make a significant contribution in the pre-logical-stage thinking. The problem of pictorial images gathered through designers’ and students’ precedent studies of other design examples is the static, frozen, and invariable attributes that reside in the photos, which could fall into a stereotypical imprint in their cognitive process. This study assumes that abstract thinking based on archetypes in the early stage of the ideation process may work as sources of dynamic pictorial sense images and generative abstract concepts, which do not appear as one single image but as a transformative one with supposedly unlimited variables.

1.2.3. Breaking out of the White Cube

From a more focused point of view, this research takes the form of a typology study of museum and exhibition spaces. Among other identified types, the White Cube has been the most dominant type, widely used since its introduction in the 1920s. The dominant aesthetic concept in museum design, the White Cube, was first seriously discussed in 1976 by Brian O’Doherty (1976/1999) in Artforum, where he argued that the basic principle behind this strictly held philosophy is that “the outside world must not come in . . . Walls are painted white. The ceiling becomes the source of light . . . The art is free, as the saying used to go, ‘to take on its own life’” (p. 7).
Since then, this prevalent model has been challenged by artists, philosophers, curators, designers, and architects. O’Doherty (1976/1999) states, “Space now is not just where things happen; things make space happen” (p. 39). As focus gradually moved from the objects to human experience (Hein, 2014), artists and museum designers have attempted to rejuvenate museum spaces as places where visitors could have emotional, multisensory experiences, and memories. Moreover, designers have examined ways to conform to the multiple commitments and roles of contemporary museums in various ways. In a museum space, interior elements, including spatial form, color, lighting, circulation, and internal views as well as display aesthetics are treated as a means to enhance the quality of the visitors’ experiences and to deepen meaning. Moreover, in recent years, the boundary between artwork and space has become blurred, and objects are blended into the surroundings. Perceiving art without context has become impossible. Putnam (2001) states that objects tend to interweave with the context of the museum and therefore building forms, color, lighting, and display aesthetics reflect the intermingled characteristics of the art instead of setting them apart from one another.

Especially during the last three decades, artists, curators, and museum designers have made numerous attempts to accentuate appreciation of art and enrich the visitors’ museum experience. As a result, a variety of physical forms and designs have appeared over time, implying certain repeated patterns that may be categorized under their own idiosyncratic traits and distinctive characteristics that differentiate one from another. The second rationale of this study is thus based on the conceptual ground that values the emotive power of interior spatial elements and blended culture in display aesthetics that fosters an interconnected network between art and space.
1.2.4. The Triad of Content, Pedagogy, and Technology in Design Education

From the fourth point of view this study raises questions about the use of technology in the ideation process: How can ideation be redefined for design projects in the age of technology? Can a new approach to the ideation process surpass the current use of the computer as a rapid visualization tool and use it as a tool for the exploration of another realm of design aesthetics? High-end technology, such as virtual reality technology, is available to us. But do educators really use them fully understanding the benefit of what it could do to assist designers? It is crucial that design educators reexamine the role of technology as a pedagogical tool to maximize student learning in design education. Technology integration has been a critical educational component in contemporary design education. In various forms technology has played important roles in architecture and interior design, especially in 3D modeling, sculpting, 2D documentation drawings, and in various forms of design communication. Computer-aided design (CAD) is regarded as assistance for visual communication, rather than a “mutual interactive partner” (Reffat, 2003). Séquin (2008) states,

> CAD tools are most helpful in the final phases of design, where a lot of the validation depends on much detailed, tedious computation, which humans gladly offload to machines. Today’s CAD tools are probably the least helpful at the very beginning of the design process in the initial, creative phase of conceptual design (p. 16).

The most critical problem with using computers during the ideation process is that representations of ideas and design thinking are not vague enough to be useful for more intuitive exploration and perceptual interpretation (Stacey & Eckert, 2003). For this reason, some studio instructors do not allow students to use computer programs during the ideation process to prevent
them from selecting a final design prematurely during the idea exploration. Although using software during the beginning phases of design may have its limitations (Ibrahim & Rahimian, 2010), it is crucial that designers and educators recognize that the computer is more than a rapid visualization or communication tool. Rather than prohibiting students from using software during the ideation process, educators and computer-aided design program developers should pay more attention to implementing appropriate technology in the ideation process because it would benefit students by exposing them to another realm of ideation where a computer and a designer may collaborate to initiate and to evolve design ideas.

My exploration in this study is based on the educational concept of Technological pedagogical content knowledge (TPACK). TPACK refers to “an understanding that emerges from interactions among content, pedagogy, and technology knowledge” (Koehler & Mishra, 2009, p. 66). Koehler and Mishra argue that each technology has unique propensities that behave in a particular way, and this unique temperament should be carefully considered when integrating technology into education. In regards to the integration of technology in design education, collaboration among design theorists, educators, and technology specialist is crucial. Ertmer et al. (2012) argue that in addition to the understanding of the complex interplay among the basic components of TPAC, technology integration requires the teachers’ beliefs and positive attitudes about the relevance of technology to students’ learning. Tsai and Chai (2012) suggest that teachers’ design–thinking skills can enable them to re-organize or create learning materials using technology for successful implementation. They argue that technology integration in education is “not simply . . . a state of technology, rather it becomes a state of art” (para. 7). Therefore, it is crucial for educators to implement technology in their teaching based on a
thoughtful understanding of the content of what they teach, pedagogical strategies, and the design of the teaching materials.

In this study, emphasis was placed on the importance of a pedagogical strategy based on the typological approach in design education and the artful use of technology in the pre-logic stage of the ideation process. This study is also founded on the belief that the relations between computers and technology can be thought of as “mutual interactive partners” (Reffat, 2003) that support design search in the ideation process.

1.3. Purpose of Study and Research Questions

The main purpose of this study is to clarify misconceptions of archetypes and typological thinking, and to implement IGAs to make archetypes useful in the ideation process. In this study I investigate the conceptual attributes of archetypes focusing on museum exhibition design and display aesthetics in order to understand the general structure of the archetype, and I explore the possibility of employing an interactive genetic algorithm (IGA)—a biology-inspired computational program—into the structure of museum interior archetypes to determine whether the proposed system makes the conceptual understanding of museum interior archetypes discernible and its practicality viable.

Typically, the goal of adopting the mechanism of the Genetic Algorithm (GA) in manufacturing, bioinformatics, engineering, or economics is to establish one single optimized solution. Unlike other applications of the GA, the main intention behind employing its mechanism in this study is not to find one single best solution. Instead, the implication underlying the use of the genetic algorithm in this research is that students understand the transformative quality embedded in the malleable structure of museum interior archetypes and
their rich potentials while perceiving the computer and technology as interactive partners in the ideation process.

This research is founded on the following three questions:

1. How can the archetype’s structure be redefined to communicate its transformative quality? 2. How can the intrinsic underlying concept of museum interior archetypes be made apprehensible? 3. How can archetypes exercises become more useful in design education?

Based on these main questions, the following three hypotheses were developed:

1. Kubler’s morphological approach to understanding the history of things will serve as a foundation to explain the malleable structure of archetypes.

2. Applying interactive genetic algorithms will help visualize the malleable structure of museum interior archetype in its core signal and peripheral.

3. If implemented carefully in design education, the proposed generative abstraction system will be useful in teaching the typological approach to design ideation.

3.1 The proposed IGA-based generative abstraction system will help students understand the malleable structure of archetypes and their potentials for future invention.

3.2 Different archetypes teaching methods will show differences in enhancing students’ creativity and creative confidence in an ideation workshop.

3.3 In delivering archetypes exercises, implementing virtual reality technology may make a difference in students’ creativity and creative confidence in an ideation workshop.
In order to design the goals of this study, to answer the main questions, and to prove the developed hypotheses, the following general research questions and sub-questions were developed to support this study:

General Question 1: Identification—Redefinition of the malleable structure of archetypes

1. Can museum interior archetypes be explained based on the principles of biology (e.g., mutation, crossover, and coevolution)?

2. Is the proposed dual structure of archetypes (a core signal/peripheral) found in the six selected museum interior archetypes?

3. How can core signals be defined to communicate the principles of each museum interior archetype?

4. What kinds of peripherals are found that react to contexts and cause changes?

General Question 2: Application—Application of IGAs to the dual structure of museum interior archetypes

1. Will the IGA mechanism work in the application of museum interior archetypes?; i.e. Can the dual structure be mapped into the genetic algorithms?

2. How can mutation and crossover be defined with regard to museum interior archetypes?

3. What do evaluation and fitness mean in the application of IGAs to the archetype-based generative abstraction system?

4. Can multiple museum interior archetypes be combined in the proposed generative abstraction system?

5. Will the design evolve towards the designer’s intended scheme in the proposed generative abstraction system?

6. Can this application result in unconventional aesthetics?
7. Can it be expanded to other archetypes applications?

General Question 3: Validation—Validation of the educational potentials of the proposed archetype-based generative abstraction system in design education

1. If the application of IGAs to museum interior archetypes is viable, will this help participants understand the malleable structure of archetypes and their potentials for invention?

2. Does the coevolution process (the combination of two or more different archetypes) in the proposed system trigger a synthetic thinking process?

3. Does using the proposed generative abstraction system help participants improve creativity in an ideation workshop?

4. Does using the proposed generative abstraction system help participants improve creative confidence?

5. In delivering the archetypes exercise, does implementing virtual reality technology make a difference in students’ creativity and creative confidence?

1.4. Research Structure

The research is structured around three main research points: identification, application, and validation (Figure I-I). In the first part dealing with identification I focus on the conceptual understanding of archetypes based on Kubler’s (1962) idea of understanding the history of things and investigating the dual structure in the six selected archetypes. Thus, the main goal of Part 1 will be to identify the core signals (the core principles that are transmitted in the same archetype throughout time) and peripherals (the variables that make the archetype appear different in applications) in the six selected archetypes. The signals and peripherals in selected archetypes
found in Part 1 were used in designing the proposed archetype-based interactive generative abstraction system (IGATY). In Part 2 I determine whether the system can generate offspring from an initial population through the user’s evaluation and selection processes. The main goal of Part 2 will be to design and test the system that is intended to enable students and designers to see the core signals and peripherals and their rich transformative quality for design exploration. In Part 3 the proposed IGATY system was carefully integrated into an educational lesson plan for the validation process of this study. A quasi-experiment was conducted: During the experiment, the participants’ self-assessment, Consensual Assessment Technique (CAT) results, and mini focus groups were used for validation of the educational potentials of the IGATY system.

Figure 1-1. Research structure (identification – application – validation)

Chapters are organized based on the research structure. Chapter 2 provides the conceptual framework based on a literature review: it informs readers of various theories and discussions of type study and biological interpretation of archetypes to propose the dual structure of archetypes; it gives an overview of the genetic algorithm, an application of IGAs in design to introduce the application of IGAs to the dual structure of archetypes; and it provides a literature review of the phenomenological understanding of art to suggest an integration of virtual reality technology in the proposed system. This chapter also provides an overview of the creative ideation process as a basis for the validation process of this study.
Chapter 3 discusses the methodological framework used in Parts 1, 2, and 3: (1) The rational for using qualitative content analysis and case studies methods for Part 1 of the study; (2) the design of the proposed system based on the mechanisms of genetic algorithms for Part 2 of the study; (3) and the detailed descriptions of the procedure for the quasi-experimental design for Part 3 of the study are included.

Chapter 4 reports the results and analysis based on the three parts in this study. Part 1 provides a redefined structure of the selected six archetypes focusing on the existence of the dual structure, identification of core signals and possible peripherals, evolution in the linked sequence, and possible transformations. Part 2 demonstrates how each archetype is mapped into the proposed system and how the IGATY-beta system behaves in terms of mutation, crossover, and coevolution. Part 2 also shows if the IGATY-beta system can make designs evolve towards the designer’s intention. Part 3 reports the findings of the pilot study and quasi-experiment, and specifically focuses on the differences among the three treatment groups regarding the improvement of creativity, creative confidence, and the understanding of archetypes.

Chapter 5 presents discussions and expanded interpretation of the findings from the data presented in Chapter 4. The topics discussed in this chapter includes the dual structure of archetypes; evolution of archetypes—mutation, crossover, and coevolution; the dual structure of archetypes and IGA; archetypes and foundation of ideation process; IGATY archetypes exercise and the creative ideation process; archetypes exercise with VE and its effect on creative confidence and creative performance; IGATY, synthetic thinking skills, and creative design; archetypes in a virtual environment and creativity.

The final concluding chapter presents implications of this research, limitation of the study, future directions, and final remarks on the research.
1.5. Delimitations and Limitations

In my master’s thesis, entitled *Theory Briefs: Contemporary Interior Design in Museums and Exhibition Spaces*, I defined twenty-one contemporary museum interior archetypes, including Red Room, Room Autonomy, Accent, Light Space, Translucent Wall, Poetic Light, Exaggeration (renamed Scalar), Memory Path, Meandering Path, Sprit Road, Internal Plaza, Enfilade, Serial Vision, White Cube, Context as Medium, Spatial Drama, Devouring Space, Simulation, Wunderkammer, Vitrine, and Grid. To set the boundary for this study, I focused on six representative museum interior archetypes as a test set to examine the possibility of applying IGAs to museum archetypes and its educational potentials. Once the hypotheses noted in the Research Questions and Hypotheses section are proved through the validation process, the study will provide a foundation to extend the proposed idea and the generative abstraction system to develop them further by applying them to numerous other archetypes. The following museum archetypes were selected for exploration of this study:

1. **A representative Archetype 1 that is free of context**

   **Grid**: a systematic arrangement in rows and columns or in three-dimensional intersections at right angles

2. **A representative Archetype 2 that is a combination of context and object**

   **Wunderkammer**: an installation aesthetic in which a multitude of diverse, collected objects are arranged as categorized, taxonomic, or random-order displays on walls, floors, ceiling planes, in cabinets, or three-dimensionally in space

3. **A representative Archetype 3 that is context itself**
**Spatial Drama**: an exhibition space manipulated three-dimensionally according to a theme and an idea of an exhibition or a specific paradigm of an art group

4. *A representative Archetype 4 that is associated with light*

**Poetic Light**: natural or artificial light that is artistically combined with colors as a medium of art so that visitors perceive light as a work of art and as a spatial experience

5. *A representative Archetype 5 that is a non-physical object*

**Scalar**: display aesthetics associated with projection

6. *A representative Archetype 6 that appears only with certain other archetypes (a dependent archetype)*

**Vitrine**: display aesthetics associated with a container for displaying significant or ordinary objects

The nature of typology has innate limitations when one seeks the representative models communicating their core principles. Setting a basic starting point for each type will be limited in representing all different possible subtypes, especially because museum archetypes are closely related with specific objects displayed in exhibitions. Moreover, only six archetypes were selected for this study to test the conceptual framework designed for this research. For the third part of this study—validation of the educational potentials of the proposed IGATY system—participants were recruited only from sophomore students in the department of architecture and interior design at Iowa State University. The participant size was limited because of the restricted numbers of equipment (Oculus Rift DK2 HMD). Because the proposed system is new beta version and has not been tested for usability, the software was not perfectly stable for the experiment.
1.6. Definition of Terms

The terms used in this study are defined specifically for this research as follows (The detailed aspects of each term are described in Chapter 2):

**Design Archetype**: A representative abstract idea, image, or concept of a set of design that has inherent shared characteristics among the group members that are unique in their attributes and have the universal emotive quality. An archetype consists of a core signal and a set of peripherals. (Types and archetypes are used interchangeably in design. However, archetypes emphasize the experiential and emotive quality embedded in the principles (This-Evensen, 1987). Archetypes are different from prototypes in that archetypes, as original fundamental concepts, work as sources of initial ideas at the beginning of the ideation process; whereas prototypes are created after a concrete idea is formed to refine a selected design before production.)

**Core Signal**: An unchanging set of principles and essential rules that define the core attributes of a specific design archetype.

**Peripheral**: A set of parameters that cause the embodiment of a core signal to dynamically change, evolve, and transform.

**Chromosome (or Individual)**: A design example that is created in a GA based generative abstraction system.

**Mutation**: A process of evolution of design that switches positions of some of the genes in the same chromosome (definition based on chromosomal translocation).

**Crossover**: A process of evolution of design that switches some of the genes from one chromosome with some of the genes from another chromosome (definition based on uniform crossover).
**Coevolution**: A process of evolution of an archetype that evolves together with other archetype(s).

**Typological Thinking**: The creative design process that is initiated based on the understanding of the malleable structure of archetypes and focuses on exploration through the variation, combination, and transformation of archetypes.

**Creative Cognitive Ideation Process**: The beginning stage of a design process that includes divergent thinking (Okudan & Tauhid, 2008), and a generation process by idea mutation, idea recombination (Thoring & Müller, 2011), and idea transformation (Boden, 1998).

**Synthetic Thinking**: A design process that is associated with creating a network connection among different ideas (Fauconnier and Turner, 2002; Johansson, 2004; Johnson, 2010; Root-Bernstein & Root-Bernstein, 1999) to foster innovation in design.

**1.7. Substantial and Original Contribution of Knowledge**

**1.7.1. Suggest a Meaningful Approach to the Understanding of Design**

In this research, I attempt to clarify the misconceptions of understanding archetypes and reexamine the rich potentials embedded in the structure of archetypes. This research will answer fundamental questions regarding the complex, innate relationship between design and culture, and present a conceptual framework applicable to related research and education that effectively reveals the multifaceted characteristics of design and culture in the present age.

Dilemmas are inherent in global design, the results of which are sometimes almost identical regardless of unique settings because of the tendency to grasp design as a whole with respect to a particular style or trend without fully apprehending the core and the deviation. Perceiving the entire design project as a mere symbolic expression also hinders one’s true
understanding of design and culture. The conceptual framework on which this dissertation is based derived from Kubler’s (1962) morphological approach to the history of things and Hillier and Leaman’s (1974) biological approach to understanding archetypes. Kubler viewed the history of things as a “system of interlocking, reciprocally supporting routines of course drifts and sways, and swells and shrinks, in response to many conditions” (p. 66). The biological approach to understanding types facilitates the interpretation of Kubler’s idea of signals and mutants as something more applicable in the real world.

Reframing the conceptual foundation of design and culture will allow design educators to empower students not only to discover potential ground upon which culture and identity can dynamically intervene but also to witness the core design archetypes that tie genuine global understanding to design.

1.7.2. Propose an Archetype-Based Ideation Aid Tool for Exhibit Design

Despite the potential benefit of understanding archetypes and the typological approach to the design process, there is a lack of evidence for how archetypes actually help within the beginning stage of the ideation process. Moreover, in implementing IGAs in design, most of previous studies have focused on prototype design (such as a window, a dome, a roof, or a bridge) that is useful after a selection of an idea, and especially when a design task is related to one specific building component or a single product. The integration of IGAs has not examined the potential of using a set of multiple museum interior design archetypes as a collective tool created based on fundamental generative abstractions that aids pre-logical aesthetic cognition (Root-Bernstein, 2002) and enables coevolution among multiple museum interior archetypes as part of a designer’s initial aesthetic search. This research is significant in that it provides empirical
evidence of using a set of multiple museum interior archetypes integrated with IGAs as generative abstractions that facilitate the creative ideation process before an idea is formed. Like geometric patterns and other ordering devices, these archetypes are expected to work as starting points of a designer’s activities (Lyndon & Moore, 1996) in the ideation process. Each museum interior archetype introduced in this research may have considerable potential in its ability to be transformed and developed into an innovative new schematic design. The results could support many theorist’s arguments about the potential benefits of using archetypes in the ideation process and may demonstrate that a type is the “frame within which changes operates” (Moneo, 1978, p. 27). This research is also expected to show the specific part of the ideation process in which the system is most advantageous.

The proposed system is potentially beneficial not only for designers and curators but also for artists in terms of enlivening their imaginations. In the contemporary art world, an increasing number of opportunities for collaboration have arisen among artists, curators, designers, creative thinkers, and technology experts. The boundary between art and display has become blurred because the display aesthetics is its own art component in the completion of an art exhibit. The proposed generative abstraction system is expected to foster collaboration especially among exhibit designers, artists, and curators.

1.7.3. Suggest a New Definition of Crafting Using Museum Interior Archetypes

Some researchers argue that using software during the beginning phases of design may have its limitations (Ibrahim & Rahimian, 2010). This study is significant in that it introduces museum interior archetypes as generative abstractions and proposes using evolutionary algorithms to help visualize the transformative quality of museum interior archetypes and make
them useful in the ideation process. The results of this research demonstrate how this technique can be employed to the optimal use of museum interior archetypes in the field of design.

This research demonstrates the use of the IGA in generating a variety of possible schematic design solutions by using museum interior archetypes via mechanisms that have been inspired by biological evolution, such as selection, mutation, crossover, and coevolution. The proposed system shows that while maintaining the main set of instructions that defines each design archetype, diverse schematic designs of one type can be produced as the initial population. Feasible solutions that are selected through the fitness evaluation process are used in the reproduction of the following generations. The primary focus of this research is to determine how the designer can interact with the computing process to foster the designer’s creativity in crafting based on museum interior archetypes. During the process, the designer can input new rules, parameters, or add other archetypes to promote further transformation (mutation and crossover) and combinations with other museum interior archetypes (coevolution).

Unlike other applications of the genetic algorithm, the goal of adopting the mechanism of the genetic algorithm in this research is not to find one single best solution: The implication underlying the use of the genetic algorithm in this research is that the designers and students understand the malleable structure of museum interior archetypes and perceive the computer and technology as mutual interactive partners. The result of this research will help reframe the concept of crafting by allowing students to observe the hidden opportunities embedded in each archetype, showing the importance of interacting with the computer system in the process, redefining aesthetics, and facilitating students’ innovative ideation process.
CHAPTER II. CONCEPTUAL FRAMEWORK

Chapter 2 contains the literature review that crystalizes the conceptual framework of this research (Figure II-1). The first two sections (2.1. and 2.2.) cover a review of the literature related to type study, focusing on an understanding of the structure of type: discussions in these two sections allow me to develop a theoretical understanding to demonstrate the essential properties of the malleable structure of archetypes and justify the potential application of the interactive genetic algorithms (IGAs) to the structure. The third primary discussion point (2.3.) is the concept of evolutionary computation and its application in the field of design: It provides readers information about what has been working and what issues have been discussed. Phenomenological interpretation of art display (2.4.) is discussed in the fourth section to examine the potential benefits of integration of virtual reality technology in IGA application. Lastly, a topic regarding the creative cognitive ideation process (2.5.) is included.

Figure II-1. Framework for the review of the literature designed for this study
2.1. Archetypes in the Continuum

In discussing types, it is critical to initiate discourse from the perspective of a continuum. Developing a conceptual structure based on the perspective of a continuum will help designers and educators understand the intrinsic value and potential rooted in archetypes.

2.1.1. Style, Type, and Archetype

The first discussion starts with understanding the historical basis of various recurrent patterns found in museum display aesthetics. During the Renaissance private owners collected and displayed artifacts and paintings in private homes and palaces. When museums became separate structures open to the public in the mid-18th century, museum design practice and display aesthetics came into being. Since that time, some attributes of museum design practices repetitively appear several times throughout a historical period of time. In defining these clusters of attributes, style may not be appropriate. Kubler (1962) points out the deficiencies of style. To him, the use of the broader term is problematic because the term used in a historic style often does not specifically describe the variety and the transformations of artistic practice under each style: He states, “thus the seventeenth-century architects align either with a planiform tradition or a curvilinear one, and it is confusing to call them both Baroque” (p. 117). Kubler (1962) argues that “the whole arrangement of style is unstable” (p. 3) in describing its meanings and specifying time: For instance, “the key word has different meanings . . . signifying at times the common denominator among a group of objects, and at others the impress of an individual ruler or artist” (p. 3). Multiple examples of a certain pattern may, however, appear at widely separated times. Based on Kubler’s argument, describing museum design and display aesthetics according to historic styles such as neoclassical, international style, modern, etc. is inappropriate because of
the ambiguity and inconsistency of style in describing specific forms, principles, or content. By contrast, a type identifies certain rules and principles that can be widely applied and be distributed in time and place producing a group of similar kinds. According to Kubler, replications in “a linked succession of prime works” (p. 119) can be distributed in time as a variety of versions of the similar kind of action. Kubler did not extensively use the term *types* or *archetypes*; however, he conveyed the idea of types and archetypes by describing the “category of substantial events . . . arranged in a pattern” (p. 18).

Rossi (1966/1982) defines types as “elements that cannot be further reduced” (p. 41). In this study, to understand museum interior and display aesthetics I use the term archetype, which is based on the implicit conceptual ground of Kubler’s argument about types. The terms *type* and *archetype* are used interchangeably; however, according to Brill (1994), differences exist between them in that archetypes emphasize emotive and experiential quality (p. 76). Brill argues that types are “generic images of physical forms that are produced through their recurrent historic manifestations” (p. 76). Brill believes that the type theory derived from Quatrèmere de Quincy also denotes the concept of type as “something never knowable or seen” (as cited in Brill, 1994, p. 76), implying that type is obvious in principle and concept but elusive in appearance. Brill argues that types, as generic forms need cultural manifestation to make them visible in forms.

According to Thiis-Evensen (1987), the term archetype was first used by Zucker (1959) when he described five square archetypes in *Town and Square*. It is worth noting the original Greek meaning of the word archetype that Portoghesi (1968) defines: ‘first form,’ or ‘original model’ as it exists as a basis for all later variations and combinations (Thiis-Evensen, 1987, p.
In describing archetypes in *Archetypes in Architecture*, Thiis-Evensen (1987) emphasizes the “architectural effect,” “intended expression,” and “correlations between space and [specific] experience” that the space creates (p. 15). He argues that a theory of archetypes must have the following goals:

The first is to classify the archetypes in a concentrated overview. The second is to attempt to describe them in order to point out the potential expression which exists within them. The third goal has to do with the following question: will the expression be at all perceived by the user, and does not the experience of architecture vary from person to person? The aim of this goal must then be to show that there is a common language of form which we can immediately understand, regardless of individual or culture (p. 17).

Thiis-Evensen’s understanding of archetypes, therefore, is that an archetype contains the same quality as types; however, when the term archetype is used, it focuses more on the emotive quality embedded in each archetype and the spatial experience it creates. Brill also claims that archetypes are more “spirit driven” (p. 76) and experience oriented. Especially when describing museum interior and display aesthetics, it is crucial to include the expression of certain display aesthetic concepts and the experiential qualities they create. Unlike Kubler (1962), who tries to detach meaning from forms, Brill believes that form is very important to the production of meaning (p. 76). Brill’s argument about the distinction between types and archetypes suggests that an archetype possesses a quality similar to a type that makes it unique; however, it also contains an inherent layer that carries meaning, temperament, vitality, and a dynamic essence, which are all visible through its manifestation and experience in reality. Knapp’s (1986)
interpretation of archetypal architecture is also relevant in that he points out the two contradictory contents coexisting in an archetype:

Archetypal architecture is a physical representation of the psychological and functional condition of an individual, cultural, class, and period. It is a composition of opposites: rhythmic yet static, subjective yet objective, timely yet eternal, affecting the sense of those who create it, live in it, and look at it in its own day, and also the generations to come . . . It is a microcosm of the macrocosm (p. viii).

In describing archetypes, Schön (1988) argues that archetypes are images of “experienced” objects or settings in the built environment and have “emotive power” and “universality” (p. 187). He also claims that archetypes serve as “generative images” that are capable of providing the “major premises for chains of design reasoning” (p. 187). Schön’s notion of archetypes as major premises plays a major role in understanding the significant conceptual framework of archetypes in this study. Archetypes as premises have considerable potential to be further developed, morphed, transformed, and mutated to something new. For this study I use the term archetype because I focus on the experiential quality of archetypes along with their universality and their generative aspects for variation, combination, and transformation.

The existing literature on the concept of archetypes strongly suggests that the archetype as the first model or an original form has (a) the universal characteristic of possessing shared common traits; (b) the potential to evolve to create variations and combinations; (c) emotive power and experiential quality.
2.1.2. Types: Seeds or Prisons?

From the literature two extreme arguments were identified. Typology, the study of types and archetypes, has been criticized mainly because the understanding of types and archetypes has been perceived as mere classification or identification. Furthermore, because of the misunderstanding of the potentials embedded in archetypes, using archetypes in the ideation process has also been criticized and neglected. Nevertheless, there are also a number of scholars who emphasize the benefit and potentials of understanding and using archetypes for their transformative power.

Since the advent of type study in the 18th century, urban designers and architects examined and developed the typological approach to understanding the existing environment. Despite the fundamental benefit of using archetypes in design, the study of types has been criticized because of misconceptions related to their structure. Scolari (1985) argues that the notion of type as principle is a mere theoretical statement and the idea of type “remained ambiguously between simplicity and oversimplification” (p. 45). De Carlo (1985) argues that types have become stereotypes and “do not admit variations, additions, subtractions” (p. 48). Gregotti (1985) critically pointed out that the problems of types reside in their exclusiveness: “this stone-hard value of laws independent from any heteronomous situation has caused many problems for architectural design” (p. 4). Ungers (1985) also warns that the type could “freeze into a stereotype, a cliché” (p. 93) rather than contributing to creative ideas or concepts. Rossi (1966/1982) argued that when the “type is reduced to a simple scheme of organization and a diagram of circulation routes” (p. 46), typology study is not helpful in examining “aesthetic intentionality” (p. 46) and the spatial experience each type creates.
A number of scholars also see the potential and benefit of using archetypes as seeds of ideas. Specifically, Oechslin (1985) points out that a type can be used in the design–making process as “an ingredient” (p. 66). Schön (1988) states that types are “sources of leading ideas” (p. 188). Moreover, Unger (1985) argues, thought in typology must be understood as “thinking in transformations” (p. 93). The existing literature shows that a number of researchers believe types to be a critical starting point—seeds of ideas—and an ingredient that plays an essential role in the ideation process; however, the underlying implications of the criticisms also provide an important notion in that if the idea of types is not carefully defined and applied to design education, types also could turn into stereotypes.

2.1.3. Signals and Patterns

Unfortunately, the study of types has been criticized among designers, architects, and theorists in spite of the potential benefits. According to Güney (2007), one of the main criticisms is caused by “the danger of type turning into stereotype” (p. 15). I believe that it is mainly because of a misunderstanding of archetypes, more specifically, a misunderstanding of the structure of archetypes as imprisoning static standard forms. In this section I explore the origin of this misconception and propose a dual structure of archetypes.

As mentioned previously, Kubler (1962) believes that all human products carry certain defined or undefined signals in various forms as mutants, which sometimes appear novel despite their shared essence. Kubler argues, “a particular signal is carried by matter arranged in a pattern” (p. 18). In this study I interpret the term signal as certain governing rules and principles shared among similar forms. In art museums and memorials recurrent patterns consist of unique design principles that distinguish a particular group from others. For example, a Grid in which
objects are arranged in x and y scale dimensions includes the design principle of the specific layout of equidistance between objects. It can be found in various magnitudes in its realization; however, the pattern’s own shared signals are transmitted in various morphed forms.

Hillier and Leaman’s (1974) understanding of design resembles Kubler’s (1962) idea of signal and mutants. Both focus on the morphological perspective of types and their evolutionary sequence in time as a critical factor to consider in understanding the type’s mutations. One unique aspect found in Hillier and Leaman’s proposal of transmission and transformation of prestructure is that they used the biological terms genotype and phenotype: “Design may be seen as both the transmission of the abstract ‘genotype’ structure as a whole and its transformation to realize a particular ‘phenotype’” (p. 8).

Rossi (1966/1982) proposes a slightly different approach to understanding typology. For Rossi type is constant and permanent principles that exist prior to form (p. 41). I interpret his notion of type as a core signal, a set of governing rules that make each type unique and remain constant and unchanging. Rossi also emphasized the importance of observing “modalities within which it [type] operates” (p. 41). Rossi recognized the factors that cause type to dynamically change: like other type theorists, he also valued the evolutionary attributes of type in its operation. However, by describing type as a constant and permanent principle and positioning type separate from the modalities, it still gives an impression that type, as one entity, is constant and unchanging.

One important argument consistently found in the work from the scholars mentioned above is that archetypes are associated with two contradictory characteristics. Oechslin (1985) referring to Durand and Quatremère de Quincy, claims that a “typology is not a simplistic model,
nor a standardized or reductive one . . . but rather it is a carefully built structure, in which the architectural conditions, whether systematic and historical, form a single whole, in which both forces depend on one another” (p. 66). On one hand, all of the scholars argue that there is a principle; however, archetypes are also believed to have another property that constantly changes. Confusion arises when the structure of archetypes is considered as one entity. Moreover, the complication is exacerbated when the core principle of archetypes that defines the unique characteristics of each archetype is considered as something that evolves and changes. Kubler viewed signal as something that changes and deforms, making it unclear what specifically is changing and what is not when trying to understand types. Considering archetypes as one entity causes the following problems: (a) defining the unique properties in each archetype is unclear if the core is believed to change and evolve; (b) exploration of future manipulation and transformation becomes limited if the general attribute of archetypes is regarded as constant and unchanging.

I believe that both components in archetypes are critical to understanding the potential embedded in archetypes (Figure II-2). As Moneo (1978) suggests, the type is the “frame within which changes operates” (p. 27). Rossi claims that although type is constant and predetermined, “it reacts dialectically with technique, function, and style, as well as with both the collective character and the individual moment of the architectural artifact” (p. 41). Although Rossi is using one term, i.e. type, in his explanation of the two different attributes, his understanding of types strongly suggests the dual structure of archetypes.

In this study I propose a dual structure of archetypes, one including (a) a core signal: unchanging principles that make each type unique and that have potential intended expression
and universal experiential qualities; and (b) a peripheral: layers of modalities or parameters that respond to context and make archetypes appear different in each context. One important aspect where the proposed structure differs from Kubler’s idea of understanding types is that the core signal does not change but the peripheral does. In other words, the governing rules and principles categorizing each type are preserved throughout time and across the universe; what makes the expressed form of each type diversified is the peripheral that responds to each culture, social settings, context, the maker’s philosophical ground or personal aesthetic preferences. The peripheral would thus explain why types appear different in various settings over time. One thing that makes the dual structure different from Rossi’s (1966/1982) definition of types is that in the proposed dual structure, the peripheral is inherently attached to the core signal. The peripherals, as layers of modalities or parameters, reside in the structure of archetype. Therefore what is constant is the core signal, not the archetype. Through a dynamic development of peripherals, the attributes of archetypes can also evolve while keeping the core signal.

Figure II-2. The proposed structure of an archetype
Figure II-3. Transmission of a core signal (diagram): The core principle remains constant and peripheral elements change reflecting social, cultural, thematic, philosophical, personal aesthetic preferences, and contextual differences.

The first goal of this research is to detect the sharing principles as a core signal and variations as a peripheral in each pattern of art museum display and installation aesthetics that were previously not clearly defined, and to reunite them under the “rubric of visual forms” and “collective identity” (Kubler, 1962, p. 8) that Kubler previously attempted. I believe that this understanding of the dual structure of types will facilitate an explanation of the characteristics of archetypes and their complex process of formation clearly.

2.2. The Malleable Structure of Museum Interior Archetypes

With a clear understanding of the dual structure of archetypes, in this section the discussion focuses on the transformative quality embedded in archetypes.

2.2.1. Transformation in Relays

Kubler’s (1962) understanding of the history of things is based on a morphological approach. He views the history of things as a “system of interlocking, reciprocally supporting routines of course [that] drifts and sways, and swells and shrinks, in response to many conditions” (p. 66). He clearly explains that the types appear in various ways implying the archetype’s important characteristic of flexibility in different contexts. He argues that the mutant gene exhibits the behavioral differences and “prime objects” as principal inventions that express the
most dynamic and effective prime traits or a “mutant fraction” (p. 36). According to Kubler, mutants are dynamic in their expressions depending on the context: They “deform the signal according to their own historical position” (p. 19), by transmitting “composite signals” (p. 19), all of which can be found in replicas, reproductions, copies, and derivations. Although his argument of the changing properties of the signal makes the understanding of types somewhat vague by mixing the nature of the core signal and the peripheral, he provides a significant conceptual framework that helps one apprehend the flexible essence of archetypes precisely.

The original intent behind type in the 18th century also entailed the meaning of transformation. The term typology emerged around the mid-19th century when the term was used to refer to the study of types, the comparative analysis and classification of structural or other characteristics into types (Güney, 2007, p. 5). Among historians, theoreticians, and architects who formed and developed the theory of type, in the late 18th century protagonist Quatremère de Quincy was perhaps the most influential protagonist; he provided the most meaningful and compelling central ideas in the theoretical and practical framework of the study of type. Quatremère de Quincy’s metaphorical theory of type was primarily based on three concepts: “origin, transformation, and invention” (Güney, 2007, p. 6). For him understanding the type’s evolution and transformation and the use of types in the process of invention is as important as identifying each type’s unique character and originality. Güney (2007) argues that Quatremère de Quincy’s aim was not merely to classify types but also to “make type more practical by putting it into the context of use and need” (p. 6). In interpreting Quatremère de Quincy’s idea of imitation, Güney states that the intent of imitation is not to copy but instead to “represent the laws of nature” (p. 7) and this is “the basis for invention, new combination of pre-existing elements through grasping the principles and spirit of nature” (p. 7).
In the modern era, however, type theory has focused on the production process; its core ideology was the reproduction and repetition of a prototype reflecting the social paradigms of industrial capitalism. Gregotti (1985) criticizes that type has become “a production-oriented model and universally applicable and scientifically based” (p. 4). Somehow the type theory in modernist ideology has lost the essence in which Quatremère de Quincy grounded it in terms of its importance to transformation and invention.

The first goal of this study is to redefine some of the recurrent interior design patterns based on the dual structure of archetypes. In this study I focus on six archetypes that museums and exhibitions have employed in creating spatial experiences; however, creating standardized stereotypes is not my essential focus. The fundamental goal of this research is to understand an archetype as a starting point for the ideation process and more importantly to recognize its potential to transform and evolve. Understanding the linked solutions of each type is important so that the way an archetype grows, or even combines with other archetypes and interweaves to create something more than simply one standardized form, can be anticipated.

### 2.2.2. Continuity and Evolution

This research is also based on the late-1960s model of neo-rationalist theory which centers on the continuity, evolution, and the dynamic procedural sequential quality of archetype. The neo-rationalist theory of type was applied primarily to describe the natural process of the growth of cities and the elements of the city: Rossi’s (1966/1982) theoretical approach to understanding the city and Muratori’s examination of the urban texture were considered as the neo-rationalist theory of type (Güney, 2007). Although their discussions are primarily based on urban design, the neo-rationalist theory of type’s underlying conception is significant for
understanding type theory in general. In *The Architecture of the City* Rossi (1966 / 1982) compares the city to an artifact and argues that the city should be understood as a whole in its totality. He emphasizes the universal and collective character of types that can be visible through evolution over time instead of focusing on the temporary differences of types. Rossi clearly separates the rigid rule of function from types, differentiating the functional types that were conventionally understood as types in architecture. Moreover, he argues that through functionalism “the aesthetic intentionality . . . that characterize[s] the urban artifacts” (p. 46) cannot be analyzed.

Jung’s psychological framework of archetypes (1919/1968), based on morphological constructs, is also relevant. According to Jung, the archetype is a “tendency to form representations of a motif,” and more importantly, he claims that representations can “vary a great deal in detail without losing their basic pattern” (Jung & von Franz, 1968, p. 57). In a similar vein the architecture critics Hillier and Leaman (1974) state, “Design is therefore both the transmission and transformation of prestructures, a process of elaboration and discovery, within which every solution may be unique” (p. 5).

The neo-rationalist theory of types was later developed further in Hillier’s space syntax theory in which he expanded the spatial organization concept to social and cultural patterns. Hillier and Leaman’s (1974) understanding of design is similar to Kubler’s (1962) idea of signal, mutants, and the linked solutions. Both focus on the morphological perspective of types and their evolutionary time as a critical factor that influences the type’s mutations. One unique aspect found in Hillier and Leaman’s proposal of transmission and transformation of prestructure is that they used the biological terms genotype and phenotype: “Design may be seen as both the
transmission of the abstract ‘genotype’ structure as a whole, and its transformation to realize a particular ‘phenotype.’” (p. 8). Hillier and Leaman viewed genotype and Kubler viewed signal as something that changes.

Although the space syntax approach is not a focus of this research, the underlying idea that emphasizes transmission of prestructure and its transformation over time strongly supports the fundamental conceptual framework of this study. It is worth noting Bafna’s (2012) criticism about Hillier and Leaman’s (1974) and Hillier’s (1996) notion of genotype as the “description of a generative production mechanism” (p. 76). Bafna claims the need to revisit the definition of genotype and pay more attention to redefining type focusing on “the causal processes that may generate them” (p.76).

To summarize, the existing literature on type study strongly suggests the dual quality of archetypes: (a) a universal, consistent, constant, and fundamental principle that is unique and is found repeatedly; (b) a morphological and transformative quality that evolves and changes reflecting multiple variables in context. It appears that criticisms about the study and application of type are caused by the tendency of understanding the structure of types as one single substance and focusing primarily on the universal principles. In this study I propose the dual structure that these two different attributes coexist: In the evolution of archetypes, the core signal retains the rules and principles that communicate throughout time in a continuum, but because its peripheral—that also has its own attributes—reacts to changing factors, dynamic transformation is possible. The core signal inherently conveys expression and experiential quality that can be understood regardless of culture. Understanding this malleable dual structure of archetype is critical in that it may help students and designers understand and interpret current design and
culture from an analytical perspective. Current individual design practice can be redefined as one structure comprising two coexisting components: A core signal is a set of particular principles that construe a certain design pattern or type of design practice, and the peripheral is another set of traits embedded in design that can be morphed and transformed, reflecting social, cultural, and contextual specificity. If the dual structure of types can be understood intrinsically, instead of by focusing too much on identifying types and categorizing them into boundaries, the fundamental understanding of museum archetypes as well as complex contemporary design ideation processes would be enhanced.

2.3. Biological Analogy in Design and Genetic Algorithms (GAs)

2.3.1. Biological Analogy: Mutation, Crossover, and Coevolution

A compelling relationship exists between the malleable structure of archetypes and biology; so claim a number of theorists and scholars, including Kubler (1962) in *The Shape of Time*, Jung (1921) in his theory of personality types, and neo-rationalist theorists in their space syntax approach (late 1970s and 1980s). Kubler used the term *signal* to refer to certain “kinetic energies impounded in . . . the categories of substantial event” (p. 18). Hillier and Leaman (1974) used the biological terms *genotype* and *phenotype*, describing genotype in relation to the transmission of abstract prestructure, and phenotype as the actual realization of genotype in a physical context (p. 8). Although each scholar and theorist defines and explains the core element and mutants slightly differently, the underlying concept suggests that archetypes have two different innate attributes, one of which evolves and transforms over time.

One of my primary goals is to make this malleable structure of archetypes unambiguous to students and designers. More specifically the aim of this study is to demonstrate how the core
principles can remain constant while various transformations are made through evolutionary computation processes because it would help students understand the malleable structure of archetypes and enable them to observe how designers can use archetypes in more meaningful way to manipulate and transform them for further dynamic future invention.

The parametric associative model, such as Generative Components (GC), could provide a function for generating multitudes of design alternatives. GC is useful in that it provides multiple different design options; however, its disadvantages have also been discussed. According to Wu and Katta (2009), parametric model-making programs are limited in providing an effective design alternative search because the user has to adjust the variables manually until the user finds the final design solution after trying a number of design alternatives.

In this study I explore the potential use of interactive genetic algorithms to make the relationship of core signal and peripheral comprehensible to designers and students and to make archetypes useful to them. Genetic algorithms are a heuristic computation method developed based on the inspiration from processes found in natural evolution (Ramsden, 2009). Since Holland (1975) introduced genetic algorithms in *Adaptation in Natural and Artificial Systems* in 1975, they have also been used in a number of nonbiological domains such as art, music, and design. Gero’s (1996) research about the integration of genetic algorithms with the prototype organization of function, behavior, and structure, has been very influential to a number of researchers on computational models of product design. Recently, GA-based optimization has also been used in engineering applications such as optimization of building envelope features – the design and control of HVAC systems (Tuhus-Dubrow & Krarti, 2010). Although the original function of genetic algorithms is the optimization of solutions, the GA has the potential to be
beneficial in this study in that it complies with biological analogy, and if programmed slightly differently, it can be useful in the visualization of the dynamic malleable structure of archetypes. The primary goal of GAs is to find one single optimal solution through fitness function. In this study, acquiring one single best solution is not the primary goal. Instead, my main focus is (a) to visualize the core signal (a set of rules and principles of an archetype) as an initial descriptor to define each archetype and the peripherals as variables to cause dynamic transformations, (b) to examine how the program behaves in generating a variety of mutants, and (c) how the user can interact with the system during the process.

Figure II-3 illustrates examples of mutation and crossover operations used in genetic algorithms. In GAs, crossover is defined as “the creation of a child . . . by combining randomly chosen parts from two selected parents,” whereas mutation is “the creation of a new child . . . by altering a randomly chosen part of a selected parent” (Poli, Langdon, McPhee, & Koza, 2008, p. 2). Once the set of principles of the core signal is encoded, the genetic algorithm will keep the shared core characteristics among the alternatives of an archetype generated based on another set of parametric variables (peripherals). The progenies of an archetype will evolve through the crossover and mutation operators. Each element (gene) in one design (chromosome) can be combined and switched to mimic the biological evolutionary process of mutation and crossover. In this way, the system would be able to demonstrate the dual structure of archetypes and the rich population of variations of each archetype.
2.3.2. Genetic Algorithm (GA) Mechanism

A genetic algorithm is one type of evolutionary computation (EC) that focuses on search. In computer science and in artificial intelligence a search algorithm is used to define a computational problem in terms of a search space—“a massive collection of potential solutions to the problem” (Bentley & Corne, 2002, p. 4). According to Bentley and Corne (2002), a GA makes use of two separate spaces: one is “the search space, a space of coded solutions to the problem” (p. 11), and the other is “the solution space, the space of actual solutions” (p. 11). A GA starts by generating initial populations of individuals, produced based on defined problems. Individuals are evaluated based on a fitness score that the user defines: The greater evaluation scores are more likely to be selected as survivals to produce next generations (Figure II-4). By
comparing multiple possible alternatives based on the fitness function and by discarding the weakest performing solutions, the genetic algorithm optimizes alternatives towards the final solution. In the next generation, the selected parents undergo crossover and the mutation process. If I apply the genetic algorithm to the two components in the proposed dual structure of archetypes, while going through the repeated processes of parent selection, crossover, and mutation, observation of the dynamic mechanism of archetypes would be possible: the core principles remain over time but the peripheral transforms generation after generation.

Figure II-5. An example of a genetic algorithm: “One complete cycle constitutes one generation. Survival selection strategy determines which offspring, and which parent, are allowed to pass through to the next generation and which of those are allowed to become parents in the next cycle” (Ramsden, 2009, p. 101).

In order for this system to be useful for an ideation process, the user’s dynamic interaction with the system is critical. Typically in a GA fitness evaluation is processed by the algorithm. In the field of art and design, however, where subjective aesthetic judgment is significant, the best outputs such as visual images, objects, or music must be evaluated by humans from the user’s impressions, preferences, emotions, and design intentions (Takagi, 2001). The key element of IGAs is therefore optimization based on human subjective evaluation. The interactive feature has often been implemented in evolutionary computation, especially in graphic art and computer graphics animation, music, industrial design, editorial design, and face image generation (Tagaki, 2001).
2.3.3. Application of Genetic Algorithms in Design

GAs have been adopted in various disciplines, especially since the 1990s. In this section I discuss two main streams of applications of GAs found in the literature: One focuses on performance-oriented form generation, and the other focuses on the search for design aesthetics, which requires user interaction in fitness evaluation. The GA satisfies the former, and the latter justifies the needs of human interaction. Studies show that researchers have attempted to include human involvement in the process of a genetic algorithm to add a designer’s input based on aesthetic preferences, creativity, intuition, and emotion. This study focuses on the user’s interaction and subjective aesthetic judgment in genetic algorithms and not on optimization of solutions in performance-oriented design.

GA application in performance oriented design

One simple example of some cases in which a GA is applied in performance-oriented design is the X-band antenna developed by NASA (Raes, McWilliams, & Barendse, 2010). The fitness function was determined based on performance criteria, and each generation was tested with a software simulator (Reas, McWilliams, & Barendsa, 2010). In architecture GAs have been applied to geometry design optimization as form-generation tools. In most cases, design optimization is functional goal-oriented, for instance, to achieve the best possible building performance in lighting, energy, structural, or acoustic properties of a building (Jones, 2009; Wu & Katta, 2009). Jones (2009) applied GA to a house envelope design in relation to minimizing the house’s energy requirement for heating, cooling, and lighting. Wu and Katta (2009) proposed a GA-based stadium roof design to minimize unique polygon shapes and to reduce manufacturing costs.
IGA application in search for aesthetics

A genetic algorithm is an efficient tool when there is a clearly stated functional problem that can be easily calculated and evaluated by a machine. In this case fitness values can be algorithmically incorporated and evaluated by the computer through the process. A digital media artist and computer graphics research scientist Sims (1993) argues, “It is difficult to measure the aesthetic visual success of simulated objects automatically” (p. 467). He introduced a different method in which a human user evaluates the success based on his or her subjective visual perception. For example, Sims’ art installation called Genetic Images (1993) allows museum visitors to evaluate and select images to reproduce the next generation. Sixteen monitors display images generated by a genetic algorithm, and visitors are encouraged to participate in the process. Visitors can select images by standing on sensors in front of the images. Takagi (1998, 2001) also states that images or sound detected by the human senses should be evaluated in terms of the user’s intuition, impressions, preferences, sensation, cognition, emotions, and understanding.

In IGAs or collaborative GAs, user interaction takes over some or all of the roles of the fitness function (Bentley & Corne, 2002). An interactive module provides “control and choices for the designer to guide the selection of desired solutions” (Oxman, 2006, p. 254). IGAs have been applied to generate various alternative melodies or rhythms of percussion (Biles, 1994; Nelson, 1993; Horowitz, 1994; Unemi & Nakada, 2001). Most of the IGA-based music composition systems allow the user to interact with the system to either select alternative melodies generated by the genetic algorithms or to change the parameters of fitness function in real time. For instance, for Vox Populi, an IGA-based digital sound composition system, the
researchers included graphical controls that allow the user to manipulate fitness and sound attributes (Moroni, Manzolli, Von Zuben, & Gudwin, 2000).

Aoki and Takagi (1997) introduced an IGA-based 3-D CG lighting design support system to aid designers’ judgments on lighting conditions based on positions, colors, and intensity of lighting in photographic CG simulation. Their results showed that the IGA was more useful for CG designers with little or no experience and was not significantly useful for experienced CG designers. Takagi’s and Aoki’s research implies a meaningful notion about the use of an IGA in beginning-design education. Nishino, Takagi, and Utsumiya (2000) proposed a digital prototyping system for art education that was useful to relatively unskilled art students. In order to foster both an artistic sense and those skills that are essential for creating art, Nishino et al. developed an interactive evolutionary computation-based educational system that helps beginning design students enhance their artistic sense. The system displays 3D CG alternative models based on a given motif (e.g., 3D green peppers).

Kelly, Papalambros, and Seifert (2008) have proposed unique interactive genetic algorithms as creative enhancement tools. Instead of discarding unselected alternatives, the algorithms collect the unselected individuals and use them to generate convergent and divergent parent populations. Their idea was to foster convergent thinking and divergent thinking by forcing the user to view offspring produced based on the formula. For instance, to model divergence the researchers intentionally applied very high mutation rates. As a result the algorithm can generate extremely randomized mutations. Park (2007) has proposed a GA+CSS-based webpage generator Evo-Web that uses an online preference survey for the evaluation process. Turrin, von Buelow, and Stouffs (2011) proposed a hybrid system called ParaGen,
which combines a parametric design and a GA. In their case study of the RadioDome shape design, they added a user-evaluation function so the user can add input to the system based on subjective aesthetic judgment.

2.3.4. IGA Issues Related to Human Computer Interaction

In this study I focus on the application of IGAs during the ideation process where conceptual design thinking and aesthetic judgment are critical. According to Horváth (2003), “conceptual design is a creative problem-solving process enabled by human knowledge, intuition, creativity, and reasoning” (p. 92). Interactive evolutionary computation was introduced because creative design always needs subjective, intuitive, and sensitive human judgment to some extent. With an IGA, how humans interact with the system is a critical component of the main function of the algorithm because it deals with the subjective judgment of the aesthetics of art.

Exploration of design alternatives is one of the most important steps in the creative ideation process. According to Woodbury and Burrow (2006), two main benefits related to the exploration of design alternatives are revelation and comparison. On one hand, a GA is very helpful in generating a large search space with numerous alternatives that often reveal sometimes rare and unthinkable options, opening up the designer’s imagination for further investigation: However, comparing a large number of objects is challenging for humans because of the limited cognitive load as well as fatigue. Alvarez and Cavanagh (2004) claim that “the capacity of visual short-term memory is limited to four or five” (p. 110) items and the visual information load per item also plays an important role in the storage limit. IGA designers and developers must take this into consideration: Users’ visual short-term memory will be limited, and remembering what they have selected in the IGA process is extremely difficult for them. Therefore, if the selection
itself as part of the ideation process is designed to be essential and meaningful for the function of the system, the interface must be carefully designed for users to track their previous selections.

A number of researchers have identified human fatigue as one of the inherent problems with using IGAs (Buonanno & Mavris, 2005; Cho, 2002; Galanter, 2010; Machwe and Parmee, 2007; Takagi, 2001). To overcome this shortcoming, Buonanno and Mavris (2005) suggest using a combination model in which the user still plays the role as an evaluator while the machine optimizes all the other quantifiable goals. Machwe and Parmee (2007) propose implementing a case-based reasoning (CBR) system as a solution to reduce the load of continuous evaluation placed on the user by suggesting ranks among the candidates. The researchers used the machine learning subsystem within the interactive evolutionary design environment (IEDE) that stores user preference data from previous evolutions and uses them for recommendations (Mackwe & Parmee, 2007).

Horváth (2005) emphasizes the importance of attention to the fundamental mechanisms of conceptual design in the development of design support systems. He argues that a number of artificial intelligence principles and techniques, such as qualitative reasoning, genetic algorithms, and rule-based computational tools, have not exceeded their initial goals. He also states that “many industrial designers consider design automation an educated academic exercise without strong theoretical support” (p. 99). In criticizing the current use of computer-aided design support systems he claims that “the concepts are typically represented by some sort of schemas that serve as the basis of the embodiment of a product or of a system” (p. 92).

Another important shortcoming of genetic algorithms is the lack of complexity (Galanter, 2010). Because of the given set of a fixed parameter, a single level of emergence from one set of
principles for certain genotype and phenotype will be unable to generate the level of complexity that art requires (Bentley and Corne, 2002; Galanter, 2010). Most of the researchers focus on the optimization of one single-object geometry design, such as a roof structure, a dome shape, a bench, or the overall shape of a bridge. Based on an understanding of the inherent complexity in nature, the application and performance of genetic algorithms lag far behind the ultimate goal of their becoming a fundamental value to design.

To summarize, criticisms of the current use of genetic algorithms illustrates what IGA designers and developers should acknowledge:

1. A theoretical and conceptual foundation is an essential addition to the IGA application to design.
2. A well-defined set of represented schemas is necessary as the basis for an IGA operation.
3. Quantifiable user goals must be determined and included in the algorithms, separate from users’ fitness evaluation process, in order to reduce human fatigue.
4. Users’ cognitive visual information load and short-term memory must be carefully considered in the interface design.
5. To be useful in the field of art and design, the level of complexity an IGA can generate must be taken into consideration.

2.4. Phenomenological Understanding of Art Display and Virtual Environment (VE)

2.4.1. Phenomenological Understanding of Art Display

Brill (1994) emphasizes the integration of all senses in experiencing archetypes (p. 76), arguing that all senses, including “smell, humidity of places, acoustic quality, or the feel of the
air” (p. 76), play an important role in experiencing archetypes. When designing exhibitions and display aesthetics, consideration of all aspects of human experience created by both the object and the surrounding context is crucial. Considering the appreciation of art as a whole human experience, I believe that form, emotion, multisensory aspects of the context, and meaning are all mutually inclusive. In the appreciation of art, understanding how the object is seen, perceived, and experienced through display aesthetics in the specific spatial context, and understanding how the meaning behind is effectively delivered, are crucial. Thus this study follows Böhme’s (1993) definition of aesthetics as “a theory of perception in the full sense of the term, in which perception is understood as the experience of the presence of persons, objects and environments” (p. 116).

The French phenomenological philosopher Merleau-Ponty (1908-1961) emphasizes visual as well as mobile aspects in the “fabric of the world” (p. 295): the form, size, light, shadows, color, texture, reflection as well as body position and movement are all correlated to create perceptual characteristics. Crowther (2009) successfully interprets the intrinsic meaning of Merleau-Ponty’s notion of the fabric of the world: “Nothing is, in perceptual terms, simply there. We recognize a visual item or state of affairs on the basis of its position within a complex network of bodily competences and visual relations” (p. 74). This emphasizes the critical point of the importance of experiencing museum archetypes using all sensory faculties. The division and the boundary between the designer’s world and the design space where he or she is exploring design solutions must be blurred to enhance the understanding of the experiential quality of archetypes.
Crowther’s interpretation of Merleau-Ponty’s perceptual characteristics of body position can also be related to the manner in which the German perceptual psychologist and art theorist Rodolf Arnheim (1969) describes “visual noise”: An object or a group of objects can be truly perceived only to a certain extent, not the whole of what is viewed. One important reason that people do not perceive the whole aspect of visual noise is perhaps their physiological limitation. For example, from each position humans can view perspective images only within the boundary of the field of view. Humans can perceive only a limited amount of visual information that includes a “perceived shape with more or less vague details and nuances” (Arnheim, 1969, p. 27). A number of psychologists have proved that only part of information we perceive is processed in full detail while the remainder is left relatively unprocessed (Desimone & Duncan, 1995; Egeth & Yantis, 1997; Niebur & Koch, 1998). This suggests that in the ideation process, what we see, recognize, and understand play a critical part in the creative cognitive process, and the rest of the information not recognized is left unprocessed. In teaching and using archetypes as well as in designing exhibit spaces, students must be able to effectively experience, perceive, and analyze design and recognize critical components mixed in the design, or they will not be able to process most of the information.

2.4.2. The Meta-Pattern

In describing the importance of recognizing patterns, Root-Bernstein and Root-Bernstein (1999) use the term *meta-pattern* (p. 99), referring to a multisensory mixed pattern in which visual, aural, kinesthetic patterns are “melted” into one seamless pattern. Root-Bernstein and Root-Bernstein argue that not only visual stimuli but also the emotions and kinesthetic feelings of a body in the sensing of space are other sources of artistic ideas. Root-Bernstein and Root-
Bernstein’s notion of a meta-pattern supports the conceptual framework in understanding the dynamic essence of archetypes. Each archetype is unique in its organizing principles; furthermore, to understand the experiential quality of archetypes, one must actually experience the meta-pattern created by combinations of multiple archetypes.

2.4.3. Sense of Presence in a Virtual Environment (VE)

The underlying implication of the phenomenological interpretation of the display of art advocates the importance of the user’s sense of presence in viewing or interacting with a display of art in the simulated environment. In order for a person to perceive and appreciate the aesthetic quality of the display of art as well as to feel the experiential quality created by design archetypes, the person has to be in the “fabric of the world” (Merleau-Ponty, 1961/2004, p. 295). The user’s kinesthetic feeling of body movement with visual stimuli is one of the important essences of the appreciation of art; the human and the art coexist and evolve in time.

A Virtual Environment (VE) is an immersive computer-simulated environment where the user can view and interact with three-dimensional objects in space. Bowman, Kruijff, LaViola, & Poupyrev (2004) define a VE as “a synthetic, spatial (usually 3D) world seen from a first-person point of view” (chap. 1). A 3D object displayed on the screen is what is simply there; a virtual environment is capable of transforming what is there into an experienceable reality in Merleau-Ponty’s “fabric of the world.” A virtual environment provides a substantial benefit for the designer to see something that does not yet exist or that is difficult to be physically present within the setting. Virtual environment technology that allows stereo cues, surrounded vision, a viewer-centered perspective, real-time interaction, and directional sound (Das, Franguiadakis,
Papka, DeFanti, & Sandin, 1994) is capable of providing realistic environments. VE allows users to experience the coexistence of a viewer and the objects before they come into being.

According to Witmer and Signer (1998), presence means “a normal awareness phenomenon that requires direct attention and is based on the interaction between sensory stimulation, environmental factors that encourage involvement and enable immersion, and internal tendencies to become involved” (p. 225). In a VE a certain means that encourages the user to be involved in virtual environment must be present, such as navigation or other types of 3D interaction. Flach and Holden (1998), in their original definition of presence, emphasize “action” instead of the appearance of things. I believe that interaction leads users to transmit their existence mentally from the previous realm to another realm where the interaction arises; as a result the user senses becoming a part of that realm where the interaction takes place. The user’s sense of presence, the mental status of feeling its existence in the simulated immersive environment, is a result of a their deep involvement (Figure II-6).

![Figure II-6](image.png)

*Figure II-6.* Chain of the sense of presence in a VE: VE Technology enables interaction; interaction causes immersion; as a result the user experiences the sense of presence (diagram by author).

A deep involvement through navigation and interaction in the simulated immersive environment will allow artists, designers, and students to experience the sense of presence in the
fabric of the world where their artwork and objects are three dimensionally manifested, ultimately allowing the user to experience a sense of “being there.”

2.4.4. Application of VE in the Ideation Process

In genetic algorithms the visualization of design alternatives must be thoughtfully considered. The typical method of viewing and manipulating three-dimensional objects displayed on a two-dimensional screen has some inherent problems. Comprehending a complex three-dimensional space on a limited two-dimensional screen is difficult (Das et. al., 1994). One of the issues with viewing three-dimensional objects on a two-dimensional screen is occlusion, which occurs when objects are hidden by other nearby objects. Especially when a display contains complex geometries or when the overall density level is high, occlusion is exacerbated (Carpendale, Cowperthwaite, & Fracchia, 1997).

Virtual environment technology is a useful design tool in manufacturing, process engineering, construction, and aerospace industries (Zorriassatine et al., 2003). In architecture and interior design, however, virtual environment technologies are believed to be useful in the presentation of final design: Architectural models are displayed through virtual reality for clients to see and experience the space in advance, before the building is actually built. Designers tend to focus on using virtual environment as a means of visualizing a final design to show what it would look like and what kinds of spatial experience the designed space would create (Drettakis, Roussou, Reche, & Tsingos, 2007) as some sort of “foretaste.” Kefi, Richard and Barichard (2011) criticize the current use of VE technology, asserting that it is used as a pure visualization tool for assessing the final design. Especially in architecture and interior design, the true benefit of employing virtual environments in the ideation process is almost neglected. To make VE
integration more useful, the concept of using VE technology for showcasing the final design to draw people’s attention must change to something directly associated with the ideation process and interdisciplinary collaboration. A 3D user interface can be used to allow designers of real-world artifacts to work directly in a realistic 3D context; for example, an architect can navigate through a proposed new building and make changes to its design directly instead of working in the traditional 2D medium of drawings and plans (Bowman, Wineman, Hodges, & Allison, 1998).

In the ideation process of a design studio project, students and designers need rich information to prevent idea fixation, defined as “a blind, and sometimes counterproductive adherence to a limited set of ideas in the design process” (Jansson & Smith, 1991, p. 3). Students need rich sensory experiences to stimulate their emotion and appropriate teaching tools to increase motivation. Though imperfect, a virtual environment can provide a rich simulated full-body experience; however, this does not mean that virtual environment technology should replace the other teaching materials or other sensory experiences. During the ideation process, designers need qualitative and “imprecise external visualizations to interact with their mental images” (Dorta, Perez, & Lesage, 2008, p. 3). Manual sketches and physical models facilitate this interaction (Dorta, et al., 2008) and enable students to visualize cognitive artifacts (Visser, 2006) of design. In teaching archetypes, multiple methods are crucial to deliver the conceptual and practical understanding behind using archetypes; possibly by using symbols and diagrams, real world examples in still pictures as well as moving images will help students understand the practical side of archetypes. Participating in a hands-on workshop to try to generate variations of archetypes will also help students transfer abstract understanding to a tangible substance. Virtual environment experience with the viewing and selection processes of IGAs may even strengthen
their sensibilities by bringing what they see into the realm of full-body experience. It will be meaningful to examine which visual method of teaching plays the critical role in enhancing students’ conceptual understanding of archetypes, creativity, and creative confidence in archetype-based teaching.

2.4.5. Application of IGA in a VE

Das et al. (1994) used virtual reality to display the evolution of the shape of a few simple objects and sound via genetic programming; they used a wand with three buttons as an input device. Objects can be selected by pointing to it, and a button allows manipulation of the selected object. Holt et al. (2004) used pinch gloves to interact with a GA-based engineering design system. Chandramouli and Bertoline (2014) integrated GA-based Multiobjective Optimization (MOO) with CG-based virtual scene-rendering techniques that display alternatives of library interior space planning options. The researchers used a 2D graphic interface to display iconized elements on the floor plan options, and the final GA results were put into the cells of a graphic interface. The graphic interface then was used as a reference for constructing the 3D virtual world scenario. The researchers used a desktop VR-based graphic visualization system to display the 3D views for further interaction, including changing positions of objects using a keyboard and a mouse. Integration of VE technology with IGAs has not been extensively explored: This shows the need for research on implementing VE technology in the process of IGAs.

The value of using virtual reality technology in design to foster creativity is discussed in Hakak and Biloria’s (2011) research. They claim that virtual environment provides direct access to unconventional ideas and prepares the user psychologically to apply ideas from unfamiliar sources to real world scenarios. There is a need for empirical research to examine the benefits of
incorporating virtual reality technology in an IGA-based ideation system. The aim of this research is to examine the potential benefits of integrating virtual environment technology with an IGA-based generative abstraction system in the ideation process.

2.5. Creativity and the Ideation Process

2.5.1. The Creative Cognitive Ideation Process

Creativity is a vague term, but the large literature on the subject suggests at least two common attributes: the quality that is unique and unpredictable. Among numerous theories on creativity, Gero (1994) and Boden (1998) offer the most meaningful insights into creativity for this study. Gero (1994) defines creative design as that “design activity which occurs when a new variable is introduced into the design” (p. 11) and the creative design process as a process that introduces such new variables.

Boden (1998) also provides a meaningful definition of creativity for this study. For Boden, there exist three different types of creativity: (a) “combinational” creativity involves a new improbable connection among existing elements; (b) “exploratory” creativity involves the generation of novel ideas “by exploration of structured conceptual spaces . . . that are not only novel, but unexpected” (p. 348); (c) “transformational” creativity involves creativity by the process of transformation. I interpret her theory of creativity as a creative ideation process that requires a certain set of prestructures that could be developed further through the combination, exploration, and transformation processes. The prestructures could be prior knowledge or experience. In this research archetypes serve as a starting point for combination, exploration, and transformation. Her definition also strongly supports the need of a coevolution process in the proposed system because it fosters the combination of existing ideas. The importance of
providing categories or concepts in the creative problem solving process has been discussed by a few scholars (Siegler & Richards, 1982; Baughman & Mumford, 1995). Although the research experiment was based on describing general categories not design related, it is worth noting Baughman and Mumford’s (1995) meaningful findings from their research: the categories given to the participants served as the basic raw material for further combination and reorganization, which lead to the creation of new categories. Furthermore, the existing literature strongly suggests that creativity is concerned with the transformation of existing ideas to bring unique and unconventional attributes to design.

2.5.2. Divergent Thinking and Synthetic Thinking for Creative Ideation

Divergent and convergent thinking as well as synthetic thinking are critical elements in creative design. Divergent thinking is characterized by “fluency, flexibility, and originality” (Gomez, 2007); and convergent thinking emphasizes “reproduction of known concepts and the adoption of known responses to new situations” (Gomez, 2007). Okudan and Tauhid (2008) state: “Divergent steps relate to the generation of concept alternatives and convergent steps relate to evaluation and selection of the best concepts among the proposed alternatives” (p. 244).

Divergent thinking helps create insights and innovations, and convergent thinking enhances adapting known ideas to new needs or circumstances (Tardif & Sternberg, 1988). Gomez (2007) states that generating alternatives is one of the basic characteristics of creative thinking. As discussed earlier, Gero (1994) defines creative design as “design activity, which occurs when a new variable is introduced into the design” (p. 11), arguing that creative design processes are not for making the artifacts produced in this process judged to be creative, instead “these processes have the potential to aid in the design of creative artifacts” (p. 11). Although a
number of alternatives might look neither feasible nor realistic, a deliberate generation of alternatives encourages designers to push the boundary and often open the door to innovation.

In the taxonomy of creative design—a creativity strategy model proposed by Nilsson (2011, p. 59)—the variation that comes after imitation explains the importance of divergent thinking in creative design. Nilsson (2011) explains that in variation, modification continues without changing the essential form or content. The underlying implication behind variation is that, based on the clear understanding of principles, this process encourages students and designers to go further to generate similar but unique alternatives while keeping the principles intact. In other words, to some extent the designer can change the peripheral while keeping the core signal within each element.

In Nilsson’s model (2011), combination comes after variation in enhancing the level of novelty in form and in content. Ideation activities related to combination, network, connection, and union are significant in heightening the chance of creativity. A number of theorists and scholars argue that creativity is not a single flash moment but a connected network (Johansson, 2004; Johnson, 2010; Root-Bernstein, 1999). Johansson (2004) introduces the idea of intersection among unfamiliar territories as the best chance to create innovate new ideas. Root-Bernstein & Root-Bernstein (1999) claims the importance of *synosia*, the union of different forms of knowledge. Gough (1976) found in a word association test that “moderately unusual associations were positively correlated with rated creativity in their samples of architects” (as cited in Barron & Harrington, 1981, p. 451). Once some intersection points are introduced, a variety of different combinations can be encouraged for further transformation and invention.
The previous research about the creative ideation process provided me significant information about the meaningful ways to design the proposed system. I believe that one of the important functions required for the proposed archetypes-based generative abstraction system designed for this study is the combination of more than two different archetypes to facilitate synthetic effects. In biology, coevolution (also called correlated mutation) is “the change of a biological object triggered by the change of a related object” (Yip et al., 2008, p. 290). A coevolution function needs to be integrated into the proposed genetic algorithm as one of the most important features of the system to foster the synthetic thinking process.
CHAPTER III. METHODOLOGICAL FRAMEWORK AND PROCEDURE

Chapter 3 includes the methodological framework in which three categories of general research questions are answered. In Part 1 I explain the methods used to define the core signals and peripherals in the selected six museum archetypes in order to establish the set of principles and parameters to be used in the proposed system. In Part 2 I present an overview of the proposed IGATY-beta system to demonstrate its structure: general functions including mutation, crossover, and coevolution; user interaction; and the selection process. In addition, I explain how the proposed IGATY-beta system operates by providing an overview of the graphic user interface that is displayed on a 2D screen and the virtual environment setting in which the user views objects and interacts with the system. Finally, in Part 3 I present the validation process for the proposed system to examine the system’s educational potentials.

3.1. Part 1: Identification of Core Signals and Peripherals and Their Evolution in Six Museum Interior Archetypes

The primary goal of Part 1 is to investigate the dual structure of archetypes and to identify the core signals and peripherals. Part 1 of the study takes the form of qualitative research. Bogdan and Taylor (1975) state that “qualitative methodologies refer to research procedures which produce descriptive data: people’s own written or spoken words” (p. 2). Qualitative analysis is “addressed to the task of delineating forms, kinds of social phenomena” (Lofland, 1971, p. 13). To answer the first question about understanding museum archetypes based on a core signal–peripheral structure, the primary research includes a content analysis of architecture and interior design trade magazines and secondary resources as well as case studies (Figure III-
To limit the study, this study focuses on the selected six museum interior archetypes among the previously defined twenty-one archetypes (Suh, 2004).

Figure III-1. Overview of research Part 1

3.1.1. Qualitative Content Analysis

The content analysis research method was used for this study to answer the question about how the concept of archetypes is redefined, based on the proposed dual structure. The primary analysis methods include inductive category development analysis and genre analysis that focus on “what makes certain types of messages similar” (Potter, 1996, p. 141). Following Potter’s (1996) suggestions, the analysis for constructing archetypes was conducted by (1) identifying and describing basic structural similarities such as themes, settings, or character among a group of examples and (b) looking at the evolutions of groups in terms of historical, technological, ideological, and aesthetic factors (p. 141). The analysis, however, was focused on the diachronic sequence of each archetype to perceive development and evolution through time from a holistic perspective rather than strictly following the static ontological classification.
(Marradi, 1990). The main focus of Part 1 in this study is not to create a set of classified types but rather to verify the dual structure and find the means for transformative evolution. Therefore this study also involves a qualitative content analysis that has emerged from a phenomenological and interpretive paradigm (Cassell & Symon, 2004, p. 2). As Denzin and Lincoln (2007) argue, in qualitative content analysis the interpretation of connotations embedded in fragmented information and the reconstruction of meanings behind texts and visual images are crucial. Another qualitative research analysis method used for this study was hypothesis testing (Potter, 1996) and deductive application analysis methods. I started with the general proposition of a theoretical model of the dual structure of an archetype; then examples were analyzed to test the core signal–peripheral structure of an archetype.

This study includes a content analysis of two nationally published and disseminated trade magazines to identify core principles and peripherals used in six selected museum archetypes. Design trade magazines, including *Architectural Record* (issued 1907–2014) and *Interior Design* (issued 1940–2014), are used as primary sources for building and developing components of each archetype. They offered detailed information about design practices in museums and exhibition spaces over time as well as significant evidence of recurring patterns of museum archetypes. I concentrated my analysis on trade magazines from 1980 to 2014, a significant time period when designers of museum interiors broke away from the dominant design concept, the White Cube. I expanded the survey to an earlier period to trace early examples or precursors. Secondary sources, such as interpretive books and critical articles about museum design, were also consulted to shape reflections regarding the driving factors that cause transformations of archetypes, such as social frameworks that include economic, religious, cultural, and design paradigms. These references center on sources from museum history, philosophical museum
theory, contemporary exhibition design, and display and installation theory as well as general
design theories. Among numerous secondary sources, the most helpful ones for this study were
this Century; Feireiss’s (2001) The Art of Architecture Exhibitions; Kanjo’s (1997) Blurring the
History of Exhibition Installations at the Museum of Modern Art; Kachur’s (2003) Displaying
the Marvelous; Hein’s (2014) Museum in Transition: A philosophical perspective; Arnheim’s
(2001) Art and visual perception: A Psychology of the Creative Eye; Bachmann & Bernhardt’s
Potential of Artists’ Interventions; Whitehead’s (2012) Interpreting Art in Museums and
Galleries; Davidson & Rylands’s (2004) Peggy Guggenheim & Frederick Kiesler: The Story of
Art of this Century.

The search for core signals and peripherals in the six selected archetypes involved the
following process: (a) data collection of potential groups of six archetypes, which includes a
content survey of trade magazines and secondary sources; (b) identification and organization,
which includes gathering of facts, organizing data, and identifying core signals and peripherals;
(c) evaluation, which includes analysis, interpretation, and assessment; (d) narration and
visualization, which includes description and diagramming. For visualization a representative
image was created to communicate the core signal. The Oxford Encyclopedic English Dictionary
defines an image as “a representation of the external form of an object, a figurative illustration or
a likeness of something real or imaginary” (Hawkins and Allen, 1991). Because a core signal
was defined as a schema that does not have a specific physical material attributes to make its existence visible, a very basic peripheral was used to represent each archetype.

3.1.2. Case Studies

A case study is an empirical inquiry in which a researcher investigates a phenomenon or setting (Groat & Wang, 2002). The research follows the multiple-case strategy and cross-cultural approach in an effort to interpret and relate significant and meaningful examples to each other in order to trace shared character and properties embedded in each case. This process is achieved by examining patterns of similarities and interrelationships across them. The strength of the case study is its capacity for generalization to theory because it can prove how a representative sample is applied to a larger population (Groat & Wang, 2002, p. 429). A fundamental aim of the study is to provide a rich and holistic account of the six selected museum archetypes and make the dual structure practical to real-life situations. In addition to discovering multiple cases that show the shared, defined character of each archetype, a case study of a few best representative examples of each type were thoroughly examined, the emphasis being to focus on embedded characteristics and determine how the shared traits are applied to real-world circumstances. The sampling (Table III-1) was based on the purposeful sample method where information-rich cases are strategically and purposefully selected (Patton, 2005). The selected information-rich cases provide insights to “learn a great deal about issues of central importance to the purpose of the inquiry” (Patton, p. 230). By describing how the defined character morphs in the real context, case studies in this research also help readers understand the fundamental concepts of museum archetypes that center on transformation and invention.
**Table III-1.** Museums and exhibitions selected for case studies.

<table>
<thead>
<tr>
<th>Archetype</th>
<th>Name of museum/exhibition (designer/artist)</th>
<th>Location, year</th>
<th>Significance of the case</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grid</strong></td>
<td>The American Lawn: Surface of Everyday Life (Elizabeth Diller)</td>
<td>Canadian Center for Architecture, Montreal, Canada, 1998</td>
<td>Basic Grid system was combined with multimedia exhibition. Multi-dimensional layers were used suggesting 3D Grid.</td>
</tr>
<tr>
<td></td>
<td>Form/ContraFrom (Bekkering Adams Architecten)</td>
<td>Architecture Biennale, Palazzo Mora, Venice, Italy, 2014</td>
<td>Manipulated 3D Grid system with numerous objects that delivers the message of ‘infinity.’ Combined with light projections that change the color, shape, and size.</td>
</tr>
<tr>
<td><strong>Spatial Drama</strong></td>
<td>Beyond the Wall, 26.36° (Daniel Libeskind)</td>
<td>Netherlands, 1997</td>
<td>The context was treated as part of the architect’s exhibition. The spatial configuration was manipulated as an extension of the architect’s experiment.</td>
</tr>
<tr>
<td></td>
<td>SSM/Kanno Museum of Art (Atelier Hitoshi Abe)</td>
<td>Shiogama, Japan, 2006</td>
<td>Objects’ sculptural quality is extended to the museum spatial context. The space itself becomes an extension of the sculpture pieces displayed in the space.</td>
</tr>
<tr>
<td><strong>Wunderkammer</strong></td>
<td>The Hall of Names at Yad Vashem Holocaust History Museum (Moshe Shafdie &amp; Asso.)</td>
<td>Jerusalem, Israel, 2005</td>
<td>Wunderkammer was adapted to dynamic three-dimensional form merging with the manipulated spatial configuration.</td>
</tr>
<tr>
<td></td>
<td>Gas Giant (Jacob Hashimoto)</td>
<td>MOCA Pacific Design Center, Los Angeles, 2014</td>
<td>Three-dimensional Wunderkammer. Spatial quality was maximized with 30,000 objects. Immersive kaleidoscopic experience was incorporated.</td>
</tr>
<tr>
<td><strong>Poetic Light</strong></td>
<td>Untitled (Dan Flavin)</td>
<td>Guggenheim Museum, New York, NY, 1992</td>
<td>Multiple Colored lights were used. Colored lights were interwoven with the spatial configuration combining two archetypes.</td>
</tr>
<tr>
<td></td>
<td>Vana: A Nature-Inspired Structure that Grows Like a Tree (Opproject)</td>
<td>The Brick House, New Delhi, India, 2014</td>
<td>LED light is incorporated with objects.</td>
</tr>
<tr>
<td><strong>Scalar</strong></td>
<td>Projection (Jenny Holzer)</td>
<td>North Adams, MA, 2007</td>
<td>Projected text images are exaggerated and magnified, articulating text images as well as the spatial configuration.</td>
</tr>
<tr>
<td></td>
<td>Judy Crook (Jennifer Steinkamp)</td>
<td>London, England, 2012</td>
<td>Projected images are animated changing the forms, shapes, and elements adding the sense of time.</td>
</tr>
<tr>
<td><strong>Vitrine</strong></td>
<td>UK Pavilion (Heatherwick Studio)</td>
<td>Expo 2010, Shanghai, China, 2010</td>
<td>Objects (250,000 seeds) are encapsulated in the rods (60,000) of clear acrylic that shape the undulated spatial form. A prime example of a combined form of spatial drama, Wunderkammer, Poetic Light, and Vitrine.</td>
</tr>
<tr>
<td></td>
<td>i-City Russian Pavilion (SPEECH Tchoban &amp; Kuznetsova et al.)</td>
<td>Venice Architecture Biennale, 2012</td>
<td>Objects (digital information) were embedded into QR codes that cover the entire space.</td>
</tr>
</tbody>
</table>
3.2. Part 2: Application of Interactive Genetic Algorithms (IGAs) to Museum Interior Archetypes

In this study, the primary goal of IGA application is to demonstrate the transformative quality embedded in the dual structure of museum interior archetypes. I discuss the basic structure and general functions of the proposed IGA system in Part 2. The software was developed using the game engine Unity version 4.5.5 with the implementation written in C# (C-sharp), an object-oriented programming language. Game engines such as Unity by Unity Technologies (2014) provide efficient tools to implement and test new ideas rapidly (Becker-Asano, Ruzzoli, Hölscher, & Nebel, 2014). An open source software accessible online, Unity, is easily combined with the head mounted display Oculus rift DK2, enabling the user to use the same simulation environment for both the 2D screen display and the virtual environment display.

3.2.1. The IGA Structure Proposed for This Study

Based on the results found in Part 1, the set of rules and principles as a core signal and another set of parameters as a peripheral to cause expression of archetypes, were used to design the IGATY-beta system. In the proposed system each museum interior archetype was used as a conceptual schema for the user to initiate the exploration. In C# coding, the core signal in each archetype was coded as a public class that defines the principles and behaviors of each archetype. The peripheral properties were coded for users to set parameters of variations in each archetype. The properties of the IGA operator for the mutation, crossover, and coevolution functions are inherited in each class of archetypes (Figure III-2).
Figure III-2. A mapping diagram: the IGA operator (mutation, crossover, and coevolution) is inherited in each class. The dual structure of archetypes is coded into each public class in the IGATY system. The core signal defines the principle of each archetype and a set of peripherals defines the parameters for variations of each archetype.

Figure III-3 illustrates the overall mechanism of interactive genetic algorithms designed for this study. The user interacts with the system from the beginning of the process by selecting one archetype to start with and also by defining initial parameters for evolution of the selected archetype. For instance, the user can define the basic shape of the object (e.g., For Grid and Wunderkammer the user can choose basic geometries such as sphere, cylinder, water-drop, and box.) and can set the number of objects for the Grid in x, y, and z directions. The user constantly interacts with the system by selecting individuals based on the user’s subjective aesthetic judgment or intentions, so the genetic operator can generate alternatives for the next round of selection. The system’s mutation and crossover processes were designed to aid users’ divergent thinking, and the human subjective evaluation process was added to facilitate users’ convergent thinking process (Liu, Chakrabarti, & Blight, 2003).
The IGATY-beta system overview: The user interacts with the system from the beginning by selecting one archetype to start with and by defining initial parameters for evolution of the selected archetype. The user continuously interacts with the system by selecting the individuals for the operator to generate alternatives and by choosing different archetypes for the coevolution process.

During the genetic operation process the user has options to choose different archetypes to combine (coevolution process). This function was added to foster the user’s synthetic thinking: This process enables the user to select more than two archetypes to combine with the current archetype from the next generations. In this application, the mutation and crossover processes operate separately within each archetype. For instance, when a Grid is chosen while operating within the Spatial Drama, each archetype generates offspring and displays the next generation at the same time.

3.2.2. Decision of Principles and Parameters

In the IGATY system the core signals of the archetypes are used as a set of rules and principles that each archetype will retain throughout the evolutionary process. The core signal is therefore a schema, an underlying conceptual framework that defines the specific archetype,
making it distinguished from other archetypes. The peripheral of the archetypes turns into parameters and variables of each archetype, which cause variations and transformations. The result from Part 1, driving forces that cause each archetype’s evolution, is interpreted to determine a set of variables. The evolution process works by iterative repetition of three major processes: evaluation, selection, and variation. While going through these processes, the core signal within each archetype remains unchanged, and a set of values in the parameters leads to a diverse set of variations (Figure III-4).

![Figure III-4](image)

Figure III-4. A diagram of the malleable structure of archetypes: the core signal, the immutable property of an archetype is used for the initial principle and the peripheral, the flexible expression of archetype is used for variables that cause transformation in the IGATY operation.

3.2.3. The IGA Process Design: Mutation, Crossover, and Coevolution

Chromosomes are encoded based on the permutation encoding style to give orders to each gene in each chromosome. The order is used for mutation and crossover operations. The IGATY starts with a set of 20 randomly generated initial populations, and the first set of selected individuals is used for the operation to produce children in the next generations. In the mutation process (Figure III-5), each parent gives birth to one slightly different offspring by switching the locations of 30% of the randomly chosen genes from the parent; therefore, the offspring shares
the same genes, but the position of each gene changes. This principle is applied to the mutation process of most of the archetypes: however, the variables that the operator causes to change differ. In the Grid and the Wunderkammer archetype the position of each gene will change through the process; in Spatial Drama the positional information in the three-dimensional coordinate system applied to each gene will be switched within a single chromosome; and in Poetic Light the colors applied to each source position will be used to switch within each chromosome.

![Diagram](image)

*Figure III-5.* A diagram of the mutation mechanism (an example based on a 4x3 Grid): Each parent gives birth to one slightly different offspring by changing the location of a few genes.

The IGATY operation of the crossover process in the evolutionary cycle involves two parent chromosomes that mate to produce offspring. The uniform crossover method was employed for the crossover operation instead of a single-point crossover. This enables “the parent chromosomes to contribute the gene level rather than the segment level” (Mens, Serebrenik, & Cleve, 2014, p. 110), keeping a stochastic quality throughout the operation process. With the crossover operation, the children inherit genes from both parent chromosomes by
swapping the randomly selected genes in each chromosome (*Figure III-6*). The mixing ratio 0.3 was applied for the proposed IGATY system: With the crossover operation, children have 70% of the genes from one parent chromosome and 30% of genes from the second parent.

*Figure III-6.* A diagram of the crossover mechanism (an example based on a 4x3 Grid): Two parents mate to produce offspring that inherit genes from both parents by swapping the randomly selected genes.

The IGATY system allows coevolutionary selection operations (*Figure III-7*): Two populations are evolved using an independent genetic algorithm in each archetype (combined gene approach (Maher & Poon, 1996)). The user has the option to set the current archetype populations to the freeze mode to maintain the selection and have the genetic algorithm in the added archetype evolve for the next generations. The GA cycle is repeated only in the added archetype while keeping the previous archetype fixed. If the freeze mode is not selected, two archetypes populations evolve independently using the genetic algorithm in each archetype.
3.2.4. Graphical User Interface (GUI)

The IGATY system starts by selecting the museum interior archetype the user wants to explore. When one archetype is selected, the system asks the user to set the initial parameters such as basic shapes and the number of objects (Figure III-8). Because of the unique characteristics of each archetype, the initial parameters the user can set differ by archetype. For instance, the Grid archetype asks the user to choose the number of objects in x, y, and z directions, which is unique to the Grid archetype. It also asks whether all the objects in each scene will transform consistently and maintain a uniform quality or if the user wants to see diverse sizes applied to each object in one chromosome.
Figure III-8. A Graphical User Interface example 1: The interface allows the user to set initial variables to start the IGATY-beta system.

Figure III-9. A Graphical User Interface example 2: History window shows a collection of chromosomes that user selects.
As previously discussed, the capacity of visual short-term memory is limited to four or five simple items (Alvarez & Cavahagh, 2004), and it is overly difficult for the users to recall what they have selected during the process. The history window on the right will aid the user to get a sense of which design alternatives he or she has selected (Figure III-9).

The system works in two versions: IGATY-beta beginning-designer version and IGATY-beta advanced-designer version. A direct three-dimensional manipulation of objects is not included in the IGATY-beta version system; however, in the advanced user version the user can choose specific objects in an active Unity window to manipulate the object. The manipulated objects are used as part of the survived offspring for the production of the next generations. This function enhances interactivity between the system and the user by providing better user input during the operation.

3.2.5. The IGA in a Virtual Environment

The Virtual Environment version of IGATY was designed to provide the user with a holistic experience, including the kinesthetic feeling of body movement with visual stimuli. For the output device a head-mounted display (HMD), the Oculus Rift Development Kit 2 (DK2), was selected because of its ready availability and overall performance. Oculus Rift DK2 provides a low-persistence OLED display, “a 100-degree field of view, stereoscopic 3D viewing, and low-latency six-degree-of-freedom head tracking” (Avila & Bailey, 2014, p. 103).

The input devices in 3D interaction design are the physical tools used to implement various interaction techniques (Foley & Wallace, 1974). In order to make communication with the application natural and efficient, choosing an appropriate set of input devices is crucial. In this study further development of 3D interaction in VE was not included. While the user is
wearing the HMD he or she can see different perspectives of a chromosome in the virtual space by moving his or her head and can navigate the virtual space by using up/down/left/right keys on the keyboard to move body positions forward/backward/left/right. More importantly, users view three dimensional elements displayed in the virtual museum space with the sense of presence, and the HMD allows the user to experience spatial quality created by the three dimensional objects. In a virtual environment the user perceives multidimensional spaces where different perceptual structures are embedded. Another important consideration when choosing an input device in an immersive environment is logical mapping (Bowman et al., 2004). After the validation process VE integration with the IGATY system will need to be further developed to enhance the quality of 3D interaction. In this study the users use the same keys on the keyboard as the ones they use when viewing the images displayed on a screen.

3.3. Part 3: Validation of Educational Potentials

This section explains the research methodology used in Part 3 of the study to answer General Question No. 3: Validation of the educational potentials of the proposed archetype-based generative abstraction system in design education. Mixed methods were selected for this study to examine processes and experiences along with outcomes (Clark, 2010). In order to answer the question whether the proposed IGATY-beta system is useful to enhance students’ creative museum exhibit design, a quasi-experiment was conducted. In order to understand participants’ behavior and attitude toward the typological approach to design education and the IGATY system, survey questionnaires were distributed to the participants. To explain the mechanism behind the survey results (Clark, 2010), mini focus groups were also included in this study.
An extensive usability test was not included in this study because the primary focus of this study is to examine the fundamental potential of the IGA mechanisms applied to an archetype-based generative abstraction system and not to test the usability of the interface. This study focuses on students’ conceptual understanding of the flexible structure of archetypes and the potential of using the IGATY-beta system in the ideation process. The result of this study will provide insight for future development of the IGATY system: an extensive usability study will be necessary once the results demonstrate the usefulness of the system.

3.3.1. Quasi-Experimental Design

The fundamental goal of this research is to develop a tool for students to use that will help them understand an archetype as a conceptual schema and a starting point of the ideation process, and to recognize its transformative quality. In order to anticipate whether the archetype-based generative abstraction system designed for this study enhances students’ understanding of archetypes as flexible structure and actually improves creativity in an ideation process, a quasi-experiment was conducted. In a quasi-experiment the study involves multiple groups but the participants are not randomly assigned to different conditions (Lazar, Feng, & Hochheiser, 2010). In an effort to create groups with a similar creativity level the participants were distributed based on their creativity score from Workshop 1 (see Figure III-10). If a participant answered yes to the question that asks if they get motion sickness, the participant was not included in the group expected to wear HMD.

Two workshops were designed to measure creativity before and after the treatment (Figure III-10). For the treatment between-group design was applied to avoid the learning effect and for better control of confounding factors such as fatigue (Lazar et al., 2010).
Independent Variables (IVs): Three different archetype-based activities


IV2. IGATY-beta displayed on a 2D screen: The archetype-based exercise using the IGATY-beta system displayed on a 2D screen

IV3. IGATY-beta plus experience in VE: The archetype-based exercise using the IGATY-beta system displayed on a 2D screen with 7 min. of virtual reality experience

Dependent Variables (DVs):

DV1. Creativity in exhibition ideation workshops

DV2. Creative confidence and creative performance during the ideation process

DV3. Synthetic thinking (the quality of combination process)

DV4. Understanding of the malleable structure of archetypes and typological thinking
Figure III-10. Two-day Workshop Experiment Schedule

Five trained research assistants and the researcher led the workshop and observed if there was any misconduct such as copying ideas from other participants.

Ideation Workshops

Two ideation workshops were designed to measure creativity improvement in the design ideation processes, and the workshop contents and procedures were introduced to the participants before and after the treatments. To make the design problem more realistic to the participants, an exhibition scenario with a living artist was introduced. For the ideation workshop eight pieces of artworks by David Barnett, the New York based contemporary artist, were selected. His artworks include mixed-media collages and small-scale sculptures: “The printed page in its abstract form, ink and textures manipulated, edges distorted, transparencies exploited, these are my pen and
pencil” (2015, para. 2). David Barnett gave his permission to use digital images of his works during the workshop and allowed participants to deconstruct, manipulate, reconstruct, or reproduce his artworks freely based on participants’ curatorial intentions. Two two-dimensional collage pieces (Figure III-11) under the theme of “The battle between society and automation for man’s soul” (2015, para 3) and two three-dimensional sculptures (Figure III-12) under the theme of “our current state of visual overload” (2015, para 4) were introduced in Workshop 1, and the other two two-dimensional collage pieces (Figure III-13) and two three-dimensional sculptures (Figure III-14) under the same themes were introduced in Workshop 2.

*Figure III-11. Collages by David Barnett: Used for Workshop 1
Left: Mechanical Garden, 2009, Mixed Media, 15.25 in x 15 in x 5 in (Photo credit: David Barnett)
Right: Fish Sticks, 2001, Mixed Media, 22.5 in x 28.5 in (Photo credit: David Barnett)
*Reprinted with permission of the artist.
Figure III-12. Sculptures by David Barnett: Used for Workshop 1
Left: Toy Story, 2004, Mixed Media, 27.5 in x 16 in x 16 in (Photo credit: David Barnett)
Right: Reunion #1, 2003, Mixed Media, 10 in x 13 in x 9 in (Photo credit: David Barnett)
*Reprinted with permission of the artist.

Figure III-13. Collages by David Barnett: Used for Workshop 2
Up: Hasburg Steeplechase, 2012, Mixed Media, 43.5 in x 23 in (Photo credit: David Barnett)
Down: Crecy and Agincourt, 2010, Mixed Media, 21.75 in x 28 in (Photo credit: David Barnett)
*Reprinted with permission of the artist.
David Barnett’s artworks were suitable to be used for this research because the idea of variation, combination, and transformation as the major conceptual framework of this research resonates with his idea of collage as a juxtaposition of objects that lead to an aesthetic vision. In his Statement and Descriptions provided for this study, Barnett (2015) stated, “Whether it’s a rusted pieces of metal, branches from an oak tree, or a torn scrap of typography, the right juxtaposition can always find its way into one of my constructions – the more absurd, the better. The end result happens when these various found or created elements come together to form a believable vision” (para. 1). His artistic endeavor and attempt to explore the multi-dimensionality of visual communication also resonates with the research direction that focuses on the synthetic-thinking approach to design. Barnett stated, “the two-dimensional surface seems at times limiting . . . Using found objects coupled with original structural surfaces . . . I found my artistic palette could be unlimited” (para. 2). For each workshop, two collage pieces from his recurring theme “One: the battle between society and automation for man’s soul” series and two sculpture pieces from his recurring theme “Two: visual overload” series were chosen. Barnett’s
two minute introduction video was included as part of the project introduction. In the video he explains his background and shows boxes of materials he normally uses for his artworks as well as his studio space. For the research process information about the artist and examples of the artist’s collage and sculpture were provided in color and printed on 11”x17” paper.

The workshop scenario designed for this study was as follows:

DESIGN PROBLEM: You are invited to redesign a 12’x12’ museum gallery space in a large open museum space at Dia Beacon, New York, NY. A museum curator came up with the white cube space to display David Barnett’s four artworks. The museum director stated, “The proposal does not effectively tell the story. The intention of this exhibit is to convey the artist’s imagination. Let’s invite a designer and give freedom to utilize the whole 12’ X 12’ space and enhance the detailed aspects of David Barnett’s artistic imagination. The design should enrich the multisensory exhibition experience.” You are hired to redesign the space for this mission. The designer’s artistic reproduction, manipulation, and transformation of the selected artworks are permitted for this exhibition; therefore, you have options to display (or not to display) the original artwork as part of your exhibit design.

A total of 90 minutes was given for the first workshop: 10 minutes for research about the artist and 80 minutes for the ideation workshop. For the 10-minute research section participants were asked to use the information sheet provided for the experiment. Using the Internet or any other materials were not allowed. For Workshop 2 a total of 80 minutes was used in the main quasi-experiment instead of 90 minutes because we observed during the pilot study that students finished all the processes earlier than expected in Workshop 2.

To examine the ideation processes and their relationship with creativity in the final design, participants were asked to follow five steps ((Figure III-15): 1) Initial brainstorming; 2) Variation; 3) Combination; 4) Transformation; 5) Final design. In step 1 participants were encouraged to sketch or annotate their initial brainstorming ideas for the project. In step 2, the Variation stage, participants were asked to generate various ideas and fill blank square boxes with rough thumbnail sketches of their ideas. Twenty-one blank square boxes were drawn on an
11”x17” paper (Appendix D), and extra sheets were available for participants to use. In step 3, the Combination stage, participants again received an 11”x17” sheet containing the same format with twenty-one blank square boxes, and participants were asked to combine two or more different ideas from their sketches and ideas in the variation process to create something different. Extra sheets of paper were available for participants to use if needed. In step 4, the Transformation stage, participants were asked to transform part of their previous ideas by changing medium, materials, dimension, angles, and the like to enhance their design. Extra sheets of paper were available for participants to use if needed. The requirements for the final design included one perspective sketch and one simplified floor layout as well as design concept descriptions. Each participant was allowed to use a pencil, a mechanical pencil with an eraser, a black pen, and 24 colored pencils.

Figure III-15. The ideation process designed for the workshop: research, initial brainstorming, variation, combination, transformation, and final design.

*Museum Archetypes Lecture and Pattern Recognition Exercise*

On the second day of the ideation workshop, a short lecture about the museum archetypes was given to all of the participants, followed by a pattern recognition exercise. The duration of
the lecture was about 20 minutes. The lecture content included a brief introduction to archetypes: definition, purpose, and examples. The lecture prepared participants for the pattern recognition exercise which consisted of identifying shared core principles and parameters. For the pattern recognition exercise 30 selected images in a random order based on six archetypes (Grid, Wunderkammer, Spatial Drama, Poetic Light, Scalar, and Vitrine) were given to participants and they were asked to recognize shared common traits among a certain group. Participants collected images of up to five that have shared characteristics to form a few potential archetypes. They were reminded that each group should have unique common principles that make the group distinct from other groups and asked to write the principles they devised. Participants were then encouraged to recognize and write parameters that caused each example to be different from each other (see Appendix C).

Treatment

After the archetypes lecture and the pattern recognition exercise each group was guided to a designated room for different treatments. Group M, the manual exercise group, used studio room A for the designed treatment. The selected six archetypes with descriptions printed in color with manual exercise instructions were distributed to participants in this group. The participants were asked to explore and sketch variations, combinations, and transformations of the six archetypes. Each participant was allowed to use a pencil, a mechanical pencil with an eraser, a black pen, and 24 colored pencils. A research assistant assisted the group to give guidelines of the manual exercise and answer questions. Group IGATY-S, the IGATY-displayed-on-screen user group, used the computer lab D for the designed treatment. Group IGATY-VE, the IGATY-displayed-on-screen-with-HMD user group, used the computer lab E. Both Group IGATY-S and IGATY-VE used the software developed for this research. All participants were introduced to the
same six archetypes: The same descriptions and the same representative images were used for all three groups. For the groups IGATY-S and VE a 7-minute training synopsis was included for the participants to familiarize themselves with the IGATY software program. Using the software, participants were asked to explore the six archetypes and generate variations, combinations, and transformations. Two trained research assistants participated in the training sessions. During the 30-minute exercise, the VE group participants were asked to use the HMD for 7 minutes each to experience and see their design via the head mounted display. The instruction of the activities for the three groups was fundamentally the same: the exploration was based on the six selected archetypes and an ideation exercise using variation, combination, and transformation.

3.3.2. Consensual Assessment Technique (CAT)

Amabile’s (1982, 1996) Consensual Assessment Technique (CAT) relies mainly on the independent subjective judgments of individuals familiar with the domain in which the products were made. According to Starko (2014) the Consensual Assessment Technique is “one of the most well-documented and frequently used measures in current creativity research” (p. 337). Based on the guideline Landis & Koch (1977) provided, inter-rater correlation coefficients can be interpreted as the following: “A correlation coefficient of .00 to .20 represents slight agreement; a coefficient of .21 to .40 represents fair agreement; a coefficient of .41 to .60 represents moderate agreement; a coefficient of .61 to .80 represents substantial agreement; and a coefficient higher than .81 is considered almost perfect” (Baer, Kaufman, & Gentile, 2004, p. 116). Interpretation of inter-rater reliability should be based on the research purpose: In creativity research, correlation coefficients between .70 and .80 are typically accepted as a strong agreement among raters (Amabile, 1996).
This research follows the following guidelines proposed by Amabile (1982, p. 1002).

1. Use judges who have some experience with the domain.
2. Have judges make their assessment independently.
3. Have judges make assessments on other dimensions such as technical goodness as well as the creativity cluster.
4. Rate products relative to one another on the dimensions in question.
5. Have each judge rate products in different random order.

A total of six experts participated in the CAT assessment in this study: two experts in the pilot study and four experts in the main quasi-experiment. The evaluators were unaware of the goals of the study. Based on the CAT measurement criteria proposed by Amabile (1982), a few other items were added to make it more appropriate to measure museum display aesthetics of ideation workshop products. The following criteria was used as a creativity cluster: (1) creativity, (2) novel ideas, (3) variations in shapes, (4) complexity, (5) creative use of materials, (6) creative use of colors, (7) multi-sensory design ideas, (8) details, and (9) effort. Other dimensions such as technical goodness and aesthetic appeal were included in the judging criteria; however, only the nine creativity components in the creativity cluster as defined by Amabile were separated from the other dimensions and used for the subjective judgment of creativity.

In order to examine the correlations between the work quality of each stage of the ideation process (variation, combination, and transformation) and creativity of the final design, the judges also rated the quality of each ideation process (Appendix K).
3.3.3. Survey Questionnaires

Survey questionnaires were distributed to the participants to answer the three subquestions under the general research question No. 3 Validation of the proposed generative abstraction system in design education: 1) whether the IGATY-beta system helps students understand the malleable structure of archetypes and their potential for invention; 2) if the IGATY-beta system improves creative confidence; 3) if the IGATY-beta system changes self-evaluation of their performance of creative ideation. The researcher and five other trained assistants verbally explained the overall purpose of the study for which the data is required. The survey questionnaires were distributed before the ideation workshop 1 on day 1, before the introduction to archetypes and treatments, after the treatment, and after the ideation workshop 2 on day 2. Different sections were included at different times to examine the change before and after the treatment (*Table III-2*). The survey questions include general demographic questions and academic year in the program, questions about students' understanding of archetypes and typological thinking, learning experience of archetypes exercises-(manual sketching, IGATY with 2D display, and IGATY with VE experience); attitude towards ideation workshops asking creative confidence, and self-evaluation of ideation workshop. To get a better understanding of their experience of the workshops and activities, a few open-ended questions with specific details were added.
Table III-2. Survey sections and distribution plan

<table>
<thead>
<tr>
<th>Survey Sections</th>
<th>Survey Contents</th>
<th>Survey ONE: Before Workshop 1</th>
<th>Survey TWO: After Workshop 1</th>
<th>Survey THREE: Before Workshop 2 (After Treatments)</th>
<th>Survey FOUR: After Workshop 2</th>
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<td>Understanding of archetypes and typological thinking</td>
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<td>Section C</td>
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<tr>
<td>Section D</td>
<td>Learning experience of archetypes</td>
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<tr>
<td>Section E</td>
<td>Attitude towards ideation workshop</td>
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<td>-</td>
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<td>Section F</td>
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<td>Section G</td>
<td>Self evaluation of ideation workshop</td>
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3.3.4. 10 min. Mini-Focus Groups

The researcher and the five trained assistants met with the three groups after the experiment. The focus groups of several individuals provide the possibility of a broad range of viewpoints and insights (Lazar et al., 2010). Lazar, Feng, and Hochheiser encourage researchers to have limited doses of disagreement and to debate in highly dynamic discussions because these disputes may lead the researcher to new perspectives or new areas for further study (pp. 192-193). Each focus group was structured with prepared open-ended questionnaires and took place on the same day for about 10 min. per group. The researcher and the four trained assistants took notes, and the discussion was recorded.

3.3.5. Data Analysis

For this study a mixed method was conducted where both quantitative data analysis as well as qualitative data analysis were required. In analyzing the quantitative data from the CAT assessments and the survey questionnaires, a SPSS statistical package was used. Cronbach’s Alpha was calculated to measure reliability of the CAT criteria. The mean number of each group in the nine areas of creativity cluster in CAT criteria was compared. To measure correlation
between the quality of process work and creativity of the final design, 2 tailed Pearson Correlation method was used in SPSS. Intraclass Correlation Coefficient (ICC) method was used to measure interrater reliability among the judges.

From the research assistants field notes (Polit & Hungler, 1987) were collected as a reference. The field notes included personal notes that contain the researcher’s “own feelings during the research process” and theoretical notes as “interpretative attempts to attach meaning to observations” (pp. 272-273). In order to translate the contents of the notes from the research assistants, I met with them two times after the experiment to ask questions and discuss their informal observations.

Although brief, the mini focus groups were informative and useful in working towards a general, holistic understanding, and finding common structures and themes (Lazar, Feng, and Hochheiser, 2010); in addition, the mini-focus groups provided a better understanding of the participants’ perceptions and attitudes towards the concept of archetypes and their experience with the quasi-experiment. Coding, the examination of frequency of terms and co-occurrences, were used for the analysis of the qualitative data gathered in this study. Codes are used to “retrieve and categorize similar data chunks so the researcher can quickly find, pull out, and cluster the segments relating to a particular research question, hypothesis, construct, or theme” (Miles, Huberman, & Saldaña, 2013, p. 72).

3.3.6. Validity Enhancement Methods

Validity refers to whether the findings of a study “accurately reflect the situation” and “research findings are supported by the evidence” (Guion, Diehl, & McDonald, 2011, p. 1). To establish the validity of this research, triangulation was used. According to Thurmond (2001),
triangulation increases “confidence in research data, creating innovative ways of understanding a phenomenon, revealing unique findings, challenging or integrating theories, and providing a clearer understanding of the problem” (p. 254).

For this research, methodological triangulation, investigator triangulation, and theory triangulation methods were used. Both quantitative and qualitative data were carefully used in this study along with the results from the focus groups. The use of several researchers and evaluators is crucial in investigator triangulation. The CAT evaluation team for the main quasi-experiment consisted of four design educators as experts. Five trained research assistants conducted focus groups and informal observations. The findings from each evaluator and investigator were gathered and compared to develop broader and deeper understanding of the phenomena. To interpret the data from different perspectives I met with professionals from various disciplines and shared the findings to gain further insight through their interpretations of the data. I also used multiple theoretical perspectives such as the phenomenological understanding of the display of art, creativity-related theories, and the synthetic thinking theory to interpret data. According to Patton (2002) the goal of triangulation is not just “to arrive at inconsistencies across data sources or approaches” (as cited in Guion et al., 2011). In Patton’s view, inconsistencies found in data triangulation should be considered as an opportunity to reveal different aspects or deeper meaning in the data.
CHAPTER IV. RESULTS AND ANALYSIS

The results and analyses of the three parts of this study are presented in this chapter. Based on the three initial questions, the results are organized into the following three sections: (a) Part 1: Identification: Redefine the malleable structure of archetypes; (b) Part 2: Application: Application of IGAs to the dual structure of archetypes; (c) Part 3: Validation: Validation of the educational potential of the proposed archetype-based generative abstraction system in design education. In Part 1 I define the core signals and peripherals based on the extensive qualitative content analysis and case studies of the six selected archetypes: Grid, Wunderkammer, Spatial Drama, Scalar, Poetic Light, and Vitrine. In Part 2 the core signals and peripherals defined in Part 1 were used to map them into the proposed IGATY system. Part 2 gives an overview of the proposed IGATY system which includes the following: IGATY system functions; generation of initial population and multiple offspring; mutation and crossover function within each archetype; coevolution function among different archetypes; user interaction with the system; integration with Oculus Rift DK2; and others. Part 3 presents the results from the quasi-experiment conducted as a validation of educational potentials of the proposed system.

4.1. Part 1: The Dual Structure of Museum Interior Archetypes

In the first part of the research I examined the possibility of understanding archetypes based on the principles of biology. In order to answer the question, six museum archetypes were selected as a test set. I used the content survey of the two selected professional magazines (architectural record and interior design) as well as secondary sources and case studies methods to trace the evolution of each archetype: The first main focus of the investigation was to determine the existence of a core principle in each archetype that remains constant, regardless of
the course of change in the peripheral characteristics of the archetype. The second main focus was the search for the constituents of peripherals that cause divergent appearances of the archetype. I concentrated not only on the factors found in the precedent examples but also on the possibilities that were implied indirectly in some of the recent applications. Taking the form of qualitative research it is less important to list all the examples found from the content survey and secondary resources. The listed examples in this research are prime objects (Kubler 1962; Jennings, 2007) that have unique traits that convey significant variations in evolution of each archetype: Examples were grouped under sub-categories to depict the long-range evolution of each type in the linked sequence. Following the conceptual framework Kubler (1962) suggested in *The Shape of Time*, I used the term linked solutions or linked sequence to refer to the continuity and variety in the evolution of each type.

4.1.1. Understanding Archetypes Based on Principles of Biology: Core Signals and Peripherals in Museum Interior Archetypes

The conceptual framework of this research derived from Kubler’s (1962) idea of signal and mutants as well as Hillier & Leaman’s (1974) attempt to explain design based on genotype and phenotype. The existing literature has shown that both Kubler and Hiller & Leaman’s arguments appear not to be clear enough to explain the core structure of archetypes because both assume that the set of rules or principles (signal or genotype) change. The core signal in this research is defined as a set of descriptors that delineates the unique shared characteristics within an archetype. The idea of a core signal is similar to the biological term *genotype*, “the descriptor of [a] genome which is the set of physical DNA molecules inherited from the organism’s parents”
(Lewontin, 2011, para. 2). It is an abstract premise or scheme that prescribes the outlook of the type but does not appear as a physical image yet.

The goal of Part 1 in this research is to determine the existence of the unchanging descriptor (a core signal) and another set of dynamic parameters (peripherals) within an archetype. For this, multiple examples of each archetype were collected for analysis. The possible set of rules was described, modified, and refined to make the descriptor general enough to cover all the examples in each group. Then, another set of descriptors was developed based on the varying quality of appearances found in a variety of examples in each archetype. As hypothesized, the core signal was found in each archetype, and this general rule does not change throughout the course of evolution in linked solutions regardless of dynamic change in peripherals. From the content analysis, extensive parameters were found that cause various dynamic expressions that respond to contextual settings, such as cultural, social, political, or philosophical ground or personal aesthetic preferences.

4.1.2. Evolution in Linked Solutions

Jennings (2007), the founder of Intypes Research and Teaching Project, interprets Kubler’s approach in linked solutions as “a sequence of design reiterations by architects and designers” (p. 51) that can be traced through time. The first stage of solidifying each archetype can be presented as a sequence of possible “prime objects” (Kubler, 1962, p. 35) and reiterations as “mutants” (Kubler, 1962, p. 36). In each example of archetypes exists the core signal, the general principle that construes the specific type. However, as Brill (1994) argues, its appearance and physical forms in time need cultural manifestation to make them visible. From the content analysis, various forms, schemes, modes, styles, and articulations were found throughout time
from the original form to contemporary examples. The following section discusses the core signals and peripherals found in the content survey. **Definition** describes the overall principal characteristics of each type, such as its unique organizational or methodological aspects that create the aesthetic quality of the particular display system. Definition includes the experiential quality that each archetype generates following Thiis-Evensen’s (1987) definition of archetypes. The core signal is a general core principle applied to each archetype. As Rossi (1966/1982) argues, dynamic forces are acting on each archetype, making them dynamically evolve and transform in time and context. The evolution in the linked sequence discusses how each type has developed, evolved, and transformed without losing the essential attributes of the core signal. These different modalities found in the linked sequence were used to define peripherals in each archetype. A representative image was created to communicate the core signal in each archetype.

### 4.1.3. Archetype 1: Grid

A Grid is one of the most effective display aesthetics used in exhibit design to enhance the quality of three-dimensional spatial experience. A Grid is a systematic organizational scheme based on two sets of perpendicular axial lines. A Grid system inherently conveys equality, uniformity, and continuity due to its orderly pattern created by its arrangement structure. With three-dimensional objects placed in a Grid organization, each intersection point adds height value to the space and creates subdivided three-dimensional sets of repetitive, modular units of spaces. Objects may be displayed on a floor keeping two perpendicular axes and making them perceivable or may be raised from the floor with a suspension system blurring the edges and points originally created by a Grid system.
Definition of Grid

A Grid is a systematic arrangement in rows and columns or in three-dimensional intersections at right angles. In a Grid arrangement, uniformity of individual objects in the entire collection is emphasized. Its repetitive nature forms multiple sets of invisible membranes that create layered effects.

Core Signal in Grid

The core signal in Grid can be defined as an array in 2D or in 3D that creates multiple intersections.

Evolution in Liked Solutions of Grid

A Grid system has been immensely favored by curators and artists for displaying multiple objects of equal importance. Because of its embedded characteristics of equality and collective nature, a Grid system is often used as a display method to organize multiple similar artifacts with slight variations (e.g. Barbara Westermann, *Westwall Crossing the Siegfried Line*, 1989; Memorial to the Murdered Jews of Europe by Peter Eisenman, Berlin, 2004). In a Grid, understanding the entire collection as a whole is more meaningful than perceiving individual pieces as unique distinct artifacts. Vitrines or other cases can be placed in a Grid arrangement (e.g. Museum of Glass and Ceramics, 1981, Teheran, Iran; Gilt-bronze statue exhibit at The Gallery of the Horyuji Treasures, 2002): In this case, Vitrines or other cases themselves are perceived as pieces of art until a viewer finds the actual pieces of objects inside the cases. When combined with the Vitrine archetype, the aesthetic quality of Vitrine or cases in a Grid arrangement plays a significant role in the appreciation of art. For instance, in the installation *Tourisms: Suitcase Studies* in 1991, the architects Elizabeth Diller and Ricardo Scofidio arranged
fifty identical Samsonite suitcases—five across by ten deep—in the gallery space (*Figure IV-1*). All the suitcases are open and hung from the fabricated ceiling plane emphasizing the perspective view throughout the gallery space. Each suitcase was used as a case study of a tourist attraction in the fifty states in America (Diller & Scofidio, 1991). The objects, although in plan view arranged based on a two-dimensional array, still encourage viewers to gradually discover multiple layers of an invisible membrane created by the suspended subjects. Because a Grid system is associated with uniformity in nature, curators and artists typically choose a Grid system when displaying a thematic quality of an entire collection of similar objects.

*Figure IV-1. Tourisms: Suitcase Studies* by Diller & Scofidio, Walker Art Center, Minneapolis, 1991 (Photograph retrieved from ARTstor digital library, Contemporary Art, Larry Qualls Archive).

Although a Grid system is a universal design principle, it can appear in context in various ways that express artists’ cultural or philosophical approaches. For example, in Kyunghwan Won’s exhibit titled *earth* at the Rodin Gallery in 2001 in Seoul, the material and visual effect he achieved with clay represented the philosophical and cultural background of the five-elements theory in Asian culture. This strongly supports Brill’s (1994) argument that type, as generic forms, needs a cultural manifestation to make them visible in form.

A Grid system can be developed further into a three dimensional matrix along with three perpendicular axes based on an x, y, and z coordinate system. Ching (2010), in *Architecture*
*Form, Space, and Order*, describes the transformation and adaptation of a Grid system. A Grid can add multiple layers to two-dimensional arrays on top of each other. A part of a Grid can grow and expand to form something else in certain directions. Portions of the Grid can be interrupted, rotated, and transformed to alter the visual and spatial continuity across its field (p. 220). The part altered due to transformation can draw attention from viewers as the modified part works as an accent among other regular objects (Ching, 2010).

Grids became more dynamic and multi-dimensional in contemporary exhibition and museum spaces. A recent installation by Bekkering Adams Architecten at the Architecture Biennale in 2014 Venice, Italy, titled “Fundamentals: Form-Contraform” at Palazzo Mora, demonstrates how the Grid archetype can evolve into yet another innovative display aesthetic that enriches the viewer’s imagination and multi-sensory experience. Under the theme of creating spatial experience shaped not only by the physical but also beyond physical definition, the designer used a three-dimensional Grid system to fill a 2.4 by 2.4 meter cube with sphere-shaped objects. It is meaningful to notice that the Grid system was combined with two other museum archetypes, Meandering Path (Suh, 2004) and Poetic Light. The overall Grid mass was sculpted based on the designer’s idea of contraform in a cube, form, and space creating a path inside the three-dimensional Grid. With the reflective surface on the floor, numerous spherical objects are multiplied, creating the perception of infinity. Projected colored light as Poetic Light also enhances the quality of the multi-dimensional spatial experience. Another recent inspirational installation that highlights the future of Grid in museum display aesthetics is the 2008 kinetic installation by the interactive media company ART+COM at the BMW museum in Munich, Germany. One of the unique features of this display was how the 714 metal balls
arranged in a two-dimensional Grid system and suspended from the ceiling dynamically move up and down to convey the idea of the form-finding process in car design (ART+COM, 2008).

Table IV-1. Grid: definition, a core signal, and peripherals

<table>
<thead>
<tr>
<th>Archetype 1</th>
<th>Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>A Grid is a systematic arrangement in rows and columns or in three-dimensional intersections at right angles. In a Grid arrangement, uniformity of individual objects in the entire collection is emphasized. Its repetitive nature forms multiple sets of invisible membranes that create layered effects.</td>
</tr>
<tr>
<td><strong>Core signal</strong></td>
<td>An array in 2d or 3d that creates multiple intersections</td>
</tr>
<tr>
<td><strong>Peripheral</strong></td>
<td>Coordinate axes x, y, z</td>
</tr>
<tr>
<td></td>
<td>Number of objects</td>
</tr>
<tr>
<td></td>
<td>Properties of objects: shape size, color, material, etc.</td>
</tr>
<tr>
<td></td>
<td>Position: wall, floor, ceiling, in space</td>
</tr>
<tr>
<td></td>
<td>Constancy: consistent vs. various</td>
</tr>
<tr>
<td></td>
<td>Movement</td>
</tr>
</tbody>
</table>

Possible Mutation

Figure IV-2. Grid mutation 1: Two-dimensional array

Figure IV-3. Grid mutation 2: Three-dimensional array, consistent
Figure IV-4. Grid mutation 3: Three dimensional array, various

Possible Coevolution

Combined with Spatial Drama

Combined with Vitrine

Combined with Grid

Combined with Poetic Light

Combined with Scalar

Linked Sequence

**Grid with Vitrine:** Multiple freestanding glass display cases or Vitrines are arranged in a Grid organization. Usually one object is displayed in each Vitrine. Objects and the containers together as a whole are seen as works of art.

- Vitrine arrangement at The Renwick Gallery, Washington, D.C., USA, 1972
- Museum of Glass and Ceramics, Teheran, Iran, 1981
- The Gallery of Horuji Treasures, Tokyo National Museum, Tokyo, Japan, 2002

**Two-Dimensional Grid:** Multiple objects are arranged in an x and y coordinate system. Objects are perceived as a single collection of multiple objects situated in context. In some cases, artists emphasize the three-dimensional quality of objects by suspending them from ceilings or by
utilizing the z-axis. Various materials and technologies including video screen and lighting have often been used to enhance the multi-dimensional quality of exhibit.

- *Redwood sculpture Shiloh* by Carl Andre, at Paula Cooper, New York, NY, 1980
- *Westwall crossing the Siegfried Line* installation by Barbara Westermann, La Jolla Museum of Contemporary Art, San Diego, CA, 1989
- *Earth, Impressions in clay* by Kyungwhan Won, Rodin Gallery Glass Pavilion, Seoul, Korea, 2001
- *The Designing Eye: Reviewing the Slow House* by Diller & Scifidio, Gallery Ma, Tokyo, 1992
- *Suspended Forest* by Fabrizio Plessi, Scuderie del Quirinale, Rome, Italy, 2002

**Three-Dimensional Grid**: Multiple objects are arranged in an x, y, and z coordinate system. Projected light or kinetic technology is often incorporated.

- Kinetic installation by ART+COM at BMW museum, Munich, Germany, 2008.
- *Chrystal Matrix* by Erwin Redl, Computer-controlled LED and sound Installation, Swarovski, Innsbruck, Austria, 2011.
4.1.4. Archetype 2: Wunderkammer

One of the most prominent museum display aesthetic methods is to create a cluster of multiple objects in a random order, at times at a large scale. The name Wunderkammer in German means “cabinet of curiosities”: The word cabinet refers to a small chamber or a room that was used to display a collection of numerous objects, possibly because of the original idea that “the entire cosmos could be controlled within the confines of a private room” (Putnam, 2001, p. 10). Regardless of the types of objects or number of objects, this dominant display aesthetics concept evokes wonder and creative imagination because of its special quality of “capricious freedom of arrangement” and “its bizarre sense of accumulation and juxtaposition” (Putnam, 2001).

Definition of Wunderkammer

Wunderkammer is an installation aesthetic in which a multitude of diverse, collected objects are arranged in categorized, taxonomic or random-order displays on walls, floors, ceiling planes, in a cabinet, or three-dimensionally in space. Due to its unique capricious irregular arrangement method, Wunderkammer evokes visual wonder and creative imagination.

Core Signal in Wunderkammer

The core signal in Wunderkammer can be defined as a cluster, group, or assemblage of a multitude of randomly arranged objects.

Evolution in Liked Solutions of Wunderkammer

Wunderkammer appeared in Europe starting in the late sixteenth century. The first example found in a content survey was an illustration of the Wunderkammer of Ferrante Imperate in 1599
Naples (Figure IV-5). According to Putnam (2001) usually rare, precious, or sometimes bizarre objects were collected and displayed on walls and ceilings in a room “to arouse wonder in the mind of the viewer and to provide aesthetic pleasure” (p. 10). Another historic example of Wunderkammer can be found in Sir John Soane’s Museum in 1833 London. In the rotunda, the architect Soane (1753–1837) filled the space from the floor to the ceiling with various sculptures and architectural fragments, such as pieces of frieze, dentils, corbels, etc., from classical buildings. Because of the density and the arrangement of the displayed objects in space, viewers perceived the whole collection as one entire art form rather than focusing on individual pieces.

Figure IV-5. Engraving from Ferrante Imperato’s Dell’Historia Naturale, Naples, 1599 (Image retrieved from public domain, http://commons.wikimedia.org/wiki/File:RitrattoMuseoFerranteImperato.jpg).

Wunderkammer as a form of historic display aesthetics surfaced again in much of the art of Dadaism, Surrealism, and the Post-Modern Avant-Garde in the late 1960s and 1970s, perhaps because of the Wunderkammer’s inherent characteristics of imagery created by unexpected juxtapositions of unusual objects that correspond with the Surrealist and Dadaist ideology of the rejection of logic and the embracing of intuition and irrationality. One of the most meaningful characteristics found from the 1960s to the 1970s of Wunderkammer is that artists used the Wunderkammer archetype on a small scale and showed artifacts in the small compartments or drawers of a cabinet. Putnam (2001) asserted that Fluxus artists, who favored blending various
artistic media in their work, appropriated Marcel Duchamp’s Boîte-en-Valise (Portable Museum, 1941) for their numerous Fluxkit editions (p. 19). George Maciunas assembled the Fluxcabinet, a wooden cabinet with twenty drawers, and organized objects by fourteen Fluxus artists (p. 19) in it. This practice can be understood as an attempt to redefine the boundary of the collector’s cosmos.

The Wunderkammer principle has been repeatedly used in contemporary museums. The British sculptor Antony Gormley filled a gallery with 40,000 terracotta figures at the Kunsthalle Kiel der Christian-Albrechts Universität in Kiel, Germany in 1993. This type of installation entitled Field was repeated from 1989 through 2003 and installed in several other museums in Germany and China (Gormley, n.d.). He might have chosen the floor to display his artworks to establish a direct relationship between the media–clay–with the earth. In Field the individual terracotta sculpture does not draw the viewer’s attention. Instead, the group of myriad clay dolls arouses curiosity and wonder. A similar display method could be identified in Allan McCollum’s installation entitled Lost Objects at the Carnegie Museum of Art, Pittsburgh, 1991. Putnam (2001) states that the work by McCollum denotes “the taxonomical system of classification and the use of copies and replicas in museum displays to represent an absent or ‘lost’ specimen” (p. 55). The entire collection of fake bones as one massive body of art spurs viewers to question the intrinsic value of the appropriation of dinosaur fossils and the historic meaning associated with them. In a contemporary Wunderkammer, the authenticity of each object is not important. Instead, a tendency exists among artists to collect and display trivial items (e.g. the installation at the Massimo Valsecchi Gallery, Milan, Italy, 1981; Making Things by Issey Miyake, 1998–99; The Physical Self by Peter Greenaway, 1991; Attempt at a Fundamental New Assessment of the Surface by Wolfgang Stiller, 1994–99, etc.), in order to focus more on their collective effect and
attributes that density creates. Because of the indirect message that underlies the whole group, the approximate number of objects used for the display is meaningful when displayed with the Wunderkammer display principle.

Hasian (2004) argues that rhetorical functions are involved in displaying trivial items from everyday life in a museum setting because these objects “remind us of the everyday lives of humans who must have had their own dreams and desires” (p. 79). For instance, in the Tower of Faces at the United Holocaust Memorial Museum in Washington DC, thousands of pictures of individuals who died in a single day in 1941 in a small Polish town called Ejszyzki cover the walls, reminding viewers of the everyday lives they had enjoyed before the town was destroyed by the German Einsatzgruppen (Fierst, 1996). The Tower of Faces serves as a type of “wall text” (Franagan, 2000, p. 100) that, instead of describing facts literally resonates indescribable emotional feelings toward innocent victims of the Holocaust. In memorials the authenticity of objects in the Wunderkammer display may or may not be important depending on curatorial themes and approaches: whether the display is for fostering connections with historical events and keeping the memory alive or for delivering genuine information in history. In the Jewish Museum in Berlin designed by Daniel Libeskind, the objects of Menashe Kadishman’s installation titled Shalekhet (Fallen Leaves) in the Memory Void are used as a metaphor; therefore, authenticity is not applicable in this exhibition. Numerous open-mouthed faces made of heavy iron plates cover the floor of the Voids as “an architectural expression of the irretrievable loss of the Jews murdered in Europe” and evoke painful recollections of the innocent victims (Jewish Museum Berlin, 2014).
Instead of focusing on delivering specific scientific or archeological information about individual pieces, Wunderkammer emphasizes the collection itself. As an assemblage of a multitude of objects, Wunderkammer creates visual wonder; therefore viewers do not go through individual objects one by one but instead perceive the entire group as one universe in which they immerse themselves. The intended goal of Wunderkammer is to foster “creative imagination” (Putnam, 2001, p. 8) related to the theme and the objects instead of delivering scientific knowledge. It is also important to understand the museum effect Wunderkammer creates. When objects are displayed as a collective whole, even trivial objects can draw attention from viewers and provoke subconscious emotions that the individual item can hardly express.

One important aspect found from some recent examples of Wunderkammer cases is that they become more dynamic when combined with other display aesthetics. The three-dimensional Wunderkammer is especially blended with Memory Path, a circulation path, such as a bridge or a pathway through exhibition spaces that represents a historical timeline, period, or a memory of an event. When merged with Memory Path (The Tower of Faces, United States Holocaust Memorial Museum, 1995), the installation delays movement by extending time and multi-dimensional sensuous experience. Wunderkammer is now not only applied to simple straight walls but can be more dynamically employed in any type of spatial configuration, such as curved or angled walls or a domed ceiling. In the Hall of Names at Yad Vashem History Museum designed by Moshe Safdie in 2005, six hundred photos of individuals are arranged on the partly cone-shaped walls that reflect images in a pool inside an inverted cone (Dean, 2005).

Wunderkammer has excellent potential to be adapted to dynamic three-dimensional applications. Maurizio Cattelan’s (2013) installation at the Guggenheim titled All, can be interpreted as a three-dimensional Wunderkammer where a huge assemblage of a multitude of collected objects
are suspended at random heights from the center of the main atrium space, filling the entire museum space. A three-dimensional Wunderkammer is perceived as a gigantic sculptural piece that inspires viewers to apprehend the entire collection as a whole.

Another important development is the way the content is delivered. In some contemporary museums and memorials, display objects are often converted into digital information for interactive display. To enhance Wunderkammer’s aesthetic quality created by its random arrangements, an image projection can be programmed to shuffle the images to generate different random arrangements. In the exhibit at the World Trade Center Memorial Museum (Figure IV-6), titled Missing Posters (2015), missing person posters are randomly projected on a wall bringing back memories of the time when hundreds of families were desperately searching for the missing persons during the catastrophic disaster.

*Figure IV-6. Missing posters (Digital Projections) at World Trade Center Memorial Museum, New York, NY, 2015 (Photo Credit: Joori Suh).*
### Table IV-2. Wunderkammer: definition, a core signal, and peripherals

<table>
<thead>
<tr>
<th>Archetype 2</th>
<th>Wunderkammer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>An installation aesthetic in which a multitude of diverse, collected objects are arranged in categorized, taxonomic, or random-order displays on walls, floors, ceiling planes, in a cabinet, or three-dimensionally in space. Due to its unique capricious irregular arrangement method, Wunderkammer evokes visual wonder and creative imagination.</td>
</tr>
<tr>
<td><strong>Core signal</strong></td>
<td>A cluster, group, or assemblage of a multitude of randomly arranged objects</td>
</tr>
</tbody>
</table>
| **Peripheral** | Number of objects  
Properties of objects: size, color, material, etc.  
Grouping method: clustered, random, geometric form  
Density  
Position: wall, floor, ceiling, in space  
Constancy: consistent vs. various |

### Possible Mutations

*Figure IV-7. Wunderkammer mutation 1: On planes (wall, ceiling, floor)*

*Figure IV-8. Wunderkammer mutation 2: In space (3d Wunderkammer), clustered*
Possible Coevolution

Combined with Spatial Drama

Combined with Vitrine

Combined with Grid

Combined with Poetic Light

Combined with Scalar

Linked Sequence

Wunderkammer - A Cabinet as a Room: Objects from nature were the primary contents of the original Wunderkammer but fake natural objects or trivial everyday objects become the medium of art as Wunderkammer transforms them into a powerful display aesthetics.

- *Dell’Historia Naturale* by Ferrante Imperato, Palazzo Gravina in Naples, 1599
• *Shalechet or Shalekhet (“Fallen Leaves”)* by Menashe Kadishman, *The Memory Void*, Jewish Museum, Berlin, 2002

• The Israel Museum by James Carpenter Design Associates, Jerusalem, Israel, 2010

• *Tree of Testimony* by Randy Schoenberg and Hagey Bbelzberg, Los Angeles Museum of Holocaust, Los Angeles, CA, 2010.

**Wunderkammer- A Cabinet as a Cabinet:** Instead of displaying a few best selections, some artists tend to exhibit a complete collection in multiple compartments.

• *Raid the Icebox 1* by Andy Warhol at RISD Museum of Art, 1970

• *Museum of Drawers* by Herbert Distel, 1970-1977

• *Museum of Man* by Claudio Costa, 1974

• *Anthological Ontology* by Claudio Costa, 1994

**Three-Dimensional Wunderkammer:** Physical spatial confinement was one of the important characteristics in the original Wunderkammer. Objects were perceived within the physical boundaries of the museum space. In a three-dimensional Wunderkammer, designers can construct unique spatial configurations of walls as a background of the Wunderkammer, creating a dynamic spatial quality. In some cases designers and curators arrange objects three-dimensionally, shaping unique overall configurations or patterns without limiting themselves by spatial confinement.

• *The Hall of Names* by Moshe Safdie, Yad Vashem History Museum, Jerusalem, Israel, 2005


• *All* by Maurizio Cattelan, Solomon R. Guggenheim Museum, New York, NY, 2013

• *Gas Giant* by Jacob Hashimoto, Rhona Hoffman Gallery, Chicago, IL (2012) Fondazione Querini Stampalia, Venice, Italy (2013), MOCA Pacific Design Center, Los Angeles, CA (2014)

4.1.5. Archetype 3: Spatial Drama

Another major focus of the content survey was the frequent tendency for designers and curators to manipulate the spatial configuration for a specific theme or concept of an exhibit. The predominant museum concept of the White Cube has been challenged by artists, curators, and designers as attention in museums gradually shifted from objects to experience. Spatial Drama is often used as a curatorial means to communicate themes and ideas surpassing conventional ways of delivering knowledge via two-dimensional images and text information. Spatial Drama focuses on the emotive quality of exhibits as a whole rather than as individual objects reinforcing the relationship between the exhibit and the viewers.

**Definition of Spatial Drama**

Spatial Drama defines an exhibition space manipulated three-dimensionally according to a theme and an idea of an exhibition or a specific paradigm of an art group. It creates a dramatic quality of expressive, emotional, imaginative, and stimulating spatial experience.
Core Signal in Spatial Drama

The core signal in Spatial Drama can be defined as *vertical or horizontal elements manipulated with multiple angles or curves.*

Evolution in Liked Solutions of Spatial Drama

The earliest example of manipulated exhibition space found from the content survey is an unidentified group exhibition at Julien Levy Gallery in 1937, New York, curated by Frederick Kiesler. Quaintance (2004) states that the curving white wall of the exhibit at Julien Levy Gallery “anticipated Kiesler’s biomorphic spirit” (p. 209). This quietly undulating wall might be Kiesler’s attempt to give the impression of a dreamlike space that accompanies Rene Magritte’s *The Interpretation of Dreams* (1935), one of the paintings displayed in the exhibit. In 1942, Kiesler (*Figure IV-10*) designed the influential Surrealist Gallery, Art of This Century exhibit in New York, incorporating concave walls on both sides of the gallery space. Paintings were attached to the concave walls on multiple adjustable arms projected from the curved walls. Kiesler’s biomorphic curved wall idea and womblike seating were not based on the theme but on his thorough research into the mechanism of human perception and his vision of a comfortable and contemplative setting (Quaintance, 2004). Later in late 1950s the International Surrealist Exhibition (Exposition internationaLe du Surrealisme (EROS)) at the Galerie Cordier in Paris showed the artists’ attempt to incorporate this theme into a spatial form.
During the period when the White Cube was dominant in museums and gallery spaces, the idea of Spatial Drama did not frequently appear in trade magazines in the United States. However, Spatial Drama was widely practiced after the 1980s when the postmodern idea of revived expressionism came into play and communicating ideas with the public became a primary focus. For instance, Franklin D. Israel’s exhibit of *Out of Order* in 1996 showed how spatial forms could be used to tell the story (N. 1996). Instead of using conventional forms of exhibiting architectural works with texts and images, he used actual physical spatial forms such as dramatically sloped and sharply angled walls to communicate with viewers the spatial experience that physical space can provide. Daniel Libeskind’s (2001) exhibition in the Netherlands Architecture Institute (NAI) exhibition in 1997 shows how context can be treated as part of the medium of communicating the architect’s philosophy, allowing the viewers to actually experience the spatial quality created within, by, and above the physical walls and spaces created by these dramatically angled walls. His exhibit prompts visitors “to develop an awareness of architecture and to become interested in spatial issues based on their own physical
experience” (Feireiss, 2001, p. 11) in exhibitions rather than merely delivering architectural concepts through written explanations or a series of two-dimensional images. Libeskind states:

This particular exhibition presented the search for architecture and was itself a microcosm of ideas and thoughts in progress. The intension of the exhibition design was for the public to co-participate in a scheme by following an imaginative and non-linear path in order to experience the other side: the fact that architecture is not an assemblage of homogeneous components but a fusion of seemingly irreconcilable dimensions (p. 69).

Led by a few deconstructivist architects such as Frank Gehry and Zaha Hadid, Spatial Drama has also been implemented into the overall museum building structure as architectural manifestations. The central atrium of the Gehry-designed Guggenheim Museum in Bilbao (1997) was a resounding cultural statement of an amalgam between art and architecture that blurs the traditional boundary between the object and architecture as a neutral container or a background. It had a significant global impact on people’s perception of the role of a museum as a substantial public cultural hub.

The neo expressionistic attribute in Spatial Drama was a strong influence for the dominant museum display concept of making the White Cube to become more dynamic. In the case of the SSM/Kanno Museum of Art in Shiogama, Japan, Atelier Hitoshi (2006) used sculptural three-dimensional walls at varying angles that gives an impression that the whole spatial configuration was sculpted as a work of art. The visitor feels that he or she is inside a sculpture: the boundary between the object and the viewer is blurred.
Table IV-3. Spatial Drama: definition, a core signal, and peripherals

<table>
<thead>
<tr>
<th>Archetype 3</th>
<th>Spatial Drama</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Spatial Drama defines an exhibition space manipulated three-dimensionally according to a theme and an idea of an exhibition or a specific paradigm of an art group. It creates a dramatic quality of expressive, emotional, imaginative, and stimulating spatial experience.</td>
</tr>
<tr>
<td><strong>Core signal</strong></td>
<td>Vertical or horizontal elements are manipulated with multiple angles or curves</td>
</tr>
<tr>
<td><strong>Peripheral</strong></td>
<td>Manipulation properties: curves, angles</td>
</tr>
<tr>
<td></td>
<td>Degree of angles applied to spatial manipulation</td>
</tr>
<tr>
<td></td>
<td>Density of manipulated segments</td>
</tr>
</tbody>
</table>

**Possible Mutation**

*Figure IV-11. Spatial Drama mutation 1: Multiple angles and directions*

**Possible Coevolution**

- Combined with Wunderkammer
- Combined with Grid
- Combined with Poetic Light
- Combined with Scalar
Linked Sequence

**Interior Spatial Drama:** Spatial configuration inside museums is manipulated to convey the specific theme of an exhibit.

- Unidentified group exhibition by Frederick Kiesler, Julien Levy Gallery, 15 East 57th Street, New York, 1937.
- *Surrealist Gallery* by Fredrick Kiesler, Art of This Century, New York, NY, 1942.
- *Thonet display* at Chicago NEOCON, Chicago, IL, 1981.

**Building as Spatial Drama:** Spatial configuration of museum buildings is manipulated to convey the architect’s design concept and philosophy.
• The Central Atrium of the Guggenheim Museum designed by Frank Gehry, Bilbao, Spain, 1997.
• SSM/Kanno Museum of Art designed by Atelier Hitoshi Abe, Shiogama, Japan, 2006.
• Denver Art Museum designed by Daniel Libeskind, Denver, CO, 2006.
• The Military History Museum designed by Studio Daniel Libeskind, Dresden, Germany, 2011.
• Tel Aviv Museum of Art designed by Preston Scott Cohen, Tel Aviv, Israel, 2011.
• Eli and Edythe Broad Art Museum designed by Zaha Hadid Architects, East Lansing, MI, 2012.

4.1.6. Archetype 4: Poetic Light

The primary discussion regarding light and lighting in museums and galleries had focused on the functional aspects of lighting as a supplementary element for the display of art such as the intensity, color, glare, and duration of light that are appropriate to protect art as well as to support its display (Progressive Architecture, Feb. 1984). Light in museums and exhibitions however functions not merely as a supplementary element for viewing objects but also as a work of art itself. A number of examples that show the use of diffused colored illumination were found specifically from a content survey of secondary sources that deal with the Southern Californian artist group Light and Space in the 1960s. Regardless of the visibility of the light source, the emphasis is placed not on visual information, but on “a physical presence” (Butterfield, 1993, p.14) of light and the viewer’s sensory experience of colored light in space. As Holl (2003)
writes in his *Idea, Phenomenon and Material*, a pool of colored light embodies the “transcendental realm of the phenomena of architecture” (p. 27). Started as one stream of the expression of minimalism, Poetic Light became one of the most powerful display aesthetics that triggers emotional narratives in a viewer’s mind and intensifies sensory experience.

**Definition of Poetic Light**

Poetic Light is natural or artificial light that is artistically combined with colors as a medium of art so that visitors perceive light as a work of art and as a spatial experience. With intense light filling a space, Poetic Light creates an immersive quality that allows viewers to fully immerse themselves in the exhibit. The quality of experience emphasizes dreamlike emotional narratives.

**Core Signal in Poetic Light**

The core signal in Poetic Light can be defined as *diffused illumination of colored light.*

**Evolution in Liked Solutions of Poetic Light**

The prime objects of Poetic Light emerged around the 1960s-70s when the Light and Space artist group in Southern California experimented with the phenomenology of perception and situational installations using colored light. Key artists include Robert Irwin, Jim Turrell, Douglas Wheeler, Larry Bell, and Eric Orr. Butterfield (1993) argues that Light and Space art should be understood based on the idea of “art as illusion” (p. 10) and phenomenology. In Poetic Light the fabric of the world is staged with colored light and spatial configuration to bring the viewer to another realm of being pleasantly lost in one’s thoughts and mind and to provoke the awareness of one’s own being-in-the-moment in the space.
It is in this state of reverie that the participant in a work of Light and Space slowly lets go of rational, structured reality and slips into an altogether different perceptual state . . . the presence of light, the sense of color, and the feel of space merge, becoming far more real than any literal representation of them could be (Butterfield, p. 10).

One of Turrell’s Light and Space installations, Rondo from 1969, was composed of two light-edged planes on both sides of a room creating a free-floating effect. With intense but diffused colored light his Light and Space installations affect the senses: “you see it, think you could touch it, even inhale it, yet in reality it isn’t there” (Butterfield, 1993, p. 77). In describing Stuck Red and Stuck Blue by Turrell (1943–) in 1970, art critic Kanjo (1997) states that the viewer’s body feels the space “as vaporous and thick; the eye (mis)reads optical effects as haptic sensations” (p. 74). Because of the main characteristics of Poetic Light that accentuates the architectural configuration of the space, museums and galleries with unique geometric shapes were often chosen to display the Light and Space installation. Dan Flavin (1933–1996) incorporated his Light and Space installation titled To Tracy, to celebrate the love of a lifetime (1992) with Frank Lloyd Wright’s unique spiral interior in the Guggenheim Museum in New York. The entire atrium was illuminated with fluorescent colored light sculptures in warm pink, yellow, red, green, and blue as well as daylight.

The Light and Space installations by some other artists articulate the diffused yet highlighted edges of planes or illuminating objects creating a sculptural effect of Poetic Light. Light Wall installation by Douglas Wheeler (1939 – ) from 1967 to 1970 at the Ace Gallery in Los Angeles articulates the shape of the wall with intense but diffused light leaving an afterimage of color. Wheeler calls the diffused light “a cloud of light in constant flux” (Plagens,
1970, p. 83). With the diffused light at the edges, normal depth perception is distorted, and the inner part of the boundary becomes dematerialized making viewers question what is real and physical. Especially when Poetic Light is installed three dimensionally (e.g. DeWain Valentine’s (1936–) Catenary Light and Cantilevered Spectrum in 1970–1991; Dayline, Santa Barbara Museum of Art, Santa Barbara, California, March 6–April 3, 1977), it creates a dreamlike effect similar to “being surrounded by a painting rather than looking at it (Butterfield, 1993, p. 194).

Poetic Light is also used to deliver an indirect message. In line with the main idea of expressing void and absence (Libeskind, 1999), Libeskind incorporated metaphorical and spiritual language into physical forms in his design of the Jewish Museum in Berlin. In the holocaust tower (Figure IV-12) there is no single word of explanation but a gleam of light coming through a small opening at the top of the tower. The soft diffusion of natural light was used as a metaphorical language of design to convey the feeling of both desolation and hope (Libeskind, 2013).

Figure IV-12. The Holocaust Tower, Jewish Museum in Berlin, designed by Daniel Libeskind, 1999 (Photograph retrieved from ARTstor digital library. The Hartill Archive of Architecture and Allied Arts).

In one of the later works of Light and Space, Prime Matter (Installation in Los Angeles County Museum of Art, 1981), Eric Orr (1939–1998) pioneered the mixed-media method based
on Poetic Light. Orr incorporated light, gas from fire and steam from the evaporation of water with a twenty-foot sculptural column. Although the installation was not successful due to poor craftsmanship (Butterfield, 1993), this multi-dimensional approach implies the rich possibilities of utilizing the Poetic Light effect with different media. For example, Pierre Huyghe (1962–), in his installation titled *L’Expedition Scintillante, Act II: Untitled (light show)* in 2002 applied free-floating smoke highlighted by projections of multiple colored light from various angles. Constantly changing colors, sound, and smoke particles reflected by colored light collectively make the whole environment a work of art and enhance the appreciation of physical presence and viewer engagement. As mentioned earlier in Grid, Poetic Light is dynamically combined with other museum archetypes such as Grid to create a multi-dimensional spatial experience. The installation by Bekkering Adams Architecten at the Architecture Biennale in Venice, Italy, titled *Fundamentals: Form-Contraform*, at the Palazzo Mora in 2014 demonstrated how the three-dimensional Grid mass added another level of spatial experience with projected colored light.

*Table IV-4 Poetic Light: definition, a core signal, and peripherals*

<table>
<thead>
<tr>
<th>Archetype 4</th>
<th>Poetic Light</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Poetic Light is natural or artificial light that is artistically combined with colors, as a medium of art, so that visitors perceive light as a work of art and as a spatial experience. With intense light filled in space, Poetic Light creates an immersive quality that allows viewers to fully immerse themselves in the exhibit.</td>
</tr>
<tr>
<td>Core signal</td>
<td>Diffused illumination of colored light</td>
</tr>
<tr>
<td>Peripheral</td>
<td>Colors of light</td>
</tr>
<tr>
<td></td>
<td>Number of colors</td>
</tr>
<tr>
<td></td>
<td>Intensity of colored light</td>
</tr>
<tr>
<td></td>
<td>Change of colored light</td>
</tr>
<tr>
<td></td>
<td>Movement</td>
</tr>
</tbody>
</table>
Possible Mutations

Figure IV-13. Poetic Light mutation 1: Single-color variations

Figure IV-14. Poetic Light mutation 2: Multiple-color combination variations

Possible Coevolution

- Combined with Wunderkammer
- Combined with Grid
- Combined with Spatial Drama
- Combined with Scalar

Linked Sequence

Poetic Light as Sculpture: Light source and shapes are articulated. Usually fluorescent light fixtures are used to create sculptural figures.


**Poetic Light as Light + Space**: The source of light is invisible and the spatial configuration is perceived as a work of art giving the sense of presence. The viewers feel their presence as being inside the work of art rather than looking at art.


• *Fourth Situation* by Hap Tivey, Ganzfeld room installation, Fine Art Gallery, University of California, Irvine, CA, 1976.


• *Fundamentals*: Form-Contraform by Bekkering Adams Architecten at Palazzo Mora, Architecture Biennale in Venice, Italy, 2014

**Poetic Light as Mixed Media Art**: Poetic Light is combined with other mixed media

• *Prime Matter* by Eric Orr, Metal column with flame and fog, Los Angeles County Museum of Art, Los Angeles, CA, 1981.
4.1.7. Archetype 5: Scalar

Digital images have been the major display content for a number of contemporary exhibitions. The quality of constantly changing, dynamic, or at times ephemeral characteristics of projected images is one of the main reasons that artists and curators favor digital projections. Digital image projections also can amplify the size of the text and images and thereby heighten the meaning or intensify the connotation behind the projected images.

Scalar is a metaphorical name derived from physics that refers to the one-dimensional physical quality of volume, mass, speed, distance, or electrical potential inside a medium. In Scalar the directional quality is forgotten; once projected, from the point of a viewer, the source of projection is ignored, and only the physical quality of the projected images and the physical, emotional, and atmospheric quality of being in the space surrounded by the images matter to the viewer. As a museum archetype, Scalar defines digital image/text projection regardless of the type of images or whether the context consists of still images or video images.
Definition of Scalar

Scalar is display aesthetics associated with projection that sometimes exaggerates and emphasizes shapes or images of objects. Scalar arouses visual wonder and creates an immersive quality that allows viewers to fully immerse themselves in the projected images.

Core Signal in Scalar

The core signal in Scalar can be defined as *(magnified) projected images or text* as objects.

Evolution in Liked Solutions of Scalar

Chiari (1970) states that words and images are “symbols or signs whose meanings [are] constituted by the emotions: they represent absent things or mind-made notions” (p. 110). In museums and gallery exhibitions, words and images have been used not only to deliver information but also to convey meanings, to indirectly imply connotations, or to transfer nuances. Typically, digital image projection has been used in museums primarily as an additional tool to deliver information for educational purposes. The Scalar archetype, however, focuses on a digital projection used as a piece of art.

From the content survey two main categories of projection in museums and galleries were found: text projection and image projection. One of the significant prime objects of text projection could be the projected display series by American conceptual artist Jenny Holzer, titled *Projection*. Holzer (1950–) uses text messages about political, social, or cultural issues the society is dealing with and projects them on buildings and architectural structures in public spaces (Hotel Pennsylvania façade, New York, 2004; Guggenheim Museum, New York, 2008; The Pyramid at the Louvre Museum, Paris, 2009) or in a large interior space (Mass MOCA, North Adams, 2007). Projected text images in Scalar are often exaggerated and magnified,
articulating the form and shape of the text as well as the meaning behind it. Projected text images also distort the perception of the spatial configuration.

A recent text projection by Norman Foster (1935–) titled *The Gateway*, an installation at the Venice Architecture Biennale in 2012, demonstrated how text projection Scalar could be developed into something more dynamic and engaging. The overall design was based on Foster’s curatorial interpretation of *Common Ground*, the main theme of the 13th International Architecture Exhibition, as “the communal gathering space that brings us all together socially” (Saieh, 2012, para. 3). The Gateway is the first spaces of the Biennale where visitors experience an immersive environment filled with constantly moving text images of the names of the “architects, designers, and planners that have influenced our built environment over the years” (Saieh, 2012, para. 2). The multiple streams of layers of text images constantly in motion are projected on the dark floor, on columns, and on visitors, dynamically interconnecting the viewers into the exhibit.

The African American artist Kara Walker (1969 –), known for her cut-paper silhouette display that critically address slavery, violence, and other racial issues, also employed light projection using colored transparencies on overhead projectors for some of her installations (e.g. *Darkytown Rebellion*, 2001; *Insurrection! Our Tools were Rudimentary, Yet We Pressed On*, 2002; *The Angry Surface of Some Grey and Threatening Sea*, 2007). In *Darkytown Rebellion*, Walker combined her paper-cut silhouettes with vibrant colored-light projections creating an all-encompassing participatory exhibition space where the viewers and the artifacts interweave into a piece of artwork.
Viewers are further involved with the installation as their shadows are also cast onto the wall as they walk through the space. In this way, visitors literally enter the narrative and the history it suggests through their own silhouettes (The Walker Art Center, n.d. Light Projection, Para 1).

Another multi-media installation example titled *Gamepieces* (*Figure IV-15*) by Indian artist Nalini Malani (1946–) features densely layered effects with suspended objects as well as projected images on walls, movement, and sound that are interwoven in the whole dynamic exhibit. Synthetic polymer paintings on cylinder-shaped transparent Lexan materials create shadow patterns on the walls. Shadow images of creatures are constantly moving as the cylinders turn to “wipe out . . . the horror of nuclear bomb explosions” (Pijnappel (interviewer) & Malani (interviewee), n.d.). With video projection on top of the shadow images, colors and other images add multiple layers and create an immersive quality to the museum experience.

Another prime object of Scalar is Jennifer Steinkamp’s (1958 – ) digital projection series often employed at a large scale within architectural surroundings. Projected on large walls or sometimes at the perimeter of the whole interior space Steinkamp’s digital media creates immersive environments that “blend awareness of the physical and ethereal and challenge the preconceived idea of form and space” (Lehmann Maupin Gallery, Hong Kong, para. 1). One example titled *Daisy Bell* (*Figure IV-16*) is a computer-controlled projection that encourages viewer participation by adding another set of layers of silhouette images of the viewers. Steinkamp’s digital media projections feature movement of natural phenomena such as floral images, multiple layers of feathers, or trees in different seasons. In her installations, the projected images are often animated changing forms, shapes, and elements, which adds a sense of time.

*Figure IV-16. Daisy Bell* by Jennifer Steinkamp, computer-controlled projectors, Exhibited at Lehmann Maupin Gallery, Fall 2008. Photographer: Larry Qualls (Photograph retrieved from Artstor Digital Library).

One of the most significant characteristics of evolution in Scalar found from the linked solutions is an increasing interest in creating immersive environments using large displays for projections and interactive technology. Extremely large screen displays often appear in
contemporary museums (Figure IV-17. Long March: Restart by Feng Mengbo, 2008; Towards Biology by Ricardo Bofill, Taller de Arquitectura, Venice Architecture Biennale, 2014). As the display screen is becoming larger, it is blurring the boundary between the real and the virtual, and the interactive features are often added to the display itself.

Figure IV-17. Long March: Restart by Feng Mengbo, 2008. Large screen (80 feet by 20 feet) video game display installation. Installation view at MoMA New York in 2015. (Photo Credit: Joori Suh)

Table IV-5. Scalar: definition, a core signal, and peripheral

<table>
<thead>
<tr>
<th>Archetype 5</th>
<th>Scalar</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Scalar is display aesthetics associated with projection that sometimes exaggerates and emphasizes shapes or images of objects. Scalar arouses visual wonder and creates immersive quality that allows viewers to fully immerse themselves in the projected images.</td>
</tr>
<tr>
<td>Core signal</td>
<td>(Magnified) projected images or text objects</td>
</tr>
</tbody>
</table>
| Peripheral | Size of projected images  
Contents of images or texts  
Movement (Still/Moving)  
Position (Wall, Floor, Ceiling, Overall) |
Possible Mutation

Figure IV-18. Scalar mutation 1: Text, different projection angles

Figure IV-19. Scalar mutation 2: Images, different projection angles

Possible Coevolution

Combined with Wunderkammer

Combined with Grid

Combined with Spatial Drama

Combined with Poetic Light

Linked Sequence

Scalar as Text Projection: Text images are used as content of Scalar projection

• *Expressionist Utopias: Paradise, Metropolis, and Architectural Fantasy*. Exhibition at the Los Angeles County Museum of Art, exhibit designed by Coop Himmelblau, Los Angeles, CA, 1993.


**Scalar as Image Projection:** Digital or photographic images are used as content of Scalar projection


• *Insurrection! Our Tools were Rudimentary*, *Yet We Pressed On* by Kara Walker, Solomon R. Guggenheim Museum, New York, 2002.

• *Pour Your Body Out* by Pipilotti Rist, Museum of Modern Art (MoMA) in New York City, 2008.


• *Long March: Restart* by Feng Mengbo, Guangdong Museum, Guangdong, China, 2008.

4.1.8. Archetype 6: Vitrine

Originating in science and medicine, Vitrine has been one of the most significant display aesthetics in museums and galleries as an effective museological method. Numerous examples were found from the content survey and significant evolution was identified.

Definition of Vitrine

Vitrine represents display aesthetics associated with a container for displaying significant or ordinary objects. Vitrine draws viewers’ attention and adds a unique museum effect of the untouchable, rare, uncommon, and exceptional quality of objects.

Core Signal in Vitrine

The core signal in Vitrine can be defined as *encapsulation*.

Evolution in Liked Solutions of Vitrine

Traditionally the Vitrine has served as a convenient method of preserving artifacts while making them visible for viewers. Artists favored the visual power of presenting objects in Vitrines that “reinforces the notion of the unique, untouchable and unattainable . . . to catch a viewer’s attention and to stimulate contemplation” (Putnam, 2001, p. 36). Due to this powerful museum effect, there has been an increasing tendency among artists to employ Vitrine to display ordinary or bizarre objects to deliver an artist’s message. Encased in the Vitrines everyday things appear significant and even artistic raising questions and reflection. In *New Shelton Wet/Dry Tripledecker* one of Jeff Koons’ (1981) series of works called *The New*, he “recontextualized” (Putnam, 2001, p. 36) three domestic vacuum cleaners as examples of contemporary art encased
in Plexiglas, making the viewer more attentive to reevaluate the newness of everyday commodities.

The British artist Damien Hirst (1996) also employs the idea of Vitrine for many of his Natural History series displays. In his display titled Some Comfort Gained from the Acceptance of the Inherent Lies in Everything, twelve vertical sections of a cow and a bull are held in individual steel and glass tanks of formaldehyde solution. In another artwork completed under the category Natural History, titled The Physical Impossibility of Death in the Mind of Someone Living (1991), he divided the Vitrine into three cubes to display a tiger shark in formaldehyde. Hirst’s intention was to “force the viewer out of their element by introducing into a gallery setting . . . by isolating the shark from its natural habitat, the work explores our greatest fears and the difficulty involved in” (Beard, 2012). The Vitrine isolates an object from its original context and reframes it in a newly defined surreal environment that an artist creates. The effect of placing objects in a Vitrine has a metaphorical quality, and Vitrine itself is not merely a method of display but can be used as a medium of art.

Encapsulating objects or information can be achieved in a variety of ways. Two outstanding examples found from the content survey predict future development and evolution of the Vitrine archetype as one of the important display aesthetics. The first example is the UK Pavilion at Shanghai Expo designed by Heatherwick Studio in 2010. Instead of using conventional glass cases, the architect designed the pavilion with undulating shapes using 60,000 acrylic rods. A total of 250,000 seeds, as ultimate “symbol of potential and promise” (Heatherwick, 2010) are encapsulated in the tips of the rods. The acrylic rods, as numerous Vitrines, work as a medium of art as well as materials to shape the space. They even transmit
natural light from the exterior to the interior. This is a prime example that combines Vitrine, Spatial Drama, Wunderkammer, and Poetic Light.

Another meaningful example found from the content survey that features a new method of encapsulating objects or information was the i-City Russian Pavilion designed by SPEECH Tchoban and Kuznetsov at the Venice Architecture Biennale in 2012. The unique feature of the pavilion is its numerous QR codes that cover the entire interior surface of the pavilion. A series of QR codes contain information about the Skolkovo Innovation Center, the high-technology business complex in Russia. Visitors can retrieve information by scanning the codes using a tablet provided at the entrance. Understanding QR code or any type of digital code to retain information as a ‘container’ of information in the current age, including any kinds of real or virtual objects, is significant. The method of arousing or delivering visual or emotional wonder becomes a non-tangible one in some cases. The recent interactive display in 2015 at the Cooper Hewitt Design Museum, “Play designer,” “Immersion Room,” “The Pen,” and “Process Lab” pioneer the way visitors remember their unique interactions with the dynamic contents of the exhibition. A visitor is provided with a digital pen that contains dual functions: one is to interact with the display (to draw, to select, or to modify drawings) and the other is to save interactions such as virtual pattern images, three-dimensional objects that a visitor creates, or any other information that he or she chooses.
Table IV-6. Vitrine: definition, a core signal, and peripherals

<table>
<thead>
<tr>
<th>Archetype 6</th>
<th>Vitrine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Vitrine represents display aesthetics associated with a container for displaying significant or ordinary objects. Vitrine draws viewers’ attention and adds a unique museum effect of the untouchable, rare, uncommon, and exceptional quality of objects.</td>
</tr>
<tr>
<td>Core signal</td>
<td>Encapsulating objects</td>
</tr>
<tr>
<td>Peripheral</td>
<td>Container properties: size, shape, color, etc.</td>
</tr>
<tr>
<td></td>
<td>* Vitrine is a dependent archetype that requires other object based archetypes for its physical manifestation</td>
</tr>
</tbody>
</table>

Possible Mutation

![Image of possible mutation]

Figure IV-20. Vitrine mutation: container properties

Possible Coevolution

- Combined with Wunderkammer
- Combined with Grid
- Combined with Poetic Light
- Combined with Scalar
Linked Sequence

**Vitrine:** Precious objects are kept in a container

- Exhibition at Torrance Hall of Fine Arts, The Southwest Museum, Los Angeles, CA, 1917
- Vitrine display at The Renwick Gallery, Washington, D.C., 1972
- Vitrine display at The Museum of Anthropology, Vancouver, British Columbia, Canada, 1977
- Vitrine display at Museum of Glass and Ceramics, Teheran, Iran, 1981
- Vitrine display at Michael C. Carlos Hall, Museum of Arts & Archeology, Emory University, Atlanta, GA. 1985
- Vitrine display at Pre and Early History Museum, Frankfurt am Main, Germany, 1990
- Vitrine display at Groningen Museum, Groningen, Netherlands, 1995
- Vitrine display at The Gallery of Horuji Treasures, Tokyo National Museum, Tokyo, Japan, 2002
- Vitrine display at Neues Museum (the main level Vitrines designed by Michele de Lucchi, Egyptian courtyard, northwest wing Vitrines designed by Michele de Lucchi, third level gallery Vitrine), Berlin, Germany, 2009
- Vitrine display at Los Angeles Museum of Holocaust, Los Angeles, CA, 2010
• *Domusae* installation curated by Jesus Apricio and Jusus Donaire, Salon de Reinos, Madrid, Spain, 2011

**Vitrine as Art:** The property of retaining objects itself is used as part of the artwork


• UK Pavilion at the Shanghai World Expo, Heatherwick Studio. 2010

• QR Codes walls at i-City Russia Pavilion, designed by SPEECH Tchoban/Kuznetsov, Venice Biennale, Venice, Italy, 2012

• Peep holes at Russia Pavilion, designed by SPEECH Tchoban/Kuznetsov, Venice Biennale, Venice, Italy, 2012

In summary, the content analysis of Part 1 allowed me to examine the dual structure of archetypes. A number of examples that share common traits were grouped under each archetype. The common traits were refined to narrow down to the core signals that are applicable to all the examples. It allowed me to affirm that each archetype contains a core signal that is carried in the examples in the linked solutions. In terms of peripherals in the dual structure that cause diverse forms in archetype’s appearance, depending on the unique characteristics of each archetype, different parameters were found from the content analysis. Significantly, some recent examples not only show notable significant change in parameters but also convey possible future transformations and innovations.
4.2. Part 2: IGATY, An Archetype-Based Generative Abstraction System

In order to examine if the application of Interactive Genetic Algorithms to the dual structure of the selected six museum interior archetypes works, the proposed dual structure of archetypes that consists of a core signal and a peripheral was employed as a fundamental operational framework of the system. The core signals and peripherals found in the six selected museum interior archetypes from content analysis in Part 1 were used to set the rules for the core principle and variables for the parameters in the proposed IGATY-beta system (Figure IV-21). A core signal found in each archetype was interpreted as a descriptor that defines the principles and properties of specific display aesthetics methods pertaining to the core characteristics of the archetype. As discussed in the literature review, the core signal serves as a principle and requires parameters to physically manifest its existence. To limit the study, not all the properties of peripherals found in Part 1 were used as variables to set parameters, but some of the major properties of peripherals were applied to the proposed IGATY-beta system.

Figure IV-21. The dual structure of archetypes and the its conceptual framework in the IGATY-beta system
4.2.1. IGATY- A System Overview

The system

The proposed beta version of the generative abstraction system is interactive ideation software, designed to initiate and develop ideas for museum interiors and display aesthetics based on archetypes. The main component used for the beta version system includes six museum interior archetypes and the parameters for each archetype. The core signals and peripherals found in the six selected archetypes in Part 1 were used to set the rules and parameters in the IGATY system (Figure IV-22).

Figure IV-22. The basic structure of the IGATY-beta system: a core signal in an archetype is mapped into the system to define the core principles of each archetype. The selected set of peripherals is coded to give some major parameters for a user to set.

Figure IV-23 demonstrates the overall functional flow of the proposed IGATY system.

The welcome screen gives a brief overview of the IGATY system. The archetypes selection screen displays the six archetypes with the names and short definitions of each type. Once a user
selects one of the archetypes, the next screen displays an interactive feature that allows a user to set parameters such as shapes, color, images, sizes, and the like. The beta version system was coded to generate 20 offspring for each generation at a time. A user can select design solutions based on the user’s aesthetic judgment and design intention. The user can select 2–20 chromosomes and send them to the mutation and crossover operators. The user’s selections inform the IGATY system of the design direction, and the operator produces next generations based on the selected chromosomes. This function enables the design to evolve as a user develops his or her design. A user can add more than one archetype for coevolution. The selected scenes are saved in the history window to help the user remember the evolution of design and to save images after final exploration.

In testing the IGATY-beta version system emphasis was placed on the following areas to reflect the research questions: (1) Does the IGA mechanism of mutation and crossover operations work in the system? (2) Does the design evolve towards the designer’s intended scheme? (3) Does coevolution work in the system? (4) Can this application result in unconventional aesthetics? (5) Can it be expanded to other archetypes applications?
Welcome Screen

Archetypes Selection Screen to Start IGATY

Spatial Drama (Set parameters)
Grid (Set parameters)
Wunderkammer (Set parameters)
Scalar (Set parameters)
Poetic Light (Set parameters)

Vitrine (Vitrine can be added to other object-based archetypes)

Interactive Screen of IGATY operator (mutation, crossover, and coevolution)

Save History and Final Design

Introduction screen
A brief overview of the IGATY-beta system

Selection screen
A user selects one archetype to explore the IGATY-beta system

Interactive screen:
A user can generate offspring based on mutation and crossover, and can add other archetypes for co-evolution.

**Figure IV-23.** The functional flow block diagram of the IGATY-beta system
The proposed IGATY-beta system requires the user to dynamically interact with the system by reviewing and evaluating initial populations and by selecting individuals for future generation of offspring (Figure IV-24). As design intentions or directions evolve, the IGATY system produces different variations of individuals through the process of mutation, crossover, and coevolution. The proposed system is currently available in two versions: (a) The advanced-designer version allows a designer to explore design further in detail in Unity. A designer can modify a chromosome by changing locations, colors, or shapes of objects or add other custom items while the IGATY system operates. Modified objects are saved as part of 20 individuals of
mutants and can be selected for production of future generations. (b) The beginning-designer version is an independent software program that operates without the Unity software. This version operates only based on the coded system and does not allow detailed modification of individual chromosomes. In this research, the beginning designer version was used for the validation process in Part 3.

The Virtual Space for IGATY

Design exploration in IGATY starts off from a default setting of a 20’x20’x20’ white cube as a raw space to initiate three-dimensional exploration. The setting creates a virtual white space comprising one even floor, three walls (left, right, and back), and a ceiling.

*Figure IV-25. Initial setting of virtual space for IGATY exploration (f = 1 foot, 20’x20’x20’)*
Table IV-7. The six selected archetypes in the IGATY-beta system: Gene, mutation ratio, crossover ratio, and coevolution

<table>
<thead>
<tr>
<th>Archetypes</th>
<th>Gene</th>
<th>Mutation / Crossover ratio</th>
<th>Coevolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid</td>
<td>Each object in one chromosome</td>
<td>Mutation ratio: .3</td>
<td>Wunderkammer, Spatial Drama, Poetic Light, Scalar, Vitrine</td>
</tr>
<tr>
<td>Wunderkammer</td>
<td>Each object in one chromosome</td>
<td>Mutation ratio: .3</td>
<td>Grid, Poetic Light, Scalar, Vitrine</td>
</tr>
<tr>
<td>Spatial Drama</td>
<td>Intersection points of segments in each plane (for mutation)</td>
<td>Mutation ratio: .3</td>
<td>Grid, Poetic Light, Scalar, (Vitrine: with Grid)</td>
</tr>
<tr>
<td></td>
<td>Each plane (for crossover)</td>
<td>Crossover ratio: .25</td>
<td></td>
</tr>
<tr>
<td>Poetic Light</td>
<td>Each light information at 27 points</td>
<td>Mutation ratio: .3</td>
<td>Grid, Wunderkammer, Spatial Drama, Scalar, (Vitrine: with Grid or Wunderkammer)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crossover ratio: .3</td>
<td></td>
</tr>
<tr>
<td>Scalar</td>
<td>Single image</td>
<td>Mutation ratio: 0 (removed)</td>
<td>Grid, Wunderkammer, Spatial Drama, Poetic Light, (Vitrine: with Grid or Wunderkammer)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crossover ratio: 0 (removed)</td>
<td></td>
</tr>
<tr>
<td>Vitrine</td>
<td>Each object in one chromosome (on which Vitrine depends)</td>
<td>Follows the ratio set to the archetype on which Vitrine depends</td>
<td>Grid, Wunderkammer (Spatial Drama, Poetic Light, Scalar: with Grid or Wunderkammer)</td>
</tr>
</tbody>
</table>

4.2.2. IGATY- Grid Exploration

In Part 1 the Grid archetype was defined as a systematic arrangement in rows and columns or in three-dimensional intersections at right angles. I defined the core signal of a grid as a two-dimensional or three-dimensional array that creates multiple intersections. The core signal of a grid was mapped into the IGATY system as an x, y, and z coordinate system that requires the user to select the number of columns, rows, and vertical modules. Among the peripherals found in Part 1 the following items were selected to map them into the proposed
IGATY system (*Figure IV-26*): (a) properties of objects (shapes - box, sphere, capsule, and cylinder); (b) number of objects in coordinate axes x, y, z; (c) constancy (whether the size of objects in a chromosome are consistent vs. various). As for the position of the Grid in the virtual space, the central area was used as a default setting to allow both two-dimensional as well as three-dimensional Grid mutations to be created.

*Figure IV-26*. Grid parameter set-up based on the selected peripherals.

The objects in a Grid do not take up the entire exploration space. The boundary space for the Grid archetype display was set to 5 feet by 5 feet by 5 feet. The very basic starting point of the Grid archetype is a single-element chromosome created by selecting x=1, y=1, and z=1. Once the user sets the parameters, the GA operator generates the initial population of 20 chromosomes instantly (*Figure IV-27*). Each chromosome is displayed one by one for the user to review and evaluate.
In Grid archetypes two options of constancy, *consistent* and *various* were included. The option *consistent* enables objects in each chromosome in the initial population to be homogeneous. Going through the mutation and crossover function the offspring lose consistency little by little and starts showing combinations of a few different objects, but because mutation and crossover work based only on the selected individuals, the overall characteristics of consistent appearance remains to some extent. *Figure IV-28* shows another 20 chromosomes as a set of the initial population created by the parameter setting of $x=5$, $y=5$, and $z=5$. The initial population is a set of random variations produced based on the primary settings: The overall appearance is arbitrary and exhibits diverse sizes. With the user involvement through evaluations
and selections, next generations display results from the operation of IGA mutation and crossover function based only on the set of chromosomes the user selects. Figure IV-29 demonstrates how the second generation has evolved towards a more intentional set of arrays reflecting the user’s tendency and aesthetic judgments: When the user selects individuals that contain only smaller or slender cubes, the IGATY system uses only the selected parents and discards all the other individuals in the initial population that are not selected. Thus, the IGATY system produces the next generation of 20 individuals based only on the selected smaller and slender cubes (Figure IV-29).

Figure IV-28. Grid exploration 2: 20 chromosomes as a set of initial population (images based on x=5, y=5, z=5, and the option “consistent” selected)
Figure IV-29. Grid exploration 3: 20 chromosomes of the first generation based on a selected set (images based on x=5, y=5, z=5, and the option “consistent” selected)

If the user’s intention is simply to choose smaller or larger objects within the range in the parameter, reflecting the specific user intention on the next generation is relatively quicker when the consistent option was selected than when the option various was selected. This occurs because the IGA mutation and crossover function is designed to select 30% from the parent genes for mutation and crossover, and when the option various is selected, the selected genes are more diverse in size, taking longer to achieve the goal of changing the overall appearance to be more uniform. One of the research questions for Part 2 of the study was to see if the proposed system makes designs evolve towards the designer’s specific intentions. Figure IV-30 displays 20 chromosomes of the initial population generated based on x=5, y=5, z=5, and the option various was selected. The overall appearance of each individual is arbitrary and random. Table
IV-8 shows how the generations evolve towards the user’s specific intention: the user intentionally selected individuals that contain smaller cubes in each chromosome. The overall appearance changes generation after generation towards the user’s intention.

*Figure IV-30.* Grid exploration 4: 20 chromosomes of the initial population (images based on \( x=5, y=5, z=5 \), and various option selected)
Table IV-8. Grid exploration 5: five selected chromosomes at 1st, 10th, 15th, and 20th generations, demonstrating the user intention of searching for smaller objects in each chromosome (images based on x=5, y=5, z=5, and various option selected).

<table>
<thead>
<tr>
<th>Generation no.</th>
<th>Selected Chromosomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Generation</td>
<td><img src="image1.png" alt="Images" /></td>
</tr>
<tr>
<td>10th Generation</td>
<td><img src="image2.png" alt="Images" /></td>
</tr>
<tr>
<td>15th Generation</td>
<td><img src="image3.png" alt="Images" /></td>
</tr>
<tr>
<td>20th Generation</td>
<td><img src="image4.png" alt="Images" /></td>
</tr>
</tbody>
</table>

Table IV-9 demonstrates a few variations of two-dimensional and three-dimensional Grid archetypes created in the IGATY-beta system. The IGATY system is integrated into the Unity software and allows the user to manipulate objects further to develop them into a unique and unconventional design. With more detailed manipulations such as adding or removing objects and adding custom colors or images in a chromosome, the IGATY-beta advanced-designer version allows more variables to be added to the system. Table IV-9 also demonstrates
some examples that show the IGATY system’s potential to be used as a search tool for unconventional aesthetics.

Table IV-9. Extended grid exploration.

<table>
<thead>
<tr>
<th>Grid exploration</th>
<th>2-dimensional, 3-dimensional Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>Manipulation in Unity program 1</td>
<td></td>
</tr>
<tr>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td>Manipulation in Unity program 2</td>
<td></td>
</tr>
<tr>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
</tr>
<tr>
<td>Manipulation in Unity program 3</td>
<td></td>
</tr>
</tbody>
</table>
4.2.3. IGATY- Wunderkammer Exploration

In Part 1 a Wunderkammer was defined as an installation aesthetic in which a multitude of diverse, collected objects are arranged as categorized, taxonomic, or random-order displays on walls, floors, ceiling planes, in a cabinet, or three dimensionally in space. The core signal in the Wunderkammer archetype is defined as a cluster, group, or assemblage of a multitude of randomly arranged objects. Among the peripherals found in Part 1 the following items were selected to map them into the proposed IGATY system (Figure IV-31): (a) properties of objects (shapes - box, sphere, capsule, cylinder); (b) number of objects; (c) constancy (whether the object size in a chromosome is consistent vs. various).

![Peripheral 1: property of objects (Shape – box, sphere, capsule, cylinder)](image1)

![Peripheral 2: number of objects](image2)

![Peripheral 3: constancy (consistent vs. various)](image3)

Figure IV-31. Wunderkammer parameter set-up based on the selected peripherals

The Wunderkammer archetype in the IGATY system first asks the user to select the shape and the total number of the objects. The user can also choose from the two options of constancy, consistent and various: The function is the same as the one applied to the Grid archetype. In the virtual space, the Wunderkammer archetype uses a 10’ x 10’ space of the back
wall that is 2’-6” above the floor so that a user can directly see from the front view. Within this 10’ x 10’ area, the IGATY system finds random points to place the selected objects (*Figure IV-32*).

*Figure IV-32.* The area diagram for Wunderkammer object random positions

The initial population is created by a parameter set by the user, and the default algorithm with random values is applied to the objects’ x and y dimensions and positions. The overall appearance of the 20 chromosomes of the initial population is arbitrary and haphazard, waiting for the user to give a certain design direction (*Figure IV-33*). When the user interacts with the system by evaluating and selecting individuals for next generations, the chromosomes start displaying more intentional design solutions.
Figure IV-33. Wunderkammer exploration 1: 20 chromosomes of the initial population. (images based on number of objects = 55, and option “consistent” selected)

Figure IV-34 demonstrates how the first generation is created based on the user’s intentional selections: in this case, the user selected six chromosomes that contain small objects or thin horizontal objects. In the next generation the IGA algorithm produces 10 chromosomes using the mutation function and 10 chromosomes using the crossover function. The first generation *(Figure IV-34)* clearly shows that the design has evolved according to the designer’s intention.
Table IV-10 demonstrates how the design evolves further in the following generations based on the selections made by the user in each generation. Because of the crossover operation some genes in each chromosome are switched with another parent, resulting in blended combinations of genes in chromosomes.
Table IV-10. Wunderkammer exploration 3: five selected chromosomes at 1\textsuperscript{st}, 3\textsuperscript{rd}, 5\textsuperscript{th}, and 10\textsuperscript{th} generations demonstrating the user intention of searching for a combination of small and horizontal objects (images based on number of objects = 55, and option “consistent” selected)

<table>
<thead>
<tr>
<th>Generation no.</th>
<th>Selected Chromosomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Selections</td>
<td><img src="image1.png" alt="Images" /> <img src="image2.png" alt="Images" /> <img src="image3.png" alt="Images" /> <img src="image4.png" alt="Images" /> <img src="image5.png" alt="Images" /></td>
</tr>
<tr>
<td>1\textsuperscript{st} Generation</td>
<td><img src="image6.png" alt="Images" /> <img src="image7.png" alt="Images" /> <img src="image8.png" alt="Images" /> <img src="image9.png" alt="Images" /> <img src="image10.png" alt="Images" /></td>
</tr>
<tr>
<td>2\textsuperscript{nd} Generation</td>
<td><img src="image11.png" alt="Images" /> <img src="image12.png" alt="Images" /> <img src="image13.png" alt="Images" /> <img src="image14.png" alt="Images" /> <img src="image15.png" alt="Images" /></td>
</tr>
<tr>
<td>5\textsuperscript{th} Generation</td>
<td><img src="image16.png" alt="Images" /> <img src="image17.png" alt="Images" /> <img src="image18.png" alt="Images" /> <img src="image19.png" alt="Images" /> <img src="image20.png" alt="Images" /></td>
</tr>
<tr>
<td>10\textsuperscript{th} Generation</td>
<td><img src="image21.png" alt="Images" /> <img src="image22.png" alt="Images" /> <img src="image23.png" alt="Images" /> <img src="image24.png" alt="Images" /> <img src="image25.png" alt="Images" /></td>
</tr>
</tbody>
</table>

To answer the question about whether the IGATY-beta system can lead to unconventional aesthetics, the advanced version was used because it allows further manipulation
of chromosomes. Adding custom colors, images, or other objects in a chromosome breaks some rules coded in the default setting of the system and allows more variables to be annexed to the system. Table IV-11 demonstrates some examples that show the IGATY system’s potential to be used as a search tool for unconventional aesthetics.

Table IV-11. Extended Wunderkammer exploration

<table>
<thead>
<tr>
<th>Grid exploration</th>
<th>IGATY generations after manipulation of objects in Unity program: colors added</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image 1" /> <img src="image2.jpg" alt="Image 2" /> <img src="image3.jpg" alt="Image 3" /> <img src="image4.jpg" alt="Image 4" /></td>
<td></td>
</tr>
</tbody>
</table>

| IGATY generations after manipulation of objects in Unity program: object scale changed, images added to surface of objects |
| ![Image 5](image5.jpg) ![Image 6](image6.jpg) ![Image 7](image7.jpg) ![Image 8](image8.jpg) |                                                                 |

**4.2.4. IGATY- Spatial Drama Exploration**

In Part 1 the Spatial Drama archetype was defined as an exhibition space manipulated three-dimensionally according to a theme and an idea of an exhibition or a specific paradigm of an art group. The core signal in the Spatial Drama archetype was defined as vertical or horizontal elements manipulated with multiple angles or curves. Among the peripherals found in Part 1 the following items were selected to map them into the proposed IGATY system (Figure IV-35): (a) the number of segments in row and in column; (b) the degree of manipulation. Spatial manipulation is based on vertical or horizontal segments. When the user sets the number of
segments applied to each wall, the IGATY system generates irregular dynamic walls based on the number of the segments. The number in Row scale refers to the horizontal segments applied to create horizontal irregular walls; the number in Column refers to vertical segments applied to create vertical irregular walls. When the number in both rows and columns are added, the walls are segmented as an x and y matrix system to move the intersection points up or down perpendicular to the plane in order to create irregular surfaces with indented or projected parts. For mutation each intersection point is treated as a gene, and the three-dimensional coordinate system information (z value) in each interaction point is used to exchange positions in each plane. For crossover each wall and ceiling is treated as a gene to exchange between chromosomes. The degree of manipulation determines the extent the space is dynamically modified.

Figure IV-35. Spatial Drama parameter set-up based on the selected peripherals

The initial starting point of the Spatial Drama archetype, when no manipulation is applied, is the white cube, which is the default setting before any numbers greater than 1 are added. Depending on the parameter settings, the white cube becomes a dynamic space with multiple angled walls and a ceiling (Table IV-12). The higher the number of segments and the intensity
level the user selects, the more rugged and uneven the dynamic surfaces are created (*Table IV*-12).

*Table IV*-12. Spatial Drama exploration 1

<table>
<thead>
<tr>
<th>Parameter Settings</th>
<th>Examples of Spatial Drama generated by the IGATY system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row=1 Column=1 Degree=1</td>
<td><img src="image1" alt="Examples" /></td>
</tr>
<tr>
<td>Row=5 Column=1 Degree=2</td>
<td><img src="image2" alt="Examples" /></td>
</tr>
<tr>
<td>Row=1 Column=5 Degree=2</td>
<td><img src="image3" alt="Examples" /></td>
</tr>
<tr>
<td>Row=5 Column=5 Degree=2</td>
<td><img src="image4" alt="Examples" /></td>
</tr>
<tr>
<td>Row=5 Column=5 Degree=5</td>
<td><img src="image5" alt="Examples" /></td>
</tr>
</tbody>
</table>
Figures IV-36, IV-37, and IV-38 demonstrate how the IGA operator generates design solutions leading towards the designer’s specific intention. The images are based on a designer’s attempt to create a convexed or projected surface on the wall on the left. From the initial population of 20 individual chromosomes, the user intentionally selects 5 chromosomes that have a projected surface on the left wall.

Figure IV-36. Spatial Drama exploration 2: 20 chromosomes of the initial population (images based on row=4, column=4, degree of manipulation=3)

If the user keeps selecting individuals based on this criteria, in the 10th generation, the user will find more chromosomes with projected surfaces on the left walls. In the 15th generation, most of the chromosomes have projected surfaces on the left walls. This is because IGA
mechanisms discard individuals not selected, leaving survivals that meet the user’s aesthetic judgement.

*Figure IV-37.* Spatial Drama exploration 3: 20 chromosomes of the 10th generation when the user intention is to make the left wall to project out to the interior (images based on row=4, column=4, degree of manipulation=3)
The IGATY-beta advanced-designer version allows the user to go back and forth between the Unity program and the IGATY system to edit, add, and adjust objects in Unity to make the form closer to the user’s design direction while still taking advantage of genetic algorithms. To answer the question about whether the Spatial Drama archetype in the IGATY system can result in an unconventional aesthetics, the advanced-designer version was used as it allows further manipulation of chromosomes. Adding custom colors, images, or other objects in a chromosome breaks some rules coded as a default setting of the system and allows more variables to be added to the system. Table IV-13 demonstrates a few examples of what the IGATY-beta advanced
version can do with further manipulation and user interaction: These examples demonstrate some potential possibilities of the IGATY-beta system to be used as a search tool for unconventional aesthetics.

*Table IV-13.* Extended Spatial Drama exploration

<table>
<thead>
<tr>
<th>Spatial Drama exploration</th>
<th>Manipulation in Unity 1 (added colors on walls, rotated walls)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Images" /></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><img src="image2.png" alt="Images" /></th>
<th>Manipulation in Unity 2 (added color and images on walls, rotated walls)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><img src="image3.png" alt="Images" /></th>
<th>Manipulation in Unity 3 (added color and images on walls, rotated walls)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><img src="image4.png" alt="Images" /></th>
<th>Manipulation in Unity 4 (added colors on walls, added a new object)</th>
</tr>
</thead>
</table>
4.2.5. IGATY- Poetic Light Exploration

In Part 1 the Poetic Light archetype was defined as natural or artificial light that is artistically combined with colors as a medium of art. The core signal in Poetic Light was defined as diffused illumination of colored light. Among the peripherals found in Part 1, the following items were selected to map them into the proposed IGATY-beta system (Figure IV-39): (a) colors of light; (b) intensity of color.

**Figure IV-39**. Poetic Light parameter set-up based on the selected peripherals.

When the user selects colors from the seven options (purple, blue, light blue, green, yellow, orange, and red), they are used to position colored light in random locations in the virtual space. A total of 27 positions (x=3, y=3, z=3) were used. If one color is selected, only one color will be placed randomly in 27 locations in space. If four colors are selected, the four colors are put in a pool that the IGATY system selects colors from to assign them into 27 positions (Figure IV-40). The IGATY system first randomly selects one color from the pool of colors to assign the selected color in each position, then applies intensity variations based on the value that the user selects. Therefore, in some chromosomes, all four colors may appear and in others three, two, or
one color can also appear. Intensity of the light (Table IV-14) varies at each point because the algorithm uses a random range of the intensity based on the value the user sets. Depending on the degree of the intensity the user sets, the overall random value range becomes less intense (value=1) or more intense (value=10).

**Figure IV-40.** Poetic Light in the virtual space: light source distribution

Once the 20 individuals of the initial population are generated, the mutation and crossover function operates the same way as the Grid archetype. The property of light at each point in hue and intensity is treated as a gene in one chromosome. In the mutation function the property of lights at 30% of a total of 27 points is translocated within a chromosome. In the crossover function, the information of light at 30% of a total of 27 points is exchanged between two parent chromosomes.
Table IV-14. Poetic Light exploration 1: each row shows different light intensity settings. (value=2, 5, 8, and 10)

<table>
<thead>
<tr>
<th>Parameter Settings</th>
<th>Examples of Poetic Light generated by the IGATY system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color=blue</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>Intensity=2</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Color=blue</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>Intensity=5</td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>Color=blue</td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
<tr>
<td>Intensity=8</td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td>Color=blue</td>
<td><img src="image7.png" alt="Image" /></td>
</tr>
<tr>
<td>Intensity=10</td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
</tbody>
</table>

To answer the research question about whether the system drives the chromosomes to evolve towards the specific intention of a user, the system was tested based on the user’s intentional selection of specific colors. As hypothesized, it was observed that in producing generations the IGATY system operates following the user’s intention. Figure IV-41 displays 20 chromosomes in the initial population produced based on the user’s parameter setting: selected colors are yellow, magenta, light blue, and orange, and the intensity was set to 10.
If the user selects chromosomes that contain more yellow colored lights, the IGATY system uses the selected individuals to start mutation and crossover operations. *Figure IV-42* demonstrates the twenty individuals of the first generation: In the first generation, more chromosomes contain yellow colored light than in the initial population. This result confirms that the IGATY operation forces the system to evolve towards the designer’s aesthetic judgments and intentions.
In the IGATY advanced-designer version, the Unity program allows the user to explore further with Poetic Light by changing the location of light sources, adding new objects in the virtual space or changing the spatial configuration that defines the virtual space. The IGATY system recognizes the change and generates offspring reflecting the changes made in Unity. *Table IV-15* demonstrates some of the examples that the IGATY-beta advanced-designer version can create. With the manipulation made in Unity designers can experience unconventional aesthetics.
Table IV-15. Extended Poetic Light exploration

<table>
<thead>
<tr>
<th>Poetic Light exploration</th>
<th>Manipulation in Unity 1 (wall manipulation with angle)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Images" /></td>
<td><img src="image2.png" alt="Images" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Images" /></td>
<td><img src="image4.png" alt="Images" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manipulation in Unity 2 (new objects added)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Images" /></td>
</tr>
<tr>
<td><img src="image6.png" alt="Images" /></td>
</tr>
<tr>
<td><img src="image7.png" alt="Images" /></td>
</tr>
<tr>
<td><img src="image8.png" alt="Images" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manipulation in Unity 3 (new objects added, walls manipulated with angle)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image9.png" alt="Images" /></td>
</tr>
<tr>
<td><img src="image10.png" alt="Images" /></td>
</tr>
<tr>
<td><img src="image11.png" alt="Images" /></td>
</tr>
<tr>
<td><img src="image12.png" alt="Images" /></td>
</tr>
</tbody>
</table>

4.2.6. IGATY- Scalar Exploration

In Part 1 the Scalar archetype was defined as a display aesthetic associated with projection that sometimes exaggerates and emphasizes shapes or images of objects. The core signal in Scalar was defined as (magnified) projected images or texts as objects. Among the peripherals found in Part 1, the following items were selected to map them into the proposed IGATY system (*Figure IV-43*): (a) images for projection. The Scalar archetype parameter asks the user to select one image for projection. The algorithms randomly choose a projector position within a 10’ x 10’ x 5’ projector area (*Figure IV-44*) and apply a random rotation angle of the
projector (Random.Range (-20f, 20f), Random.Range (-20f, 20f), Random.Range (-20f, 20f)) to cast the image in the virtual space.

**Figure IV-43.** Scalar parameter set-up based on the selected peripherals.

**Figure IV-44.** Scalar projector position area (rotation angle range: Random.Range(-5f, 5f), Random.Range(-5f, 5f), Random.Range(-20f, -15f)).

In the IGATY-beta system, ten different images are provided in the Scalar archetype exploration including a text image, a black and white image, and full color images. The Scalar archetype in the IGATY beta version system uses only one image at a time: One single image works as a single gene for the mutation and crossover operation, making the parent images the same as the offspring. This minimizes the solution space and is not ideal for aesthetic search. Figures IV-45 and IV-46 demonstrate that the IGATY-beta version system allows the design to
evolve towards the designer’s intention. However, due to the limited number of genes in each chromosome, the first generation only shows the parents without any further variations. For this reason, in the IGATY-beta version system, only the random function (for the projector positions and angles) was used to enable the viewer to see more options in the solution space. When the user evaluates and chooses to use the projected scene, the user can use the “freeze” button to send a message to the IGATY system to stop searching for other images.

*Figure IV-45.* Scalar exploration 1: 20 initial population, five images are selected for the next generation. (images are based on the image F: clouds in blue sky).
Although the current IGATY-beta system does not allow extensive explorations utilizing mutation and crossover operations due to the limited number of genes in one chromosome, the Scalar archetype in the system demonstrated potential to result in unconventional aesthetics since it displays unfamiliar and sometimes bizarre graphical distortions in the virtual space (Table IV-16). The unconventional aesthetic appearance is maximized when the Scalar archetype is combined with other object-based archetypes such as the Grid archetype or the Wunderkammer archetype and with context-related archetypes such as the Spatial Drama archetype.
Table IV-16. Scalar exploration 3

<table>
<thead>
<tr>
<th>Images used</th>
<th>Examples of Scalar generated by the IGATY system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image A: Jelly fish in a fish tank</td>
<td><img src="image1.png" alt="Images generated by IGATY system" /></td>
</tr>
<tr>
<td>Image C: Eggs in variety of colors</td>
<td><img src="image2.png" alt="Images generated by IGATY system" /></td>
</tr>
<tr>
<td>Image G: Tree branch (black&amp;white)</td>
<td><img src="image3.png" alt="Images generated by IGATY system" /></td>
</tr>
<tr>
<td>Image I: Random Text (black&amp;white)</td>
<td><img src="image4.png" alt="Images generated by IGATY system" /></td>
</tr>
</tbody>
</table>

4.2.7. IGATY- Vitrine Exploration

In Part 1, the Vitrine archetype was defined as a display aesthetic associated with a container for displaying significant or ordinary objects. The core signal in the Vitrine archetype was defined as encapsulation. The Vitrine archetype in the IGATY-beta system is a dependent archetype that requires other archetypes such as the Grid or Wunderkammer archetypes for its
physical manifestation. In the IGATY-beta system, no parameter setting is provided for the user to set. The condition that the user can incorporate into the Vitrine archetype is (1) when the chromosome contains physical objects and (2) when the Vitrine archetype option button is on. Once these two conditions are met, the algorithm first copies each object in a chromosome and then makes it a translucent container; the original objects are reduced 30% in scale to make them appear encapsulated in the new container. This rule is applied to any object or shapes the user selects.

**Figure IV-47.** Vitrine exploration 1: (left) an example of Grid without Vitrine (Vitrine is frozen, Grid is based on x=4, y=4, z=4, object is sphere), (right) an example of Grid with Vitrine (Freeze option is off, Grid is based on x=4, y=4, z=4, object is sphere).

**Figure IV-48.** Vitrine exploration 2: (Left) an example of Wunderkammer without Vitrine (Vitrine is frozen. Wunderkammer is based on rectangular parallelepiped, number of objects=8), (Right) an example of Wunderkammer with Vitrine (Freeze option is off, Wunderkammer is based on rectangular parallelepiped, number of objects=8, Consistent option).
**Figure IV-49.** Vitrine exploration 3: examples of Wunderkammer with Vitrine (Freeze option is off, Wunderkammer is based on sphere shape, number of objects=14, Various option).

**Table IV-17.** Extended Vitrine exploration

<table>
<thead>
<tr>
<th>Vitrine exploration</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGATY generation after manipulation in Unity was applied (object scale manipulated)</td>
</tr>
<tr>
<td>IGATY generation after manipulation in Unity was applied (object color changed, new objects added)</td>
</tr>
<tr>
<td>IGATY generation after manipulation in Unity was applied (an image added to objects)</td>
</tr>
</tbody>
</table>

In the IGATY advanced-designer version, the one integrated with the Unity game engine, the system allows the user to explore further with Vitrine by changing the location of the object, adding new objects in the virtual space, or by changing the size of the objects and the like. The IGATY system recognizes the manipulated objects and generates offspring reflecting the
changes made in Unity. *Table IV-17* demonstrates some of the examples that the IGATY advanced-designer version created. With the manipulation made in Unity, designers can experience unconventional aesthetics.

### 4.2.8. IGATY- Coevolution Exploration

One of the most significant questions I asked in Chapter 1 was whether each archetype could be combined with other archetypes in the proposed IGATY-beta system. As Galanter (2010) argues, the genetic algorithm and representation will be more useful and meaningful when it overcomes the problems of fitness bottleneck and lack of innovation. In an attempt to foster innovation and creativity I focused on complexification by synthesis, employing the idea of the malleable structure of archetypes and the biological concept of coevolution. Complexification by synthesis is the process to enhance complexity in a chromosome by combining different archetypes and adding them into a single chromosome. Influenced by the coevolution (Yip et. al, 2008) process in bioinformatics, I incorporated the idea of coevolution with the idea of complexification by synthesis and implemented this concept into the system.

The coevolution map in *Figure IV-50* demonstrates the correlations among the six archetypes selected for this research. Due to its unique characteristics not all archetypes can be combined with all other archetypes. For instance, two projection-based archetypes, Poetic Light and Scalar cannot be combined with Vitrine, which always requires physical objects. However, Vitrine can appear with Poetic Light and Scalar if annexed to archetypes with physical objects such as Grid or Wunderkammer. Grid is the most inclusive among the six archetypes and can be combined with any of the other five archetypes. Wunderkammer can also be extensively combined with other types except Spatial Drama in the current version. The IGATY-beta version
is not capable of incorporating the manipulated multiple angles of segmented walls in Spatial Drama with Wunderkammer.

**Figure IV-50.** Coevolution map: Correlations among the six selected archetypes. In the IGATY-beta version, Vitrine appears when the chromosomes contain physical objects. (e.g. Grid, Wunderkammer).

Unless the *Freeze* button is off, combinations are possible to mutually evolve together in the combined chromosomes. In order to give the user control while enhancing flexibility of the combination process, each archetype can be put into the *Freeze* mode to stop its evolutionary algorithms. This freeze function enables the user to see the coevolution of other archetypes and
continue his or her aesthetic search while keeping the design of the frozen archetypes (*Table IV-18*).

*Figure IV-51* displays the coevolution map of the Spatial Drama archetype based on two, three, four, and five archetypes combinations available in the proposed IGATY-beta system.

Combinations of two archetypes

a: Spatial Drama + Grid

b: Spatial Drama + Scalar

c: Spatial Drama + Poetic Light

Combinations of three archetypes

d: Spatial Drama + Grid + Scalar

e: Spatial Drama + Grid + Poetic Light

f: Spatial Drama + Grid + Vitrine

g: Spatial Drama + Scalar + Poetic Light

Combinations of four archetypes

h: Spatial Drama + Grid + Scalar + Poetic Light

i: Spatial Drama + Grid + Vitrine + Scalar

j: Spatial Drama + Grid + Vitrine + Poetic Light

Combinations of five archetypes

k: Spatial Drama + Grid + Scalar + Poetic Light + Vitrine
Figure IV-51. Spatial Drama coevolution map
### Table IV-18. Coevolution exploration 1

<table>
<thead>
<tr>
<th>Images used</th>
<th>Examples of coevolution generated in the IGATY system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalar + Grid (Freeze off)</td>
<td><img src="Images" alt="Images" /></td>
</tr>
<tr>
<td>Scalar + Grid (Freeze on for Grid)</td>
<td><img src="Images" alt="Images" /></td>
</tr>
<tr>
<td>Poetic Light + Scalar (Freeze off)</td>
<td><img src="Images" alt="Images" /></td>
</tr>
<tr>
<td>Poetic Light + Scalar (Freeze on for Scalar)</td>
<td><img src="Images" alt="Images" /></td>
</tr>
<tr>
<td>Wunderkammer + Poetic Light (Freeze off)</td>
<td><img src="Images" alt="Images" /></td>
</tr>
<tr>
<td>Wunderkammer + Poetic Light (Freeze on for Poetic Light)</td>
<td><img src="Images" alt="Images" /></td>
</tr>
</tbody>
</table>
If multiple archetypes are combined in one chromosome, the user can experience a higher level of visual complexity (Table IV-19). With a dynamic manipulation and an interaction in Unity, the design solution space becomes larger, and the design grows into something more complex and unconventional.

**Table IV-19. Coevolution exploration 2**

<table>
<thead>
<tr>
<th>Images used</th>
<th>Examples of coevolution generated in IGATY system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalar + Grid + Poetic Light + Spatial Drama + Vitrine</td>
<td><img src="image1.png" alt="Example Image" /> <img src="image2.png" alt="Example Image" /></td>
</tr>
<tr>
<td>Scalar + Grid + Poetic Light + Spatial Drama</td>
<td><img src="image3.png" alt="Example Image" /> <img src="image4.png" alt="Example Image" /></td>
</tr>
</tbody>
</table>
In Part 2 the IGATY-beta version system was designed and its basic functions were tested. In the IGATY-beta version system the core signal was mapped to define each archetype, and the peripheral initiates the variables to give physical manifestation to the archetype. The peripheral also allows the mutation and crossover operations of genetic algorithms to work in five of the archetypes tested in this research; the mutation and crossover operation concept was not included on Vitrine because it is defined as a dependent archetype. The results in this part demonstrate that coevolution works in the system, allowing complexification of synthesis. The results also demonstrate that with user interaction the design evolves towards the designer’s intended scheme. However, due to the limited number of genes in one chromosome, the Scalar archetype showed small populations to evaluate. To overcome this problem the mutation and crossover operation was removed for the Scalar archetype in the beta version system to allow a larger solution space using only the random range for the camera positions and projection angles. The results also show that in the advanced version that is integrated with Unity, the system displayed some potential to be used as a search tool for unconventional aesthetics. In summary, the fundamental mechanism of mapping archetype’s dual structure works for most of the museum interior archetypes. If defined as a dependent archetype, it requires other archetypes to coexist to make the mechanism work. The overall performance of the system demonstrated that if the core signal and the detailed aspects of each archetype’s unique peripherals are clearly defined, this application can be expanded to other archetypes.
4.3. Part 3: Validation of Educational Potential of IGATY

This section demonstrates the procedure of the quasi-experiment conducted for this study and presents results from the pilot study and the main experiment used to answer the general question component No. 3: Validation of the educational potential of the proposed generative abstraction system in design education. The research questions are as follows: 1. If the application of IGAs to museum interior archetypes is viable, will this help participants understand the malleable structure of archetypes and their potentials for invention? 2. Does the coevolution process (the combination of two or more different archetypes) in the proposed system trigger a synthetic thinking process? 3. Does using the proposed generative abstraction system help participants improve creativity in an ideation workshop? 4. Does using the proposed generative abstraction system help participants improve creative confidence? 5. In delivering the archetypes exercise, does implementing virtual reality technology make a difference in students’ creativity and creative confidence?

4.3.1 Overview of Experiments

The pilot study was conducted on January 17 – 18, 2015 (Saturday, 2:00–4:00pm and Sunday, 1:00–4:10pm), and seven students participated. The main experiment was conducted on January 24 – 25, 2015 (Saturday, 2:00–4:00pm and Sunday, 1:00-4:25pm), and twelve students participated. Participants were recruited from sophomores in the department of Interior Design and the department of Architecture in the College of Design at Iowa State University. One typical design studio space was used for the introduction to the workshop, the archetypes lecture designed for this experiment, and the pattern recognition exercise. Both the pilot study and the main quasi-experiment were conducted in the College of Design building. Three separate design
studio spaces (*Figures IV-52, IV-53, and IV-54*) were used for the ideation workshops:

Participants worked individually and were not allowed to move to other rooms. Two computer labs (*Figure IV-55 and IV-56*) in the same building were used for IGATY training and treatment designed for this experiment. Upon completion of the two-day workshop, participants were provided with compensation in the form of $10 gift cards.
Survey questionnaires were administered four times during the quasi-experiment. Different sections were included at different times to examine the change before and after the treatment (Table IV-20).

**Table IV-20.** Survey sections and distribution plan.

<table>
<thead>
<tr>
<th>Survey Sections</th>
<th>Survey Contents</th>
<th>Survey ONE: Before Workshop 1</th>
<th>Survey TWO: After Workshop 1</th>
<th>Survey THREE: Before Workshop 2 (After Treatments)</th>
<th>Survey FOUR: After Workshop 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td>Demographic data</td>
<td>O (included)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Section B</td>
<td>Understanding of archetypes and typological thinking</td>
<td>O</td>
<td>-</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>Section C</td>
<td>Attitudes towards high-end technology</td>
<td>O</td>
<td>-</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>Section D</td>
<td>Learning experience of archetypes exercise in lesson plans</td>
<td>-</td>
<td>-</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>Section E</td>
<td>Attitude towards ideation workshop</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>Section F</td>
<td>Workshop experience</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>Section G</td>
<td>Self evaluation of ideation workshop</td>
<td>-</td>
<td>O</td>
<td>-</td>
<td>O</td>
</tr>
</tbody>
</table>

**Figure IV-57.** Two-day workshop schedule for quasi-experiment
Hardware Used for the Experiment

All participants in the IGATY-S and IGATY-VE groups used Mac OS X Version 10.9.4 (3.2 GHz Quad-Core Intel Xeon) to work with the proposed software. The IGATY-VE group also used another laptop Mac OS X Version 10.9.5 2.5 GHz Intel Core i7 to which an Oculus Rift DK2 head-mounted display was connected. The viewing height (eye level) for the head mounted display was set to 5 feet, 10 inches.

Software Used for the Experiment

For the IGATY-S and IGATY-VE groups the IGATY-beta system (beginning-designer version) developed for this research was used for the experiment. Camtasia 2, a screen recording software, was installed in all the computers that the participants used.

4.3.2 Pilot Study

4.3.2.1. Procedure

The pilot study was conducted for two days: the Day 1 component, including Workshop 1, took place on Saturday, January 17, 2015 from 2:00pm until 4:00pm and the archetypes lecture including pattern recognition exercise, treatment, and Workshop 2 took place on Sunday, January 18, 2015 from 1:00pm until 4:10pm. Seven (two male students and five female students; six within 18-20 age range, one within 24-26 age range) sophomore students in the department of Architecture (3 participants) and the department of Interior Design (4 participants) were recruited for the pilot study. Four trained research assistants participated in the pilot study. In order to minimize the potential bias of different instruction styles, there were minimal interactions between the workshop leaders and students, such as giving instructions, answering questions,
and helping students to manage time. The research assistants also encouraged participants to move on if they observed a participant spending too much time on one step.

After a short introduction to the experiment, the consent form was distributed for participants to read and sign. The survey questionnaires were also distributed before starting the Workshop 1. The survey questions included Section A: Demographic data, Section B: Understanding of typological thinking, Section C: Attitudes towards high-end technology, and Section E: Attitude towards ideation workshop. After the consent forms and survey questionnaires were collected, the ideation workshop project and the artist were introduced to participants, and 90 minutes were given for the ideation workshop.

Two experts (studio instructors in the department of architecture and the department of interior design) evaluated the participants’ projects after Workshop 1. Then participants were assigned to three groups for the day-two experiment: It was intended that the participants were equally distributed based on the evaluation results; however, due to a small number of participants the mean value of each group was not the same. On day two the archetypes lecture was given to the participants, followed by the pattern recognition exercise. The archetypes lecture and the pattern recognition exercise were given in one room to avoid any bias caused by different teaching environments. After the archetypes lecture and the pattern recognition exercise each group was guided to its designated room for different treatments. After group treatment participants followed research assistants to move to each of their designated studio spaces to work on Workshop 2.
4.3.2.2. Pilot Study Results

Creativity Enhancement

The main purpose of the pilot study was to see if the design of a quasi-experiment is suitable for this study to recognize IGATY’s contribution to creativity enhancement and the understanding of archetypes. First, in order to measure participants’ creativity in the ideation workshop, the Consensual Assessment Technique was used. In the creativity cluster, nine sub-categories were assessed.

Table IV-21. Evaluation of creativity (Consensual Assessment Technique)

*Using your own subjective definition and judgment, please rate student projects on each dimension.*

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation in shapes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novel use of materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novel idea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novel use of colors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detail</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effort evident</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novel Idea to enhance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multisensory Experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cronbach’s alpha was calculated to examine if each subject of the nine sub-categories within the creative component measures the same construct of creativity. In the pilot study,
Cronbach’ alpha was .96 for Workshop 1 and .93 for Workshop 2, indicating strong internal consistency for the overall measure of creativity. Mean values of the scores in each group were calculated to compare before and after the treatment. Figure IV-58 clearly shows that there was significant improvement in creativity for all three groups in Workshop 2 after the treatment: Group M improved from 3.83 to 5.03 in a 1 to 7 scale; IGATY-S group improved from 3.39 to 5.11; IGATY-VE group improved from 2.81 to 4.33.

![Creativity Scores (CAT)]

**Figure IV-58.** Creativity of Ideation Workshop 1 and 2 (Pilot Study, n=7: 2(M), 2(IGATY-S), 3(IGATY-VE))

- CATW1: mean value of creativity score of Workshop 1
- CATW2: mean value of creativity score of Workshop 2
- Cronbach’s alpha: .96 (Workshop 1), .93 (Workshop 2)
- Inter Rater Reliability: .86 (Workshop 1), .75 (Workshop 2)

**Figure IV-59** demonstrates that the amount of increase was different for each group: IGATY-S group showed the highest increase among the three groups. Creativity improvement was calculated by subtracting the mean value of the creativity score of Workshop 1 from the mean value of the creativity score of Workshop 2; then the increase was calculated as a percentile based on a 7-point scale. The participants’ creativity in Workshop 2 increased 1.72 in the 7-point scale, which is equivalent to a 25% improvement, marking the highest increase.
among the three groups. The IGATY-VE group showed the second highest increase (1.57, 22%); the Manual group showed the lowest increase (1.2, 17%). This data suggests that the three different archetypes lesson plans have different effects on creativity improvement in an ideation project. Several possible contributing factors may be responsible for the differences in increase. Among the possible factors the difference is likely due to the contribution of the features and functions available in the IGATY-beta system. The IGATY-beta system can generate and display multiple variations, thereby making the combination of different archetypes easier: This probably helped participants consider more options and inspired them to be more creative in the workshop.

Figure IV-59. Creativity Improvement in Workshop 2 (Pilot Study, n=7: 2(M), 2(IGATY-S), 3(IGATY-VE))
Creative Improvement = (CATW2 (mean value of creativity score of Workshop 2) - CATW1 (mean value of creativity score of Workshop 1))/7 x 100
Cronbach’s alpha: .96 (Workshop 1) .93 (Workshop 2)
Inter Rater Reliability: .86 (Workshop 1), .75 (Workshop 2)

Creative Confidence and Self Evaluation of the Creative Ideation Process

Creative confidence is considered to be an indicator for creative achievement or productivity (Barron & Harrington, 1981; Bandura, 1993; Tierney & Farmer, 2002). To see the IGATY-beta system’s contribution to the participants’ belief in being creative and creative performance, creative confidence was measured two times for each workshop. Creative
confidence before the workshops measures perceived self-efficacy of being creative. The questions to measure the overall creative efficacy before the workshops included the following:

*Table IV-22.* Questionnaire, Section E: Attitude Towards Ideation Workshop (Creative Confidence).

<table>
<thead>
<tr>
<th>I consider myself to be a creative person.</th>
<th>1 2 3 4 5 6 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel designing is a playful activity.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>I feel that I have a good imagination</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>I feel confident that I can be creative in the workshop.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>I feel confident that I can be creative in coming up with multiple options.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>I feel confident that I can be creative in combining variations.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>I feel confident that I can be creative in transforming variations.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

Self-evaluation of the creative ideation process after the workshops measured if the participants felt that they were actually able to creatively perform during the ideation process. Questions to measure the overall self-evaluation of their creative attitude during the workshop included the following (Questions were developed based on Kreitler and Casakin’s (2009) research: *Motivation for Creativity in Design Studies*):

*Table IV-23.* Questionnaire, Section F: Workshop Experience (Self-evaluation of ideation process)

<table>
<thead>
<tr>
<th>I liked the design problem.</th>
<th>1 2 3 4 5 6 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>During the course of designing,</td>
<td>1</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>I felt as if the task was like a game and that designing was a playful activity.</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I was creative during the course of designing.</td>
<td></td>
</tr>
<tr>
<td>I feel that I have had many good ideas and good design intentions that I did not apply and include in the final design.</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I was able to come up with multiple ideas or variations.</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I was able to combine multiple ideas or variations.</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I was able to transform multiple ideas or variations.</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I considered more aesthetic aspects than practical and applied aspects.</td>
<td></td>
</tr>
</tbody>
</table>

To examine the effect of the three different treatments, participants’ ratings of their creative confidence before Workshop 1 and before Workshop 2 were compared. There was no noticeable effect of the treatment on creative confidence before the workshops (Figure IV-60a). An interesting result was found in the participants’ rating of their creative performance during the ideation process, which was measured after Workshop 1 and Workshop 2 (Figure IV-60b). Although participants did not show differences in their creative confidence before workshop 1 and before Workshop 2 (after treatment), a significant increase was found especially in the IGATY-VE group in terms of their self-evaluation of their creative ideation performance ratings after Workshop 2 compared to their ratings after Workshop 1 (Figure IV-61). This result implies that the archetypes exercise using IGATY-VE helped bring the participants’ perception of their actual creative performance to the level of their perception of self as creative measured before the workshops. This trend in the IGATY-VE user group is also related to their self-evaluations of creativity in their final project.
**Figure IV-60a. (Left)** Creative confidence measured before Workshops 1 and 2. W1: mean value of creative confidence rating before Workshop 1, W2: mean value of creative confidence rating before Workshop 2.

**Figure IV-60b. (Right)** Self-evaluation of creative ideation measured after Workshops 1 and 2. W1: mean value of creative self-evaluation of creative ideation after Workshop 1, W2: mean value of creative self-evaluation of creative ideation after Workshop 2 (Pilot study, n=7: 2(M), 2(IGATY-S), 3(IGATY-VE)).

**Figure IV-61.** Self-evaluation of creative work measured by participants after Workshop 1 (W1) and 2 (W2). W1: mean value of self-evaluation of creative work after Workshop 1, W2: mean value of self-evaluation of creative work after Workshop 2 (Pilot study, n=7: 2(M), 2(IGATY-S), 3(IGATY-VE)).

**Understanding of Archetypes**

Perceiving archetypes as a flexible system is critical to fully exploit the archetypes’ relevant benefit for generating ideas through transformation. Section B in the questionnaire was
designed to measure the change of participants’ perception of archetypes and typological approach to design.

**Table IV-24.** Questionnaire, Section B: Understanding of Archetypes and Typological Thinking

**Section B: Understanding of Archetypes and Typological Thinking**
The following questions concern your general understanding of the attributes of archetypes and typological thinking approach in design.

Please indicate how you feel about relationships between the words listed and archetypes by marking the numbers on the right. (For example, if you feel archetypes and “sameness” are closely related, mark 7).

<table>
<thead>
<tr>
<th>ARCHETYPES</th>
<th>Not related</th>
<th>Closely related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sameness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Similarity</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Diversity</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

Please indicate how you feel about typological thinking in design by marking the numbers on the right. (For example, if you strongly agree that typological thinking is for categorizing, mark 7).

<table>
<thead>
<tr>
<th>TYPOLOGICAL THINKING is for</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorizing</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Imitation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Variation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Combination</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Transformation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Invention</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
The specific areas I examined were indicators that exhibited a conceptual and fundamental understanding of archetypes as a flexible system: flexibility, diversity, variation, combination, transformation, and invention. *Figures IV-62, IV-63, and IV-64* show that the archetypes exercise and treatment designed in this research positively changed participants’ general understanding of archetypes and typological approach, implying that participants considered archetype as a flexible system and appreciated the archetype’s potential for future development and innovation after the designed archetypes lessons were provided. This trend was most obvious in the IGATY-VE group: It may have resulted from the experience in both the IGATY-beta system and the virtual environment.

*Figure IV-62.* General understanding of archetypes and typological approach to design, M(manual) group (n=2(M))
Summary of Pilot Study

In the pilot study nine detailed elements were included in the creativity component to measure creativity. The high Cronbach’s alpha value indicated a strong internal consistency for the overall measure of creativity. As I hypothesized, the overall contribution of the IGATY-beta system to participants’ creativity in ideation was positive. Interestingly, although the IGATY-S group showed the highest improvement of creativity in Workshop 2, participants of the IGATY-
VE group generally showed significant improvement in self-evaluation of their creative ideation performance after Workshop 2 and positive improvement in their understanding of archetypes. This data suggests that combining IGATY software displayed on a screen with the virtual-environment experience will maximize the benefit of the IGATY system.

4.3.3 Main Quasi-Experiment

4.3.3.1. Procedure

The main quasi-experiment was conducted for two days: the Day 1 component including Workshop 1 took place on Saturday, January 24, from 2:00pm until 4:00pm, and the archetypes lecture, the pattern recognition exercise, the treatments, Workshop 2, and the 10 min. mini focus group session took place on Sunday, January 25, from 1:00pm until 4:25pm. Twelve sophomore students in the department of Architecture (10 participants) and the department of Interior Design (2 participants) completed the two-day workshops designed for the main quasi-experiment: ten male students and two female students; ten within 18-20 age range, one within 21-23 age range, and one within 30-32 age range. Five trained research assistants participated in this research: During the treatment, one research assistant was assigned to the group M; two research assistants who took the IGATY training session were assigned to the IGATY-S group exercise and workshops; and two other research assistants who participated in the IGATY with Virtual Environment integration training session were assigned to the IGATY-VE group exercise and workshops. The research assistants who were in charge of the computer labs were responsible for installing the IGATY-beta software, and the Camtasia screen recording software and collecting data of images saved by participants during the exercise and the screen recordings during the entire session. They also helped participants who had technical problems.
A few changes were made for the main quasi-experiment: During the pilot study, we observed that students did not spend all 90 minutes in the second workshop because they had already conducted research about the artist in Workshop 1. In the main quasi-experiment 80 minutes were used for workshops instead, and 10 minutes were given for research only for the first workshop. A 5-minute break was also added after the archetypes exercise and Workshop 2 after observing that participants seemed tired during Workshop 2 in the pilot study. To calculate the rate of gamers among the participants, questions that ask if they play games and the hours they play games per week were included. 83% of participants play games from less than 1 hour to 5–7 hours per week.

![Pie chart showing video game play hours]

**Figure IV-65.** Hours participants play video (or Internet) games during an average week (N=12)

Another change made in the main quasi-experiment was adding a mini focus group session after all the workshops and the surveys were complete. Each group participated in a 10 minutes mini focus group session to discuss how they felt about the archetypes and the exercise designed for each group.

During workshops, in order to minimize potential bias of different instruction styles, there were minimal interactions between the research assistants as workshop leaders and participants. Research assistants gave instructions, answered questions, and helped students
manage time by encouraging participants to move on if they observed a participant spending too much time on one step. Research assistants were asked to document the workshop in a brief observation note format. Four experts (three studio instructors in the department of architecture and one studio instructor in the department of interior design) evaluated participants’ projects. There was a wide range in levels of experience in design education from those with less than 5 years to one evaluator having 41 or more years of experience. It was intended that the participants were equally distributed based on the evaluation results, however, due to the small number of participants as well as an unexpected absence of three participants in Workshop 2, the mean value of each group was not the same. All other procedures were the same as the pilot study.

*Figure IV-66. Exercise using the IGATY-beta system. (Screen capture images from quasi-experiment)*
4.3.2.2. Main Quasi-Experiment Results

Creativity enhancement

To measure the IGATY software’s contribution to increasing participants’ creativity in the ideation workshop, the Consensual Assessment Technique used for the pilot study was used for the main quasi-experiment. Cronbach’s alpha was calculated again to examine if the nine sub-categories within the creative component measure the same construct of creativity. In the main quasi-experiment, Cronbach’s alpha was .93 for Workshop 1 and .94 for Workshop 2 which indicate strong internal consistency for the overall measure of creativity.

Figure IV-67a. An example of a participant’s final ideation workshop design 1

Figure IV-67b. An example of a participant’s final ideation workshop design 2
The mean values of the scores in each group were calculated to compare creativity in the participants’ ideation workshop projects before and after the treatment. Although the increase values are different from the pilot study, a consistent trend was obtained in the main quasi-experiment. Figure IV-68 demonstrates that there was a significant improvement in creativity in the IGATY-S group and the IGATY-VE group in Workshop 2 after the treatment: Group M improved from 4.08 to 4.71 in a 1 to 7 scale; the IGATY-S group improved from 4.33 to 5.56; and the IGATY-VE group improved from 4.73 to 5.85.
Although the increase values were not the same as the pilot study, Figure IV-69 presents that the amount of increase was different for each group: As noticed in the pilot study, the IGATY-S group showed the highest increase in creativity among the three groups. The participants’ creativity in Workshop 2 increased 1.23 in a 7-point scale, which is equivalent to an 18% improvement, marking the highest increase among the three groups. The IGATY-VE group also showed the second highest increase (1.12, 16%). The Manual group showed the lowest increase (.63, 9%). As discussed in the results of the pilot study, this data suggests that the three different archetypes lesson plans have different effects on creativity in ideation, especially between the non-IGATY user group (M) and the IGATY user groups (IGATY-S and IGATY-VE). The IGATY user groups consistently showed higher creativity improvement. Creativity improvement of the IGATY-S and the IGATY-VE groups were slightly different; however, the overall trend showed a strong consistency in the pilot study and the main quasi-experiment. This trend clearly indicates the IGATY system’s contribution to enhancing creativity in the ideation
process: this may have resulted from the function of the IGATY-beta system that generates and displays multiple variations, making divergent thinking more effective. It might also be partially due to the combination function of the IGAT-beta system: Participants can combine different archetypes and try multiple combinations, which would make the design combination process more efficient.

![Creativity Improvement Chart]

**Figure IV-69.** Creativity improvement in Workshop 2 (main quasi-experiment, n=12: 4(M), 4(IGATY-S), 4(IGATY-VE))

Creative Improvement = (CATW2 (mean value of creativity score of workshop 2) - CATW1 (mean value of creativity score of Workshop 1))/7 x 100

Cronbach’s alpha: .93 (Workshop 1) .94 (Workshop 2)

Inter Rater Reliability: .62 (Workshop 1), .70 (Workshop 2)

In order to measure detailed aspects of creativity I also looked at each sub-category in the creativity cluster used in the CAT measurement. Among the nine different categories the IGATY-S group showed the highest improvement in the following categories: creative use of materials, creative use of colors, multi-sensory design ideas, and details. This suggests that the IGATY-beta system helped the participants in the IGATY-S group focus more on the multi-sensory aspect and detailed colors and materials, and this influence might affect participants to generate more creative ideas using colors or multi-sensory design ideas. It is worth noting the following comments from the experts who served as judges:
Very unusual way of display. It was a great match with inspiration from the original artworks. (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-S group)

He/she DID variation + combination + transformation all in the brainstorming. Very good! (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-S group)

**Figure IV-70.** Improvement in detailed areas of the creativity component: M (manual) Group (n=4)

*Workshop1:* mean value of each creative component in Workshop 1

*Workshop2:* mean value of each creative component in Workshop 2
Figure IV-71. Improvement in detailed areas of the creativity component: IGATY-S Group (n=4)

- Workshop1: mean value of each creative component in Workshop 1
- Workshop2: mean value of each creative component in Workshop 2

Figure IV-72. Improvement in detailed areas of the creativity component: IGATY-VE Group (n=4)

- Workshop1: mean value of each creative component in Workshop 1
- Workshop2: mean value of each creative component in Workshop 2

Interestingly, the IGATY-VE group showed the greatest improvement in the following areas (Figure IV-72): creativity (sub-category in the creativity cluster), novel ideas, variation in
shape, and complexity. This data implies that the IGATY-VE group benefited from the virtual reality experience and it helped them generate more creative and complex ideas compared to the other groups. Although the overall creativity improvement ranked second among the three groups, this group received many positive compliments from the experts.

*It was impressive to use the whole surface of the space in various ways, very specific theme was successful (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-VE group)*

*Excellent concept and execution. Not much of brainstorming but variation sketches. True variation. (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-VE group)*

*Process and light effect was good. (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-VE group)*

*Best developed idea. Thoughtful, playful, well expressed. (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-VE group)*

*Maze of emotions! Very good plan! (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-VE group)*

*This sequence of experience makes gradation of inspiration and variations of views. Impressive. (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-VE group)*

*The final proposal is much more engaging in terms of space + experience. (From the expert’s comments on final design in Workshop 2 done by one of the participants in the IGATY-VE group)*

To measure which stage of the ideation process leads to the difference in creativity scores in the three groups, the four experts also graded each participant’s ideation process based on the quality of the process work in the variation, combination, and transformation stages. I hypothesized that the variation stage helps improve divergent thinking skills and the combination stage helps improve synthetic thinking skills. Interestingly, improvement of the quality of the ideation process in the *combination* stage shows similar patterns to the improvement of creativity
in their final work. This implies that using IGATY software might improve synthetic thinking skills and that the improvement of synthetic thinking skills leads to creativity in the final design in the whole ideation process.

*Table IV-25.* Example: Ideation sketches (variation, combination, transformation)

<table>
<thead>
<tr>
<th>Stage in Ideation Process</th>
<th>Sketch Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Variation Stage</td>
<td><img src="image" alt="Sketches" /></td>
</tr>
<tr>
<td>From Combination Stage</td>
<td><img src="image" alt="Sketches" /></td>
</tr>
<tr>
<td>From Transformation Stage</td>
<td><img src="image" alt="Sketches" /></td>
</tr>
</tbody>
</table>
In order to clarify the correlation between the synthetic thinking stage (combination process in ideation) and creativity in the final product, scores from all participants’ Workshop 1 and Workshop 2 projects were used to measure the correlation between each ideation stage (variation, combination, transformation) and creativity in final design. Correlation between the quality of the ideation process in the variation phase and creativity in the final design was weak ($r = .38$); however, the result (Figure IV-74) shows that there is a significant correlation ($r = .56$, Sig. (2-tailed) = .001) between the quality of the combination stage ideation and creativity in the final design. There is also a significant correlation (Table IV-26, $r = .50$, Sig. (2-tailed) = .005) between the quality of the transformation phase work and creativity in the final design. Moreover, correlation between combination and transformation was significant (Table IV-26, $r = .63$, Sig. (2-tailed) = .001). These data imply that if a participant’s combination stage was successfully completed, there is a higher possibility that the participant is successful in the final design. A strong correlation between combination and transformation is also important to note because helping participants to do better in the combination stage has a significant effect in improvement in the transformation stage, leading to a successful final design. These results strongly support
Mobley et al.'s (1992) creativity theory about the combination process of diverse categories to enhance creative products.

Figure IV-74. Scatterplot of correlation: quality of the combination stage in the ideation process and creativity in the final design (n=24) Pearson Correlation: r = .56 Correlation is significant at the 0.01 level (2 tailed)

Table IV-26. Correlations: w1 (creativity in final design), variation1 (ideation quality in variation stage), combination1 (ideation quality in combination stage), transformation 1 (ideation quality in transformation stage) (n=24)
Creative Confidence and Self Evaluation of Creative Ideation Process

To examine if the archetypes exercise affected the participants’ rating of creative confidence before the workshops and self evaluation of creative performance in the ideation process, the survey questions were administered four times: before Workshop 1, after Workshop 1, before Workshop 2, and after Workshop 2. Questions that measure creative confidence before the workshops ask if participants perceive themselves as creative and feel that they will be able to be creative in the ideation process. Questions that measure self-evaluation of creative performance in the ideation process ask if participants actually feel that they were able to creatively perform during the ideation process to generate multiple ideas, combine different ideas, and transform ideas further.

Creative confidence before and after workshops did not show any significant differences: This implies that there was no noticeable effect of the archetypes exercise on creative confidence before Workshop 2 (Figure IV-75a). A similar trend in the pilot study showed that participants’ self evaluation of creative performance measured after Workshop 1 dropped, especially in group M and the IGATY-VE group, implying that participants first regarded themselves as creative; however, after the actual workshop participants’ self-evaluation of their creativity performance became lower. Interestingly, a significant increase was found especially in the IGATY-VE group in their self-evaluation of creative performance rating after Workshop 2 compared to their rating after Workshop 1 (Figure IV-75b). This result implies that the archetypes exercise using IGATY-VE helps bring the participants’ perception of their actual creative performance to the level of their perception of self as creative before the workshop. This trend in the IGATY-VE user group is also related to the participants’ self-evaluation of creativity of their project as well as the actual creative performance measured by the consensual assessment technique.
**Figure IV-75a. (Left)** Creative confidence measured before Workshops 1 and 2. W1: mean value of creative confidence rating before Workshop 1, W2: mean value of creative confidence rating before Workshop 2. **IV-75b. (Right)** Self-evaluation of creative ideation measured after Workshops 1 and 2. W1: mean value of creative self-evaluation of creative ideation after Workshop 1, W2: mean value of creative self-evaluation of creative ideation after Workshop 2 (Main quasi-experiment, n=12: 4(M), 4(IGATY-S), 4(IGATY-VE)).

**Figure IV-76.** Self-evaluation of creative work measured by participants after Workshop 1(W1) and 2(W2). W1: mean value of self-evaluation of creative work after Workshop 1, W2: mean value of self-evaluation of creative work after Workshop 2 (Main quasi-experiment, n=12: 4(M), 4(IGATY-S), 4(IGATY-VE)).
Understanding of Archetypes

The experiment also measured the understanding of archetypes. Perceiving archetypes as a flexible system is critical to fully exploit the archetypes’ relevant benefit for generating ideas through the transformation of archetypes. Section B in the questionnaire was designed to measure the change of the participants’ perception of archetypes and the typological approach to design. Figures IV-77, IV-78, and IV-79 show that the archetypes exercise and treatment designed in this research positively changed the participants’ general understanding of archetypes and the typological approach, implying that participants considered an archetype to be a flexible system and appreciated the archetype’s potential for future development and innovation after the designed archetypes activities. This trend was most obvious in the IGATY-VE group: it may have resulted from the experience in both the IGATY-beta system and the virtual environment that allowed the participants to actually observe how archetypes transform and evolve creating different spatial experiences.

Figure IV-77. General understanding of archetypes and typological approach to design, M(manual) group (n=4(M))
Learning Experience of Archetypes Exercise

Section D in the questionnaire was designed to measure the participants’ general impression of their learning experience of the archetypes exercise designed for this study. This section was added to measure the participants’ subjective assessment of the archetypes exercise lesson plan.
Table IV-27. Questionnaire Section D: Learning Experience of Archetypes Exercise

Section D: Learning Experience of Archetypes Exercise in Lesson Plans
The following questions are concerned with your feeling about your learning experience with Archetypes exercise in the specific lesson plan you participated in.
Please rate the following items on the left based on your behavior in the lesson you participated.

<table>
<thead>
<tr>
<th></th>
<th>Not at all true of me</th>
<th>Very true of me</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe understanding typological thinking is important.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>I am certain I understood the ideas practiced in the lesson plan.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>I feel what I learned from the lesson plan is useful.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The exercise in the lesson plan encouraged me to think about various options that can be created with each archetype.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The exercise in the lesson plan encouraged me to think about how I may reconstruct each archetype.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The exercise in the lesson plan encouraged me to think about how I may combine various archetypes to create a new one.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The overall lesson plan was fun and enjoyable.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The overall exercise gave me a lot of ideas I can use in the workshop.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>I feel confident that I can be creative in the workshop.</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

The IGATY-VE group showed generally the most positive response among the three groups (Figure IV-80). To the open-ended question that asks their opinion of the archetypes exercise they experience, participants in the IGATY-VE group also wrote positive comments regarding their experience. It is likely that the differences in the rating of the archetypes exercise experience reflect the benefits of the participants’ experience with the virtual environment.
At first I didn't know what to expect. I found myself with the limited archetypes knowledge. I did not even know what that words such as transform fully entailed. I then found myself deeply amazed by the different types of archetypes and their properties. I then found myself eager to apply archetypes into my designs (participant A in IGATY-VE).

It was helpful to me when I want to come up with more combinations (participant B in IGATY-VE).

Playing with the software was enjoyable (even though it could fell limited sometimes), and the pattern recognition experiment helped me quickly understand the archetypes (participant C in IGATY-VE).

The participants in group M wrote positive comments about their experience with the archetypes exercise lesson plan. This proves that the manual exercise of archetypes was still helpful to enhance the ideation process. It is worth noting that one comment was about combination. This shows that the participant was able to generate new ideas by combining archetypes.

It was interesting to combine archetypes to make a new one that allows for characteristics of both while still being its own entity (participant A in group M).

I think the exercise was useful for initial formation of ideas (participant B in group M).
Although the IGATY-S group showed the highest improvement in creativity, in the rating of the archetypes exercise experience, their rating was the lowest. The participants’ comments imply that they found the archetypes and typological approach useful; however, the problem with the tab key (see p. 221) caused a negative impression of the software. This result suggests the importance of the usability test of this software as a natural extension of this study.

*The idea and lesson of an archetype was good but the program on the computer didn't fully work so I didn't get the full experience (participant A in IGATY-S).*

*The computer problems prevented me from designing what I wanted. It was more of a burden than an aid (participant B in IGATY-S).*

*It was fun and interesting (participant C in IGATY-S).*

**Attitude Towards High-End Technology**

Section C in the questionnaire was designed to answer the question about whether the implementation of high-end technology (mainly virtual reality) changes the participants’ attitude towards high-end technology or not. This section was administered to the participants who used the IGATY software (IGATY-S and IGATY-VE groups) only. The result showed that the IGATY-VE group experienced a slight elevation in their attitudes towards high-end technology. There are two possible reasons for this: (a) participants in the IGATY-S group may still believe that the software is useful; however, the technical limitations might have hampered their positive perception of high-end technology; (b) although the IGATY-VE group noticed that the software has limitations, experience with the virtual reality environment heightened their positive perception of high-end technology.
Table IV-28. Questionnaire Section C: Attitudes towards high-end technology

Section C: Attitudes towards high-end technology
In this section, we want to find out YOUR opinion of high-end technology, such as advanced computer programs, apps, devices, 3-D printers, or virtual reality simulation.
Please answer the questions and let us know what you think of high-end technology. There are no right or wrong answers, so just mark the number that comes closest to what YOU think. Please answer all items.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would like to learn more about new technology.</td>
<td><img src="https://via.placeholder.com/150" alt="" /></td>
<td><img src="https://via.placeholder.com/150" alt="" /></td>
<td><img src="https://via.placeholder.com/150" alt="" /></td>
</tr>
<tr>
<td>I feel confident that I can do a good job using high-end technology.</td>
<td><img src="https://via.placeholder.com/150" alt="" /></td>
<td><img src="https://via.placeholder.com/150" alt="" /></td>
<td><img src="https://via.placeholder.com/150" alt="" /></td>
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Figure IV-81. Attitude towards high-end technology (n=8: 4(IGATY-S), 4(IGATY-VE))

10-minute Mini Focus Groups

A short focus group session was conducted after all the processes of the quasi-experiment were complete. Each group gathered in separate rooms, and one research assistant in each room
led the discussions based on four major questions: general impression of archetypes, experience of archetypes experience, experience with the IGATY software (IGATY-S and IGATY-VE group only), and virtual environment experience (IGATY-VE group only).

**M Group (Manual exercise group):**

Participants of the manual group first expressed their feeling about the archetypes exercise as a positive learning experience. One participant in this group mentioned that learning about archetypes and the pattern recognition exercise changed his/her attitude towards understanding design and the ideation process; more specifically, it changed it from thinking about ideas randomly looking for inspirations into observing things to compile information to categorize them to see the potential to be used in the project. This suggests that archetypes encourage participants to approach ideation systematically by encouraging an analytical manner rather than merely relying on intuition.

*I guess I was able to categorize everything I see around me rather than just think of an idea in my head and just look around for inspirations. I can see around and compile them and categorize them.* (From focus group interview with Manual Group, January 25, 2015)

*Pattern recognition exercises forces you to draw some layers between things that aren’t necessary super similar. That way, it kind of gives you an idea of the ways to [form] concrete archetypes.* (From focus group interview with Manual Group, January 25, 2015)

*I guess once you narrow it down to specific categories ... it is easier.* (From focus group interview with Manual Group, January 25, 2015)

The participants in the manual exercise group also mentioned that archetypes give a ground from which to start an ideation exploration. The participants felt that starting ideation based upon a certain foundational premise was helpful. The conversation developed into a discussion regarding the ideation: The participants generally agreed that the archetypes exercise makes the design ideation easier by providing a kind of “formula” for design. Considering the
level of academic year, this suggests that archetypes might be useful especially in the early stages of design education.

*Having some places to start, where to look at things rather than looking just around as a whole in like breaking [things] down. I think it makes it easier.* (From focus group interview with Manual Group, January 25, 2015)

*I think with this exercise it is easier for us to categorize everything. Because it makes it clear in our mind. So I think this is a good way ...when you start the design to sort of categorizing everything...and make decisions based on these categorization rather than just having all the stuff... narrow it down in a way.* (From focus group interview with Manual Group, January 25, 2015)

*I like that it gives some kind of formula for design...it gives something and we combine ideas and rework again for getting done ... I am a student and I am supposed to start ... because they are sometimes [saying] like “hey, make something” instead of giving the kind of process of thinking about going about designing.* (From focus group interview with Manual Group, January 25, 2015)

*The design process is overwhelming as for students who don’t know what that means. I think it is the very foundation of design. I think [the archetypes exercise] is helpful and makes it easier.* (From focus group interview with Manual Group, January 25, 2015)

One important finding was that, on one hand the manual exercise somehow helped participants to be more efficient and expedited the ideation process dealing with limited time given to them; however some participants mentioned that their manual exploration in creating variations was not very successful because they ended up creating many similar forms. Their expressions of frustration imply that some students who struggle with generating different ideas at the beginning of the ideation process might benefit from using a tool that helps them be more efficient in generating more ideas effectively.

*I like working under pressure, having that kind of concept [of] time crunch makes me think faster and actually [be] more effective in the process.* (From focus group interview with Manual Group, January 25, 2015)

*I was a little frustrated when I had to draw more stuff when I couldn’t really...* (From focus group interview with Manual Group, January 25, 2015)
I agree on that. I went back referencing archetypes but after a while my drawings were pretty similar and it was a waste of time. (From focus group interview with Manual Group, January 25, 2015)

In answering the question about how archetypes can be developed to make them more useful, one participant suggested teaching archetypes from the perspective of the situational design approach. The central idea of archetypes is to sort out the very principles from the complex world and understand the core and the peripherals to create something new. What this conversation suggests is relevant to potential future developments of archetypes in that teaching archetypes should always emphasizes the archetypes’ close association with real world situations.

Not everything can be categorized in the same way. Because we all categorize things differently so, I think we should teach as . . . it is not just categorizing but rather ... like a grid system, if it works in a lounging area with lighting ... whatever you think is the best solution ... the categorizing ideas will find the best solution for the situational design. (From focus group interview with Manual Group, January 25, 2015)

IGATY-S Group (IGATY-beta system users, displayed on computer screen)

To the question that asks their general impression about archetypes, the participants in the IGATY-S group expressed positive impressions about the archetypes exercise using the IGATY system. The conversation suggests that participants used archetypes as seeds for ideas that can expand through the ideation, and the IGATY system was helpful in generating more ideas based on archetypes. Compared to the response from the manual group in which participants found themselves generating similar variations or got frustrated when they were asked to generate more variations, the IGATY-S group generally felt that the exercise was impressive and interesting and helped them generate more ideas. Most of the participants’ comments were about the IGATY system’s usefulness in helping their ideation. It is worth noting that one of the participants mentioned the benefit of the combination function. The participant felt that he or she
was able to make the aesthetic search more interesting by combining different archetypes. This clearly suggests that the IGATY system has potential to bring innovative ideas through complexification by synthesis.

*It allows us to expand our ideas. Going from what I was looking for in the last workshop yesterday, there were obviously more things...I was thinking more about different archetypes and how it can make the space work. (From focus group interview with IGATY-S group, January 25, 2015)*

*I think it is very impressive. Especially when I interact with the computer, I can combine different things to make it more interesting. I was able to generate more ideas. (From focus group interview with IGATY-S group, January 25, 2015)*

*I think it is good for someone like me ... it gives me a lot of thinking [in the design] process ... all I can get out from ...thinking process... oh I can do this, try to generate or which one is better and this one is more...I want to choose and to make it in my design. It helped my design thinking process. It was interesting. (From focus group interview with IGATY-S group, January 25, 2015)*

The participants discussed the advantage of viewing perspective views of objects in the virtual space displayed on the computer screen during their design search. Most of the participants in architecture and interior design are familiar with three-dimensional modeling program such as AutoCAD or Revit: Typically a designer can view one design option at a time, and if the designer wants to try many slightly different options, one should change the options one by one, in most cases in a plan view, and change the view option to see the perspectives. Their positive responses regarding the interactive dynamic perspective views in the application of IGAs is significant in this research because it suggests different points of view in understanding interactivity in the application of IGAs. The participant’s comment about changing elements or the placement of furniture using GAs implies that the participant saw the benefit of using genetic algorithms in design.

*I think it really helped. Just by looking at different colors, the way it changes the space, and the shape of the outside [perimeter wall] and how it appears inside. (From focus group interview with IGATY-S group, January 25, 2015)*
I think it would be very interesting to see if you have a certain number of objects in the premise stage, if you could take out ... just think of architecture and interior design standpoint, it you could manage to put furniture and switch out the furniture obviously you need a chair, and figure it out it could be very interesting to see if you can just switch it around in the placement...it would be interesting to see ... you know ... in a three dimensional way instead of looking at maybe a CAD plan... you can see the 3D view in CAD but you have to go back [to plan view].... (From focus group interview with IGATY-S group, January 25, 2015)

A problem with the tab key function in the IGATY-beta version was found during the experiment, and this malfunction affected participants’ view towards using high-end technology in design negatively. The tab key was used to generate next offspring after the evaluation and selection is done. The problem occurred when the user went to the Select Archetypes screen to change the parameter and came back to the main exploration screen: The user was supposed to finish the selection of the current generation and press tab to produce the next generation, then move to the archetypes selection screen to add or to change parameters. However, the system did not remember the previous selection of the previous generation once the user left the screen to change parameters. Two participants did not recognize the problem and simply evaluated and selected based on the current generation, and the other two participants wanted to change the computer assuming that it was a computer hardware problem.

I think technology does a lot for design for architecture... but when it doesn’t work when I was pressing the button to use it, it doesn’t help that... like they are here to make me creative but because we were running into problems... so the program has to be user friendly. (From focus group interview with IGATY-S group, January 25, 2015)

IGATY-VE Group (IGATY-beta system user group, used both computer screen and HMD)

The same question about their general impression of archetypes and the IGATY system was first asked to this group. The response was similar to the other groups in that the typological approach to design based on the understanding of archetypes was helpful in the ideation process,
especially in generating more ideas: It suggests the merit of understanding archetypes mainly in encouraging divergent thinking. The participants’ responses imply that archetypes provided a foundation for ideation. It is important to note that together with the IGATY-S group, this group also mentioned the benefits of using combination function (coevolution) in the IGATY system. It implies that exercises using the IGATY system helped their ideation process, especially in the combination stage.

*There were a variety of them [archetypes], and some have distinct uniqueness. I think they are helpful in generating ideas if you don’t really know how to start, you can just look at one of the archetypes and see what you can do with this. It is easier to get ideas.* (From focus group interview with IGATY-VE group, January 25, 2015)

*It makes it easier to combine to form ideas.* (From focus group interview with IGATY-VE group, January 25, 2015)

*Very neat. Very cool. We had more ideas this time. Yesterday we had no idea and did not know...what to expect.* (From focus group interview with IGATY-VE group, January 25, 2015)

The focus group with the IGATY-S group revealed that the IGATY interface that displays perspective views during the IGA operation played a significant role in the participant’s ideation process. The IGATY-VE group also appreciated the benefit of viewing chromosomes that change in form, position, or colors in the virtual space displayed on screen. One of the participants mentioned that viewing different perspectives from different angles in Virtual Reality triggered creative ideation. It is worth noting that the IGATY-VE group particularly mentioned the different perspective angles that the Oculus DK2 HMD enabled them to experience. Although it was possible to change the viewing angles on the IGATY screen, it required more time for the users to get used to controlling the keys to adjust views as desired. On the contrary, because the HMD allowed the users to view different views from various positions
and angles by tilting or rotating their head, controlling viewing angles was more convenient for
the IGATY-VE group.

\begin{quote}
It (IGATY-VE system) draws out, visualize it, so you can actually see it from different
perspectives and different angles…it generates more ideas. (From focus group interview
with IGATY-VE group, January 25, 2015)
\end{quote}

\begin{quote}
When you look at something one way and when you look at it from different ways you get
completely different ideas just by using it [the IGATY system]. (From focus group
interview with IGATY-VE group, January 25, 2015)
\end{quote}

The participants understood that it was a beta version and shared some ideas for
modification. First, one of the participants suggested making the archetypes more flexible in
terms of the combination function. The current IGATY-beta version does not allow all the six
archetypes to be combined. For instance, as the participant suggested, Wunderkammer does not
appear when the walls are manipulated with dynamic angles in the Spatial Drama archetype.
Flexibility in detailed functions of each archetype in the IGATY system should certainly be the
main focus in future developments. Interestingly, another participant recommended improving
flexibility in viewing objects at varying heights in virtual reality when using HMD. The main
intention of using HMD is to experience the presence in virtual reality from a human eye level
perspective: the viewing height was set to a typical eye level, 5’ 10” above the floor. From a
designer’s perspective on the other hand, it is also important to see the objects and the space
itself from far above or below the eye level. The current IGATY-beta version allows the user to
move the viewing position and height by using the keys on a keyboard and the mouse.

\begin{quote}
It [IGATY-beta system] was easy to use…I understand it was the beta version so it would
not be perfect… but it needs some modifications. There was no way to use all six: when
you have some things on the wall and when you want to have a dramatic space [referring
to spatial drama], I thought it would’ve been cool. Dramatic space and something on the
wall somehow. (From focus group interview with IGATY-VE group, January 25, 2015)
\end{quote}
It should be more flexible to view things like when you are making objects, if you can go up and down [in VE] it will actually be more obvious to make a turn... (From focus group interview with IGATY-VE group, January 25, 2015)

**Summary of Main Quasi-Experiment**

In the main quasi-experiment, the same nine creativity elements under the creativity cluster were used to measure the overall creativity. The high Cronbach’s alpha value indicated strong internal consistency for the overall measure of creativity. Overall, several similar trends were found in the pilot study and the main quasi-experiment: (1) the overall creativity improvement after the treatment was the highest in the IGATY-S group; (2) the IGATY-VE group generally showed significant improvement in self-evaluation of creative ideation performance after Workshop 2 and positive improvement in its understanding of archetypes and typological thinking. The results demonstrate that the improvement of the quality of the ideation process in the *combination* stage shows similar pattern as the improvement of creativity in the participants’ final ideation project. A correlation analysis that measures the relationship between the quality of the ideation process in the *combination* phase and creativity in the final ideation design showed a significant correlation ($r = .56$, Sig. (2-tailed) = .001). This implies that using the IGATY-beta system might improve synthetic thinking skills, and the improvement of synthetic thinking skills leads to creativity of the final ideation design. The focus group session also revealed some positive values of using archetypes and the proposed IGATY-beta system in the ideation process in design education.
CHAPTER V. DISCUSSION OF FINDINGS

This chapter includes the discussions and the expanded interpretations of the findings from the data analysis in Chapter 4. The main focus of the discussion is the proposed dual structure of archetypes and the previously unexplored implementation of IGAs into museum interior design archetypes. This chapter is also an amalgam of the results from the three parts of the research designed to answer the three major research categories: Identification: Redefinition of the malleable dual structure of archetypes; Application: Application of IGAs to the dual structure of archetypes; and Validation: Validation of the educational potentials of the proposed IGATY-beta system. The detailed questions designed to answer the three major research questions are as follows:

General Question 1: Identification—Redefinition of the malleable structure of archetypes

1. Can museum interior archetypes be explained based on the principles of biology (e.g., mutation, crossover, and coevolution)?

2. Is the proposed dual structure of archetypes (a core signal/peripheral) found in the six selected museum interior archetypes?

3. How can core signals be defined to communicate the principles of each museum interior archetype?

4. What kinds of peripherals are found that react to contexts and cause changes?

General Question 2: Application—Application of IGAs to the dual structure of museum interior archetypes

1. Will the IGA mechanism work in the application of museum interior archetypes?; i.e. Can the dual structure be mapped into the genetic algorithms?
2. How can mutation and crossover be defined with regard to museum interior archetypes?

3. What do evaluation and fitness mean in the application of IGAs to the archetype-based generative abstraction system?

4. Can multiple museum interior archetypes be combined in the proposed generative abstraction system?

5. Will the design evolve towards the designer’s intended scheme in the proposed generative abstraction system?

6. Can this application result in unconventional aesthetics?

7. Can it be expanded to other archetypes applications?

General Question 3: Validation—Validation of the educational potentials of the proposed archetype-based generative abstraction system in design education

1. If the application of IGAs to museum interior archetypes is viable, will this help participants understand the malleable structure of archetypes and their potentials for invention?

2. Does the coevolution process (the combination of two or more different archetypes) in the proposed system trigger a synthetic thinking process?

3. Does using the proposed generative abstraction system help participants improve creativity in an ideation workshop?

4. Does using the proposed generative abstraction system help participants improve creative confidence?

5. In delivering the archetypes exercise, does implementing virtual reality technology make a difference in students’ creativity and creative confidence?
The purpose of this chapter is to provide a holistic understanding of archetypes and to present a basis that motivates a more active and practical use of archetypes. The chapter is organized according to the following topics derived from the research findings: Finding 1: The Dual Structure of Archetypes; Finding 2: Evolution of Archetypes—Mutation, Crossover, and Coevolution; Finding 3: Dual Structure of Archetypes and IGAs; Finding 4: Archetypes and Foundation of the Ideation Process; Finding 5: IGATY Archetypes Exercise and Creative Ideation Process; Finding 6: Archetypes Exercise with VE and its Affect on Creative Confidence and Creative Performance; Finding 7: IGATY, Synthetic Thinking Skills, and Creative Design; Finding 8: Archetypes in Virtual Environment and Creativity.

5.1. Finding 1: The Dual Structure of Archetypes

The first general goal of this research is to clarify the misconception of a design archetype and redefine its overall structure to make it useful in the pre-logic stage of the creative ideation process. Design archetypes have substantial value in design education as sources of creative exploration (Schön, 1988; Symes, 1994). However, despite the suggestive potentials and benefits of using archetypes in ideation, the typological approach to creative design has been criticized for its lack of creativity (De Carlo, 1985; Bohigas, 1985; Gregotti, 1985; Reichlin, 1985) due to the absence of a crystal-clear definition of archetype and its structure. Although some researchers have argued that a type is constant and independent (Rossi, 1966/1982), others have concluded that type has a versatile and flexible trait (Kubler, 1962; Knapp, 1986; Schneekloth & Franck, 1994; Jennings, 2007; Güney, 2007).

Inspired by Kubler’s (1962) idea of signal and mutants in understanding the history of things, Hillier and Leaman’s (1974) idea of genotype and phenotype, as well as other scholars’
various interpretations of archetypes, in this study I proposed a dual structure of archetypes comprising two coexisting components: a core signal and a peripheral (Figure V-1). The core signal is a set of principles that delineate the unique characteristics of an archetype. It is an abstract premise and schema that prescribes the outlook of the archetype but does not appear as a physical image. A core signal does not change and remains constant. It creates unique expression and a specific experiential quality that is universally understood regardless of cultural differences (Thiis-Evensen, 1987). The peripheral is another set of traits embedded in an archetype that can be morphed and transformed, reflecting social, cultural, contextual specificity, and aesthetic preferences. Unlike what Kubler (1962) or Hillier and Leaman (1974) had reported, in the proposed system, the core signal does not change, and it retains the rules and principles that communicate throughout time in a continuum; however because its rich peripheral reacts to dynamically changing factors, the transformation of each archetype appears different.

**Figure V-1.** The proposed structure of an archetype (diagram): Core Signal and Peripheral

The qualitative content analysis of the two selected professional magazines (architectural record and interior design) as well as secondary resources and case studies of significant
examples were used to investigate the existence of this dual structure in the six selected museum archetypes. The six selected museum archetypes consist of Spatial Drama, Wunderkammer, Grid, Poetic Light, Scalar, and Vitrine.

In Part 1 of this research the investigation in the content analysis clearly demonstrated that this proposed dual structure exists in a number of examples of the six selected museum archetypes throughout the history of museums and exhibition space design. As hypothesized, the core signal was found in each archetype. Results from this research showed that as long as the example is defined as a specific archetype and can be put into the same group with other members of the archetype, it contains the core signal regardless of its appearance. Results also illustrate that the core signal retains its core attributes and principles throughout the course of dynamic changes in the continuum. Another critical research focus in Part 1 was to identify the peripheral—a set of parameters that cause the embodiment of a core signal to dynamically change, evolve, and transform—in each archetype. From the qualitative content analysis, extensive parameters as a peripheral in the dual structure were found that cause dynamic expressions responding to contextual settings, such as cultural, social, political, or philosophical specifics or personal aesthetic preferences (Table V-1). Depending on the characteristics of each archetype, the results show that peripherals vary in their aspects. In some cases, peripherals are modalities related to the fundamental elements that define an object’s physical properties such as geometric shapes, colors, textures, etc. In other cases a peripheral could represent physical qualities such as angles, speed, movement, size, density, or intensity. A peripheral also could represent modalities related to spatial position and quantity in three-dimension. The unique ways designers or artists apply these parameters cause their examples to be distinct from others and to be perceived as prime objects.
Table V-1. Six selected archetypes: definition, core signals, and peripherals

<table>
<thead>
<tr>
<th>Archetype</th>
<th>Definition</th>
<th>Core signal</th>
<th>Peripheral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid</td>
<td>A Grid is a systematic arrangement in rows and columns or in three-dimensional intersections at right angles. In a Grid arrangement, uniformity of individual objects in the entire collection is emphasized. Its repetitive nature forms multiple sets of invisible membranes that create layered effects.</td>
<td>An array in 2D or 3D that creates multiple intersections</td>
<td>• Coordinate axes x, y, z • Number of objects • Properties of objects: shape size, color, material, etc. • Position: wall, floor, ceiling, in space • Constancy: consistent vs. various • Movement</td>
</tr>
<tr>
<td>Wunderkammer</td>
<td>An installation aesthetic in which a multitude of diverse, collected objects are arranged in categorized, taxonomic, or random-order displays on walls, floors, ceiling planes, in a cabinet, or three-dimensionally in space. Due to its unique capricious irregular arrangement method, Wunderkammer evokes visual wonder and creative imagination.</td>
<td>A cluster, group, or assemblage of a multitude of randomly arranged objects</td>
<td>• Number of objects • Properties of objects: size, color, material, etc. • Grouping method: clustered, random, geometric form • Density • Position: wall, floor, ceiling, in space • Constancy: consistent vs. various</td>
</tr>
<tr>
<td>Spatial Drama</td>
<td>Spatial Drama defines an exhibition space manipulated three-dimensionally according to a theme and an idea of an exhibition or a specific paradigm of an art group. It creates a dramatic quality of expressive, emotional, imaginative, and stimulating spatial experience.</td>
<td>Vertical or horizontal elements are manipulated with multiple angles or curves</td>
<td>• Manipulation properties: curves, angles • Degree of angles applied to spatial manipulation • Density of manipulated segments</td>
</tr>
<tr>
<td>Poetic Light</td>
<td>Poetic Light is natural or artificial light that is artistically combined with colors as a medium of art, so that visitors perceive light as a work of art and as a spatial experience. With intense light filling a space, Poetic Light creates an immersive quality that allows viewers to fully immerse themselves in the exhibit.</td>
<td>Diffused illumination of colored light</td>
<td>• Colors of light • Number of colors • Intensity of colored light • Change of colored light • Movement</td>
</tr>
<tr>
<td>Scalar</td>
<td>Scalar is display aesthetics associated with projection that sometimes exaggerates and emphasizes shapes or images of objects. Scalar arouses visual wonder and has an immersive quality that allows viewers to fully immerse themselves in the projected images.</td>
<td>(Magnified) projected images or text objects</td>
<td>• Size of projected images • Contents of images or texts • Movement (Still/Moving) • Position (Wall, Floor, Ceiling, Overall)</td>
</tr>
<tr>
<td>Vitrine</td>
<td>Vitrine represents display aesthetics associated with a container for displaying significant or ordinary objects. Vitrine draws viewers’ attention and adds a unique museum effect of the untouchable, rare, uncommon, and exceptional quality of objects.</td>
<td>Encapsulating objects</td>
<td>• Container properties: size, shape, color, etc. (*Vitrine is a dependent archetype that requires other object based archetypes for its physical manifestation)</td>
</tr>
</tbody>
</table>

One might think that it is a simply natural phenomenon that each archetype contains a core signal. Challenges occur when students and designers deal with contemporary design in a complex world. It is important to note that understanding and recognizing a core signal in design as an unchanging principle, and training eyes to discriminate a core signal from a complex net of
peripherals, are critical in design education as it enables designers to identify and recognize the causal factors that transform design to bring about a potential revolution in design. In other words, when students and designers recognize the peripherals in design and try to apply other possible peripherals while keeping the core signal, they are able to generate innovation in design.

**Figure V-2.** Extended dual structure of an archetype: Over time, peripheral evolves into something new or different from the examples in the past. If a specific peripheral is favored by many designers and repeated for a certain period of time and disappears after a while, it may be called a style or a trend. If a specific peripheral is favored among certain groups, it may be considered as certain culture.

The dual structure of archetypes implies two relevant aspects in understanding design, style, trend, and culture. First, the dual structure explains not only the fundamental constitution of design but also how style or trend and culture can be defined based on peripherals. The result implies that a peripheral as part of the structure of an archetype may be used to explain not only the generative mechanism of archetypes but also the “deep cultural structure” (Bafna, 2012, p. 76). For instance, the *perforate* archetype is defined as “a regular pattern of consistently shaped
and spaced holes that have been cut into a material” (intypes, n. d.). The core signal of *perforate* is perforation itself. Various particular forms and shapes of the holes may reflect diverse cultural tendencies or styles and can be explained based on different cultural specifics. *Figure V-2* shows an extended version of the dual structure of an archetype. Over time, depending on the contextual condition, a designer’s philosophical aesthetic tendency, and technology available at a specific time, a peripheral evolves into something new or different from the examples in the past, transforming its appearance. If specific parameters in a peripheral are favored by many designers and are repeated for a certain period of time, and prevail throughout certain areas but disappear after an avid use, that specific peripheral may be able to be called a certain style or a trend. Likewise, if a certain peripheral is favored among a certain group, it may be considered as a certain culture.

Second, by distinguishing the two components in the dual structure, designers and students will be able to find the ground for future innovation and invention. In dealing with the complexity of design in a contemporary world, understanding design based on the dual structure will enable designers and students to discover the prolific potential that resides in a peripheral by separating it from the core signal. Gero (1994) defines creative design as “design activity which occurs when a new variable is introduced into the design” (p. 11). Keeping the core principles, students can achieve creative design by introducing a new variable within the peripheral or from another set of peripherals. One can see how different aspects can be applied to transform the peripheral to bring creativity to the current design: This constitutes a transformation of the peripheral, which brings creativity. One can also introduce other variables adding fresh aspects into design: This is a combination of peripherals, which also promotes innovation. The evidence of the dual structure of archetypes from the findings strongly supports the original conception of
its flexible structure that a number of scholars argued (Quatremère de Quincy 1775-1849; Schneekloth & Franck, 1994; Symes, 1994; Jennings, 2007) and their arguments about innate potentials embedded in archetypes and the possibility of creative exploration for future invention.

5.2. Finding 2: Evolution of Archetypes - Mutation, Crossover, and Coevolution

The dual structure of archetypes proposed in this study also provides more holistic perspectives of how innovation can actually happen in design. Previously Kubler (1962) identified the evolution of a type in the history of things using the terms signal and mutants. Rossi (1966/1982) also emphasized the continuity and evolution of a type. However, the concept of evolution was still confusing because of the lack of a clear definition of the structure of archetypes. I hypothesized that if the proposed dual structure is applied, the evolution of museum interior archetypes can be explained through the biological terms of mutation, crossover, and coevolution. Findings from the qualitative content analysis in Part 1 strongly supported the idea that in the evolution of archetypes, the core signal remains the same, keeping its unique traits. It was observed that various aesthetic manipulations were made within each archetype throughout the history of each archetype.

Figure V-3. Mutation of an archetype: core principle remains and peripheral elements change reflecting social, cultural, thematic, philosophical, personal aesthetic preferences, contextual differences, and function.
Some examples in Wunderkammer found from Part 1 of the research suggest that different peripherals appear especially with the application of new technology. For instance, the recent application of digital technology in the Secret Museum at the Seoul Art Center, Seoul Korea, 2013, demonstrates how Wunderkammer could be developed into something new using digital technology. Instead of physical paintings, the curator used digital images displayed on twelve screens arranged in a manner of a random cluster. Each screen displays moving images of gradual close up views of the original paintings.

*Figure V-4. Secret Museum at Seoul Art Center, Seoul, Korea, 2013, Curated by Minsuk Suh (Photo credit: Joori Suh).*

If a group of physical paintings arranged in a random cluster were mixed with another group of digital screens also arranged in a random cluster, it becomes a good example of crossover within the same Wunderkammer archetype. *Figure V-5* demonstrates how two different examples of the same archetype may exchange peripherals and become something new.
Coevolution in design may be explained in two different ways: One is through independent mechanisms (combined gene approach (Maher & Poon, 1996)) and the other is that one archetype somehow influences the other. In combining Wunderkammer and Scalar, if the former is applied, a set of digital images can be projected on top of a set of Wunderkammer on a wall. A recent example of Wunderkammer at the World Trade Center Memorial Museum (2015), titled “Missing Posters” could be explained based on the latter. The example is clearly a Wunderkammer archetype because each poster is arranged in the manner of a random cluster. However, because the overall display was made possible by projection, it can also be labeled as Scalar. Therefore, this example carries two different characteristics: Wunderkammer and Scalar.

Figure V-5. Crossover of an archetype: Within one archetype, two chromosomes can exchange peripherals to create new variations.

Figure V-6 Missing Posters (Digital Projections) at World Trade Center Memorial Museum, New York, NY. 2015 (Photo Credit: Joori Suh).
Figure V-7 demonstrates how the two different archetypes can evolve into something new by individually going through mutation and crossover within each archetype.

Understanding archetypes based on the biological terms of mutation, crossover, and coevolution gives important clues to overcome the misconception of archetypes as standard forms and suggests ways to bring innovation. This supports Gero and Maher’s (1991) definition of routine design as the solution of design decisions based only on known decision variables, whereas creative design is defined as the solution of design decisions based on new design variables added in the design process. By encouraging the ways to introduce new variables into archetypes, archetypes can be actively used in design education.

5.3. Finding 3: The Dual Structure of Museum Interior Archetypes and IGAs

The second general goal of this research is to implement the interactive genetic algorithm into museum interior archetypes. Although a number of researchers have presented successful applications of genetic algorithms in the field of design, other scholars have claimed that there
are problems in the application of IGAs in design. The designed functions of the IGATY system reflect previous researcher’s suggestions to make IGAs more fitting in design (Gero, 1994; Reffat, 2003; Fasoulaki, 2007; Galanter, 2010).

5.3.1. Design Theory Based Application

Among the problems and issues researchers claimed, Galanter (2010) and Horváth (2005) argued that one of the most important problems of evolutionary art, artificial intelligence techniques, and genetic algorithms applied in design is the lack of a conceptual and theoretical foundation to explain art and design. Ertmer (1999) also emphasized the importance of the pedagogical belief in applying technology. In this research I employed the theory of interior design archetypes (Jennings, 2007) and typological approach to design as a foundational structure of the IGATY system. The core concept of archetypes applied to the system is that an archetype is not a stereotype or a standard form for repetition, duplication, or imitation but a generative abstraction for further transformation and future invention. The mechanisms of IGAs allowed the proposed system to effectively visualize the conceptual framework of the dual structure of museum interior archetypes and enhanced the intrinsic understanding of archetypes.

According to Galanter (2010), aesthetics search driven by evolutionary art should focus on the process rather than the final results. The IGATY system was not designed to create a final product; rather, it is intended to foster the ideation process where a “potential to aid in the design” (Gero, 1994) resides. Therefore, the artifacts made during the process are not intended to be judged to be creative; instead, the overall quality of the search, a trial-and-error process, and the exploration itself are more meaningful aspects that aid in the design of the final creative product (Gero, 1994, p. 11). The results from the experiment in Part 3 of this research supports that the
IGATY system helped the pre-logic stage of the ideation process, and it directly affected creativity in the final ideation product. The results strongly support the idea that the interactive genetic algorithms were helpful in visualizing the conceptual understanding of the dual structure of archetypes. The proposed IGATY system in this research is meaningful in that it suggests the emergence-based IGA system can be developed based on a conceptual and theoretical framework based on museum interior archetypes still motivating the creative ideation process.

![Diagram of Stereotype (above) vs. Archetype (below)](image)

*Figure V-8.* Diagram of Stereotype (above) vs. Archetype (below)

### 5.3.2. The IGA Mechanism and the Dual Structure of Museum Interior Archetypes

The proposed dual structure of archetypes and the interpretation of archetypes based on evolutionary biology allowed me to implement IGA mechanisms into the structure of archetypes. Fasoulaki (2007) argues that the fallacy of application of GA in architecture is that the attempts are typically based on “the equalization of architecture to biology” (p. 9). In the development of
the IGATY-beta system, GA was implemented as a metaphor, an analogy, and a source of inspiration, not as a direct replication of nature. The basic mechanism of the IGATY system is derived from nature, but the baseline is how GA mechanisms and the system can effectively aid the ideation process leading to a creative aesthetic search instead of focusing too much on mimicking nature.

The core signal in each archetype defined from the results in Part 1 is mapped into the basic outline of the core function of realization of each archetype, and the peripheral was coded to visualize the transformative quality of museum interior archetypes and to determine parameters to generate various chromosomes through the mutation and crossover operation (*Figure V-9*). The fact that the design and the setting of each core signal and the peripheral descriptors in the principal IGA function is always based on the educator’s and scholar’s definition and interpretation of the unique aspects of each archetype reinforces the notion of human’s controllability in the IGA mechanism.

*Figure V-9*. The dual structure of an archetype and the IGATY system

Mutation, crossover, and coevolution operation in the IGATY system were employed to aid designers to see the intrinsic potential of archetypes as generative abstractions. The designer
can freeze evolution for a desired amount of time and resume the evolution function anytime during the operation. The results of the participants’ perception of archetypes in the quasi-experiment imply that the IGATY system has value in teaching archetypes in general, especially in changing the misconception of archetypes as stereotypes to generative abstractions. In the focus group session, the participants in the Manual group that did not use the IGATY system expressed frustration of generating variations after a certain period of time. Such results suggest that using genetic algorithms have a significant value in archetype-based ideation especially in providing variations of ideas using archetypes.

5.3.3. Aesthetic Judgment and GAs

In genetic algorithms, the fitness function is one of the most essential operational mechanisms: Every solution is evaluated by the fitness function. In many GA applications, especially in a creative or aesthetic search, human input based on subjective judgment has often been used instead of employing the GA’s computationally coded fitness function (Sims, 1991; Sims, 1993; Takagi, 1998; Takagi, 2001; Bentley & Corne, 2002). The proposed IGATY system was designed to motivate a designer to perceive the system as an “interactive partner” (Reffat, 2003). Therefore, in the IGATY system, the designer has the power to evaluate and select individuals for future generations based on one’s own subjective aesthetic judgment and the designer can even interrupt the system to change parameters or to adjust variables during the operation.

From the optimization perspective, user evaluation delays the process. However, unlike performance–oriented applications of GAs that aim at optimizing efficiency of energy, structural, or acoustical properties of a building, an aesthetic design search should be perceived as a process
of exploration that satisfies human intuition, sensation, impressions, and preferences. Human judgment is an extremely complex entity and thousands of variables come into play (Parmee & Denham, 1994). In this research, the IGA system’s responsibility is to provide unique solution spaces that aid the user’s pre-logic stage of creative ideation process interacting with the designer, not to provide one single perfect solution at the end. Therefore, I strongly believe that as long as an aesthetic search is considered, human input is essential and should not be replaced solely by advanced algorithms such as artificial intelligence.

Bentley & Corne (2002) suggest three advantages of collaborative evolutionary algorithms: First, “good search ability: the user can alter their guidance” (p. 41); Second, “a wide range of different solutions: the longer users play with such systems, the more solutions they will see” (p. 41); Third, “The ability to evolve solutions for which there is no clear fitness function” (p. 41). In terms of good search ability the proposed system allows the user to control parameters anytime and can force evolution towards the direction the user intends. The IGATY-beta system also provides a wide range of different solutions by offering different archetypes to synthesize. Though the system is still limited, variables and parameters provided by the proposed IGATY-beta system and integration with Unity enable the system to evolve solutions that are subjective and variable. Although the speed is slow, the IGATY system’s interactivity between humans and the system agrees with previous studies that suggest the advantages of a collaborative evolutionary system (Bentley & Corne’s, 2002).

5.3.4. Designer’s Intention and Evolution in IGATY

The IGATY-beta system was designed to be used in the pre-logic stage of the ideation process not to be used for prototype or final design. Emphasis was placed on the IGATY-beta
system’s potential as an aesthetic search aid tool in the beginning stage of the ideation process and was designed based on the notion that a computer can be used as an interactive partner especially in the early phase of the ideation process. When human evaluation and judgment take over the fitness function, it is crucial to design the system to evolve towards the designer’s intention. In the IGATY-beta version system, among the six selected archetypes, Spatial Drama, Grid, Wunderkammer, Scalar, and Poetic Light have the ability to evolve towards a designer’s intention. Results from Part 2 in this research demonstrate that the proposed program is capable of evolving design in a manner that reflects the designer’s deliberate intentions and desires. Such results suggest that the IGATY-beta system may have potential to be used as a tool for an aesthetic search in the ideation process reflecting the designer’s aesthetic intention.

This study was not free of problems; for instance, although the system allows the user to select as many individuals as he or she wants, if the user’s selection was only a few limited numbers in some archetypes, the design quickly evolves towards the designer’s intention. The results suggest that the time took for the system to evolve towards the designer’s intention depends on the number of objects in one chromosome. The more objects the selected individual chromosomes have, the longer it took for the designer to make the design evolve towards the designer’s intention. However, if the chromosome has only a limited number of elements defined as genes, the system displayed small populations for evaluation and selection. In the IGATY-beta version this problem of a small population size can be resolved by going back to the parameter screen and to alter the variables that the designer did not try or by adding other archetypes for coevolution. The IGATY-beta-system-advanced-designer version allows the designer to move to the Unity screen to add other objects or further manipulate objects in the chromosome to further evolve the design into something more complex and unique.
5.3.5. Coevolution: Complexification by Synthesis

Galanter (2010) argued that one of the most important issues of the current use of IGAs in evolutionary art is “the problems of sameness and lack of innovation” (p. 324). In order to overcome the issues related to sameness among variations and lack of innovation, I applied the idea of complexification by synthesis, which encourages the emergence of multiple layers of other individuals in one chromosome. For instance, in one chromosome, various archetypes can be combined which increases complexity and chances for innovation.

Galanter (2010) defines four types of genetic representations based on the complexification capacity order: (1) a fixed parametric representation which provides only limited parameters; (2) an extensible parameter which allows more extensive parameters; (3) a direct mechanical representation that allows mutation function; and finally (4) a reproductive mechanical representation that allows users to create another machine within a single individual (p. 326). Although the approach is different, it is worth noting that Galanter also mentioned multiple layers within a single individual. The proposed current IGATY-beta version is not capable of the reproductive mechanical representation function within each archetype; however, through the coevolution function, the system can increase complexity to some extent. This study is meaningful in that it suggests another way of building up layers and enhancing complexity within a single individual using multiple archetypes. It is worth noting that some of the participants in the focus group mentioned the limitation of the current version of the IGATY-beta system in that it does not allow all the archetypes to be combined. Bloomberg (1973) identified the necessary characteristics of the appropriate elements to enhance conditions for creative combination to be as follows:
(a) Available: capable of bringing into focus, (2) Selectively Activated: selectively activated in the momentary mental processes, (3) Contiguous: be activated simultaneously, (4) Salient: stand out sufficiently, (5) Free: not be so rigidly embedded or confined with respect to other cognitive structures, and (6) Fitting: the elements must somehow be mutually fitting with respect to one another (p. 58).

Because the IGATY system provides multiple archetypes it makes archetypes available for combinations. The system allows the user to make each archetype selectively activated by using the freeze on/off button; each archetype is easy to access and prevents rigid confinement; and the user can try many combinations in a relatively short amount of time to find the most fitting combinations. In terms of providing contiguousness to the system the system must be developed further to make some currently restricted combinations, such as the combination of the Spatial Drama archetype and the Wunderkammer archetype, possible.

5.3.6. Unconventional Aesthetics

Gero (1994) defines creative design as “design activity, which occurs when a new variable is introduced into the design” (p. 11). In order to enhance creativity, bringing new, unconventional, or unexpected variables into design is important. The proposed IGATY-beta system was designed to generate numerous variations through the randomization process as well as through the mutation (translocation mutation) and crossover (uniform crossover) operations of genetic algorithms. The computational coding applied to this research naturally has the potential to produce unexpected variations because the randomization mechanism fosters unpredictable arrangement or unexpected combinations. The coevolution function also provides the user options to try unconventional combinations of multiple archetypes, allowing further aesthetic
search through juxtapositions among multiple chromosomes. By changing the probability rate of mutation and crossover or by manipulating parameters the randomization can be maximized to increase chances of chromosomes emerging that are unpredictable and even bizarre.

In the proposed generative abstraction system, the chances for unconventional aesthetics is enhanced with the integration of Unity with the system while the genetic algorithms are in operation: when objects are manipulated or new objects are added to the chromosome in Unity, further exploration and transformation of chromosomes increase the chance of the emergence of unconventional aesthetics. Although the current IGATY-beta version is limited in many ways, overall this research is meaningful in that it successfully demonstrated the possibility of using multiple museum interior archetypes in the search for unconventional aesthetics.

5.3.7. Expansion to Other Archetypes

For this study, six representative museum interior archetypes were tested in the IGATY-beta version system: Grid that is free of context; Spatial Drama that is context itself; Wunderkammer that is a combination of context and objects; Poetic Light that is associated with light; Scalar that is a non-physical object; Vitrine that requires other objects for its existence (a dependent archetype). The premise was that if these representative archetypes work in the IGATY-beta version system, other archetypes that are previously defined or undefined might be able to be implemented in the IGATY system.

A representative archetype 1 that is free of context (object-based, Grid): It appears that archetypes that are free of context work well independently in the proposed system and can be easily combined with non-physical-element-based archetypes such as Scalar or Poetic Light.
Providing various parameters related to object properties with a sufficient range of variations is important to foster dynamic evolution.

A representative archetype 2 that is a combination of context and objects (Wunderkammer): If the archetype is inherently connected to another archetype, coevolution of the two archetypes is restricted in the current proposed system. More complex programming is required to allow both archetypes to evolve simultaneously, mutually affecting and influencing properties of each archetype.

A representative archetype 3 that is context itself (Spatial Drama): In the proposed system, the virtual space was designed based on a white cube composed of walls and a ceiling. In each plane intersection points were treated as genes for the mutation operation. As long as the space-defining element is carefully defined as a set of genes, the mutation and crossover operations can be applied for dynamic evolution of the archetype. Each segmented surface could also be treated as a gene and other parameters that define object properties could be added to diversify variations.

A representative archetype 4 that is associated with light (Poetic Light): In the proposed system, the property of each light at 27 points in the virtual space was treated as a gene for the mutation and crossover operations. As long as the properties of the gene are clearly defined, light-based archetypes work well independently in the proposed system and can be combined with other archetypes effectively. Depending on the properties defined for the light-based archetype, other parameters such as movement, speed, sequence or order could also be added to diversify evolution of an archetype.
A representative archetype 5 that is non-physical object (Scalar): In the proposed system a single image was treated as a gene and the limited number of genes caused a small population size. The current version displays variations only based on random camera positions and random projection angles to maximize solution space. Therefore, the number of genes in one chromosome is a critical item to consider in programming non-physical object-based archetypes in the system. Instead of using a single image, multiple images could be projected in one chromosome and each image can be treated as a gene for mutation and crossover operations.

A representative archetype 6 that appears only with certain other archetype(s) (Vitrine): In the proposed system Vitrine was used to test a dependent archetype. Vitrine requires object-based archetypes to appear in the virtual space. Once an object-based archetype exists in the virtual space, Vitrine follows the changes of the other archetypes caused by the mutation and crossover operations, and is added to each object simultaneously. In the current system no parameters were added and the default setting (30% smaller than the object) was applied to define the proportion of the transparent material in relation to the object encapsulated by Vitrine. Other parameters could also be provided to add more variables, such as the degree of transparency or colors. This may enable the dependent archetype to evolve independently while following the changes in other archetypes.

Although the proposed beta version is not flawless, the results from the research overall suggest its potential; as long as the core signal and a set of peripherals are clearly defined, this application can be expanded to other archetypes. The natural extension of this study will be to expand the system to apply other archetypes in order to facilitate more extensive search and further synthesis.
5.4. Finding 4: Archetypes and the Foundation of the Ideation Process

The major conceptual framework of this research started with Schön’s (1988) notion of archetypes as generative images and major premises for design as well as Arnheim’s (1969) idea of types as generative abstractions. The fundamental goal of this study is to offer further potential to make the theory of archetypes beneficial for design students and designers especially in the pre-logic stage of the ideation process. Section B in the questionnaire was designed to measure the participants’ perception of archetypes and a typological approach to design. The same questions were asked two times before and after the treatment. During the treatment students were introduced to the dual structure of archetypes, and three groups participated in different exercises. Although the Part 3 quasi-experiment was limited due to the small number of participants, the results that show positive change (the IGATY-S and IGATY-VE groups) in creativity in the ideation workshop after the treatment could be considered as a potential benefit of using archetypes as generative abstractions in the field of design and design education.

The 10 min. mini-focus groups also revealed benefits of using archetypes as sources of ideas, especially at the beginning of the ideation process. Participant responses from the focus group suggest that archetypes work as seeds of ideas that can possibly expand through the ideation process. Such results are compatible with Schön’s (1988) idea of archetypes as generative images, Arnheim’s (1969) notion of types as generative abstractions, and Moneo’s (1978) proposition of types as “the frame within with changes operates”(p. 27).

**Having some places to start, where to look at things rather than looking just around as a whole is like breaking [things] down. I think it makes it easier.** (From focus group interview with Manual Group, January 25, 2015)

**It allows us to expand our ideas. Going from what I was looking for in the last workshop yesterday, there were obviously more things...I was thinking more about different**
archetypes and how it can make the space work. (From focus group interview with IGATY-S group, January 25, 2015)

There were a variety of them [archetypes], and some have distinct uniqueness. I think they are helpful in generating ideas if you don’t really know how to start, you can just look at one of the archetypes and see what you can do with this. It is easier to get ideas. (From focus group interview with IGATY-VE group, January 25, 2015)

It is also worth noting that students felt archetypes worked as a formula for design when they did not know how to start the ideation process. This finding resonates with previous empirical research by Takagi (2001) that suggests the application of IGAs is useful for designers with little or no experience. To understand fully if Takagi’s (2001) research finding applies to the application of the IGA to archetype, more extensive research would be needed.

I like that it gives some kind of formula for design...it gives something and we combine ideas and rework again for getting done ... I am a student and I am supposed to start ... because they are sometimes [saying] like “hey, make something” instead of giving the kind of process of thinking about going about designing. (From focus group interview with Manual Group, January 25, 2015)

5.5. Finding 5: IGATY Archetypes Exercise and the Creative Ideation Process

The third main question of this study was to examine whether the application of the IGA improves participants’ creativity in an exhibit design. Shneiderman (2000) argued that software tools that are designed to support evolutionary creativity may “help produce revolutionary breakthroughs” but also may “restrict thinking or discourage paradigm shifts” (p. 118). Reflecting Galanter’s (2010) notion of the design process that aesthetic search driven by evolutionary art should focus on the process rather than the final results, the IGATY-beta version was designed to support the pre-logic stage of the ideation process. In order to examine if participants’ experience of the IGATY-beta version during the beginning stage of the ideation
process actually increased creativity in their ideation workshop project, a quasi-experiment was conducted.

Despite the limitations of a small number of participants and complaints about the tab key malfunction, both the pilot and the main quasi-experiment showed consistent results: The IGATY-S group improved creativity the most in their final design, and the IGATY-VE group came in second in improved creativity in the final ideation workshop project. The results from the quasi-experience suggested that experience with the IGATY system influenced creative aesthetic search and positively affected the participants’ creative design at the end. The results resonate Bentley’s (1999) notion of benefits of using an evolutionary tool in that it allows designers to consider multiple creative solutions faster and “overcome design fixation and limitation of conventional wisdom” (p. 42). This data disagrees with Shneiderman’s (2000) assumption that evolutionary computation may “restrict thinking or discourage paradigm shifts” (p. 118).

**Figure V-10.** Creativity improvement in Workshop 2 (main quasi-experiment, n=12: 4(M), 4(IGATY-S), 4(IGATY-VE))

Creative Improvement = (CATW2 (mean value of creativity score of workshop 2) - CATW1 (mean value of creativity score of Workshop 1))/7 x 100

Cronbach’s alpha: .93 (Workshop 1) .94 (Workshop 2)

Inter Rater Reliability: .62 (Workshop 1), .70 (Workshop 2)
When you look at something one way and when you look at it from different ways you get completely different ideas just by using it [IGATY system]. (From focus group interview with IGATY-VE group, January 25, 2015)

One interesting finding related to the detailed aspects within the creative component was that there were several areas where the IGATY-VE group showed the highest improvement: creativity, novel idea, variation in shape, and complexity. Due to the small sample size the data in this study did not allow me to generalize the IGATY-VE group’s improvement in these detailed areas of creativity. Although this study has limitations, these should not overshadow its strengths in that it revealed IGATY-S and IGATY-VE might have different effects on different areas of creativity under the large umbrella of the creativity cluster. In order to understand the detailed aspects of creativity improvement in using the IGATY-S and IGATY-VE systems, more extensive research would be needed to clarify the system’s benefits in enhancing specific areas of creativity.

![Figure V-11. Improvement in detailed areas of the creativity component: IGATY-VE Group (n=4)](image)

*Figure V-11.* Improvement in detailed areas of the creativity component: IGATY-VE Group (n=4)

*Workshop1:* mean value of each creative component in Workshop 1

*Workshop2:* mean value of each creative component in Workshop 2
5.6. Finding 6: Archetypes Exercise with VE and its Effect on Creative Confidence and Creative Performance

The empirical findings from the quasi-experiment provided some support for most of my hypotheses except creative confidence for which it appears that there is no effect of using the IGATY-beta system on the participant’s creative confidence measured before the workshops. However, results demonstrated that although there was no effect of the application of IGAs on creative confidence, differences in the self-evaluation of their actual creative performance were noticed: This finding disagrees with Tierney & Farmer’s (2002) study that reports creative self-efficacy as a predictor of creative performance. This might be a consequence of different domains: Creativity required in this study might belong to “domain-relevant” creativity (Amabile, 1982, 1996) and Tierney & Farmer’s (2002) argument that creative self-efficacy as a predictor of creative performance works best in understanding creative action in organization settings (p. 1137).

Interestingly, although participants’ creative confidence before the workshops did not change with the treatment, their self-evaluation of the creative performance in the ideation process improved in the IGATY-VE group: In other words, in Workshop 1 (before treatment) participants perceived their performance as less creative after they actually finished the ideation project. However, in Workshop 2 (after treatment) participants rated their performance of the creative ideation process higher compared to the one measured after Workshop 1. This result implies that participants’ creative confidence before actual creative work is not the same as their perception of actual creative performance during the workshop. The IGATY-VE exercise brought the participants’ perception of their actual creative performance during the ideation
process to the level of their original creative confidence measured before the workshops. This trend was observed both in the pilot study and the main quasi-experiment. Such findings suggest IGATY-VE’s value in keeping up students’ creative confidence throughout the process and connecting creative confidence with creative performance until the project is complete.

5.7. Finding 7: IGATY, Synthetic Thinking Skills, and Creative Design

One of the most important goals of this research is to investigate how the exploration using the IGATY system designed based on the dual structure of archetypes, may help in the creative ideation process. More specifically, I hypothesized that the coevolution function in the IGATY-beta system would trigger synthetic thinking skills. Reflecting Nilsson’s (2011) model of the taxonomy of creativity, the ideation process for the quasi-experiment was designed to measure the quality of the ideation process during each stage of variation, combination, and transformation. Results revealed a strong correlation between the combination stage ideation and the creativity in the test subjects’ final work ($r = .56$, Sig. (2-tailed) $= .001$). Interestingly, correlation between the quality of the variation phase and creativity in their final design was weak ($r = .38$).
Figure V-12. Improvement in the combination stage: Improvement in combination stage = CW2(Workshop 2 combination stage ideation quality rating) – CW1(Workshop 1 combination stage ideation quality rating) (n=12: 4(M), 4(IGATY-S), 4(IGATY-VE))

Figure V-13. Scatterplot of correlation: quality of the combination stage in the ideation process and creativity in the final design (n=24) Pearson Correlation: r = .56 Correlation is significant at the 0.01 level (2 tailed)

Given the fact that the increase trends are similar between the improvement of the combination phase ideation and the creativity in the final workshop design, these experimental results could indicate that using the IGATY system enhances creative ideation possibly because it is mostly beneficial in helping with synthetic thinking skills in the combination stage. The fact that the quality of the combination stage ideation process has a significant relationship with creativity in the final workshop design empirically supports a number of researchers’ argument
about creativity as a connected network (Johansson, 2004; Johnson, 2010; Root-Bernstein & Root-Bernstein, 1999).

The focus group discussion also revealed that the system made the combination of different archetypes easier and their aesthetic search more interesting. One of the suggestions the participants made to improve the software implies that the participant would appreciate a more flexible coevolution function. This comment suggests that the IGATY system has the potential to bring enhanced creativity and innovation through complexification by synthesis. Taken together the results demonstrate that when using the IGATY system, participants have the tendency to explore new ideas through the coevolution process, and this should be considered in the development of IGA-based ideation systems.

*I think it is very impressive. Especially when I interact with the computer, I can combine different things to make it more interesting. I was able to generate more ideas. (From focus group interview with IGATY-S group, January 25, 2015)*

*It makes it easier to combine to form ideas. (From focus group interview with IGATY-VE group, January 25, 2015)*

*It[IGATY-beta software] was easy to use...I understand it was the beta version so it would not be perfect... but it needs some modifications. There was no way to use all six: when you have some things on the wall and when you want to have a dramatic space [referring to spatial drama], I thought it would’ve been cool. Dramatic space and something on the wall somehow. (From focus group interview with IGATY-VE group, January 25, 2015)*

These results resonate the art historian Panofsky’s (1968) interpretation of the Italian architect Vasari’s (1511-1574) argument about design. In his *Idea: A Concept in Art Theory*, Panofsky writes:

*This [Vassari’s argument about design] says, then, the idea not just presupposes but actually originates in experience; not only can the idea be readily combined with observation of reality, it is observation of reality only clarified and made more*
universally valid by the mental act of choosing the individual from the many and then combining the individual choices into a new whole (p. 62).

Panofsky’s interpretation of Vassari’s argument suggests that for design and ideation, in order to generate a “derivative of reality” (p. 62), a combination of individual choices or archetypes in this research is crucial. In later work many other researchers, including Johansson (2004), believe that art and architecture in the Renaissance flourished due to the discovery of the combination method in the ideation process. Findings in this study and supporting literature imply that in developing an archetype-based generative abstraction software, the developer should pay attention to the combination function among multiple archetypes and carefully implement the idea of complexification by synthesis to foster an enhanced ideation process.

5.8. Finding 8: Archetypes in a Virtual Environment and Creativity

5.8.1. Phenomenology in Experiencing Museum Interior Archetypes

The integration of virtual environment technology with the IGATY-beta version system was based on theories proposed by previous researchers. Most importantly, the IGATY-beta system was designed to reflect Brill’s (1994) notion of the importance of integrating all senses in experiencing archetypes and Böhme’s (1993) explanation about aesthetics as a theory of perception in which “the presence of persons, objects, and environment” (p. 116) is crucial. Currently in design education, however, there is no such tool that allows designers and students to experience museum interior archetypes multi-dimensionally. Results in this research that show positive change in understanding archetypes as well as the enhancement of creativity in the final workshop design are conceivably a consequence of the participants’ experience of archetypes in a virtual environment. Looking at the objects from different angles, and more importantly being
in the context where they could sense the “fabric of the world” (Maerleau-Ponty, 1961/2004) might have transformed the participants’ conceptual or theoretical understanding of archetypes into something more tangible and empirical.

The significance of visual and multisensory perception in the exhibition of artworks has been widely discussed among phenomenologists. Among others, Crowther (2009) argues that the matrix of visual and kinesthetic aspects is crucial in the phenomenology of perception. Providing virtual environment that allows the viewer to experience the form, size, light, shadows, materials, color, reflection, transparencies, along with body position and movement may have extremely important benefits for designers especially in aesthetic search because all of these are correlated to create perceptual characteristics.

*It (IGATY-VE system) draws out, visualize it, so you can actually see it from different perspectives and different angles…it generates more ideas. (Interview with IGATY-VE group, January 25, 2015)*

The results also resonate with Santayana’s (1904) interpretation of aesthetics defined by Benedetto Croce (1860-1952): “the science of expression; expression being itself so defined as to be identical with every form of apperception, intuition, or imaginative synthesis” (p. 320). As Santayana (1904) argues, “the imagination must first have exercised the senses; it must first have stimulated some animal reaction, engaged attention, and intertwined itself in the vital process” (p. 324), before jumping into the realm of reality and value. The result that demonstrated the IGATY-VE group’s highest improvement in a few areas of creativity, novel idea, variation in shape, and complexity implies that the virtual environment technology may have values in fostering exercising the senses, engaged attention, and “imaginative synthesis” (p. 320).
5.8.2. Virtual Environments and Creativity

The participants’ responses in the focus group with the IGATY-VE group also revealed that the dynamic visual perception in the virtual environment fostered the process of generating different ideas. Although this study is limited in that the IGATY-VE system only allowed using the keyboard and a HMD to navigate and to view dynamic perspectives, the responses revealed the value of using virtual environment technology in employing IGAs to design an archetypes-based generative abstraction system. This result along with the result that showed the IGATY-VE group’s improvement in creativity in the final ideation workshop design implies the potential benefits of aesthetic search in the virtual environment and its positive effects in creative ideation.

*When you look at something one way and when you look at it from different ways you get completely different ideas just by using it [IGATY system]. (Interview with IGATY-VE group, January 25, 2015)*

Some scholars believe that exposure to virtual environments may “lead individuals to access unconventional knowledge when back in the physical world” (Hakak & Biloria, 2011, p. 971). Hakak and Biloria (2011) explain the rationale behind the experience of virtual environments in fostering creativity as follows:

By (a) providing direct access to novel ideas and concepts in virtual environments, (b) creating the ability to see multiple underlying functions behind the same form, (c) destabilizing conventional knowledge structure, (d) creating a psychological readiness to recruit ideas from unfamiliar sources and places, and (e) supporting synthesis of seemingly incompatible idea from another environment (p. 972).
Although Hakak & Bilogia’s explanations are focused more on the experience of unconventional virtual environments rather than any kinds of imaginary spaces both plausible and quixotic, and their research was not empirically studied, their interpretation provides valuable clues in understanding aesthetic search in the virtual environment and its value in enhancing creativity.

In this chapter I presented an expanded interpretation of the findings referring back to the results in Chapter 4. Discussion topics included the following: Finding 1: The dual structure of archetypes; Finding 2: Evolution of Archetypes - Mutation, Crossover, and Coevolution; Finding 3: The Dual Structure of Museum Interior Archetypes and IGAs; Finding 4: Archetypes and Foundation of the Ideation Process; Finding 5: IGATY Archetypes Exercise and the Creative Ideation Process; Finding 6: Archetypes Exercise with VE and its Effect on Creative Confidence and Creative Performance; Finding 7: IGATY, Synthetic Thinking Skills, and Creative Design; Finding 8: Archetypes in a Virtual Environment and Creativity. Overall, the results have promising implications for the development of an archetype-based generative abstraction system primarily because they suggest positive improvement in understanding of archetypes, improvement in synthetic thinking, and enhancement of creativity in ideation. Additional research focusing on the detailed aspects of creativity enhancement, especially in relation to the integration of IGAs with an archetypes-based generative abstraction system and with virtual environment technology, would be of great interest and value.
CHAPTER VI. CONCLUSION

A number of theorists and scholars have discussed type theory from the time of the enlightenment of philosophy through modernist ideology to the neorationalist perspectives (Güney, 2007). As much as the importance of understanding types has been discussed, the type theory has also been criticized due to misconceptions. This research was an exploration of reestablishing the value of implementation of archetypes as generative abstractions in design education. The fundamental structure of archetypes was redefined, and a dual structure was introduced. This dissertation is the first report on implementation of the proposed dual structure of museum interior archetypes with IGAs: the IGATY-beta version software was developed based on the proposed conceptual framework, and a quasi-experiment was conducted as a preliminary validation test. In this final chapter I discuss six significant implications of the research and the limitations of the study, and I propose directions for future study followed by final remarks.

6.1. Implications of the Study

This study gives researchers significant insight into a more intrinsic understanding of museum interior archetypes and informs them of possible ways to implement the theory of archetypes into a practical tool in the ideation process in design education.

First, this study expanded the literature regarding type theory by proposing the dual structure of archetypes. The proposed dual structure of archetypes clarifies previous confusion and misconceptions of understanding archetypes. Through the understanding of a malleable dual structure, both contradictory concepts of archetypes, *consistency in continuity* and *diversity in evolution* can be explained simultaneously. With the dual structure, social and cultural aspects of
archetypes can be further interpreted in complementary relationships, reinforcing the cultural
diversity as well as the global understanding of design. Reframing the conceptual foundation of
design and culture will allow design educators to empower students not only to discover
potential ground upon which culture and identity can dynamically intervene but also to witness
the core design archetypes that tie genuine global understanding to design. The archetypes
exercise will promote a way of looking at design in an interconnected global reality and will
enhance the ability to see the differences and similarities in the characteristics of contemporary
designs in a complex world. This study demonstrates that the proposed structure was found in the
six selected museum interior archetypes: It is my hope that this research will ignite additional
interest for follow-up research of obtaining a deeper understanding of the complexity of
contemporary designs based on archetypes.

Second, this study demonstrates that the proposed dual structure of museum interior
archetypes was extended with the application of IGAs in a way that promotes many previous
researchers’ original concept of type as a generative abstraction for transformation and future
invention. Mapping the dual structure of archetypes into the IGA descriptors turned into an
efficient logic that transcends the theoretical basis of archetypes into more of a transformative
one. Once a core signal and a set of peripherals are defined in an archetype, this suggested
mechanism could be applied as an operational channel for numerous already defined or
unidentified archetypes to be used in the generative abstraction system as a collective tool. Of
particular importance is the finding that the archetypes–based generative abstraction system
developed in the IGA successfully illustrated the transformative quality of museum interior
archetypes. This study highlights the importance of understanding archetypes as generative
abstractions and typological thinking as a transformative ideation method. The study empirically
demonstrated the embedded generative power each museum interior archetype bears. Such results disagree with criticisms about typological thinking that disregard the innate proficiency each archetype carries. As Güney (2007) argued, “typological thinking might facilitate a way of looking at life that promotes thinking in transformations, a way of thinking that combines in a morphological continuum” (p. 16). The study demonstrates that the practical application of transformative quality in museum interior archetypes might be optimized when archetype theory is implemented with genetic algorithms. The IGA successfully demonstrated the dynamic evolution of museum interior archetypes based on concepts inspired by biology: mutation, crossover, and coevolution.

Third, this study demonstrates that exercise with the proposed archetype-based interactive generative abstraction system implemented in IGAs has a positive effect on the pre-logic stage of the ideation process and improvement of participants’ creativity in an ideation project more than the conventional manual-sketch-based archetypes exercise. It is my hope that such finding will ignite the interest among educators for implementation and further development of the archetype-based generative abstraction systems employed in design education.

Fourth, this study demonstrates that the proposed archetypes-based IGATY-beta system improved synthetic thinking skills. The participants in the group that used IGATY-S (IGATY system displayed on screen) who showed the highest improvement in their final design in Workshop 2 also showed the highest improvement in their overall ideation quality in the combination process of ideation compared to the other groups. A correlation analysis that examined relationships between the quality in each phase in the ideation process (in three stages:
variation, combination, transformation) and creativity in the final ideation design showed a significant correlation between the quality of ideation in the combination stage and creativity in the final ideation design. This finding deepens the understanding of the detailed aspects of the ideation process in relation to an archetype-based approach to design. In search of innovation, novelty could be brought by a search in the variation phase and also by the ability to combine different ideas. This study highlights the importance of a designer’s ideation skills in the combination process as a predictor of creativity in the final ideation project.

Fifth, this study illustrates positive educational effects of the implementation of virtual reality technology as part of the archetype-based ideation process. The study demonstrates that using IGATY-VE (the archetype-based generative abstraction system integrated with Oculus rift-DK2 HMD) generally improved understanding of perceiving archetypes and the typological thinking approach as tools for the transformative ideation process. This study also illustrates the potential benefit of using virtual reality technology as part of the ideation process in maintaining students’ creative confidence throughout the process, which eventually connects initial creative confidence with actual creative performance until the project is complete. This study is meaningful in that it demonstrates a powerful example in which computer and virtual reality technology were used as interactive partners during an archetype-based ideation process.

Sixth, this study gives researchers significant insight into the development of educational tools using technology based on a relevant conceptual, theoretical, and pedagogical basis rather than focusing too much on the functional aspects or the efficiency of the tool. This study thus suggests that developers of educational tools should give thoughtful attention to careful
integration with more intrinsic educational philosophy and a pedagogical and conceptual framework specific to the particular domain.

6.2. Limitations of the Study

This study is not free of limitations; for instance, the study of typology has innate limitations when one seeks the representative models communicating their shared principles representing all possible members in each type. Moreover, only six museum interior archetypes were selected for this study to test the conceptual framework designed in this research. Further exploration and follow-up research are needed to make the proposed structure of archetypes more convincing and broadly applicable to other design archetypes. Interestingly, bringing the shared principles to the very fundamental level of core signal in each archetype and grouping other variables in a range under peripherals to some extent helped clarify each archetype.

Another limitation of this research is the small sample size. Participating in a two-day, six-hour workshop during weekends in addition to their busy studio work was not an attractive proposition for design students. Another reason for the small sample sized was the limited number of equipment (e.g., Oculus rift DK2) available for the research. The small sample size did not allow me to evaluate detailed aspects of creativity improvement under the broad category of the creativity cluster. Nevertheless, this limitation should not overshadow the importance of the different increases in each area of the creativity component that each treatment group showed; for example, the fact that the IGATY-S group improved overall creativity more than the other two groups and the particular areas that the IGATY-VE group showed highest improvement such as creativity, novel ideas, and complexity deserve more attention in future research.
Because the proposed IGATY system is new beta version software and has not been tested for usability, the software was not perfectly stable for the experiment. An unexpected malfunction occurred during the main quasi-experiment: the tab key did not work the way it was intended and the selection process in each generation had to be complete if the user wanted to change parameters. Scalar projections work well in the Windows operating system, however, the projected images of the Scalar archetype did not appear to show two or more variations in the Mac OX operating system used for the HMD integration. Although these problems did not seriously impact the overall experiment, the first natural extension of this study would be a usability study to refine the detailed functional aspects of the software and the interface.

6.3. Future Directions

Additional research focusing on the following areas would be of great interest and value:

First, multi-level comparison studies that examine the proposed generative abstraction system’s potentially different effects on the following groups of people: beginning level students/designers and advanced level students/designers; low performing students and high performing students; designers who play computer games regularly and designers who are not gamers; students with low creative confidence and students with high creative confidence. Research in determining the impacts of IGATY on different users would be beneficial to determine the target audience in order to introduce the proposed generative abstraction system.

Second, it is my hope that this study will stimulate the interest for developing archetype-based generative abstraction systems integrated with IGAs to be used for the ideation process in design education. The proposed IGATY-beta system is the beginning. The system should be developed in the following areas: (1) The parameters should be diversified to prevent negative
impressions of prescriptive solution space. The parameters in the GA system are critical in performance of a GA (Van Kemenade, Kok, and Eiben, 1995). To expand the research even deeper, in the crossover function, developing an exchange operation that switches characteristics of each chromosome (Fasoulaki, 2007), not genes, would be of great value. (2) The system also should include multiple archetypes to make them available for more dynamic aesthetic search and synthesis. (3) IGA interaction in the virtual environment in the IGATY-VE version should be refined to make interaction more convenient.

Third, although it was not part of the research questions, participants’ preferences and patterns of using certain archetypes were observed during the quasi-experiment. Once enough archetypes are mapped into the system, implementing a prediction model such as a hidden Markov model (HMM) would reveal the ways to design the system to predict a designer’s preference or tendency and would suggest more customized sets of archetypes or parameters. Implementing a prediction model would be beneficial in that it could both (1) expedite ideation by recommending preferred sets and (2) lead the designer to avoid idea fixation by suggesting particular sets of archetypes or variables rarely used by the designer.

6.4. Final Remarks

In search of opportunities for future inventions, taking the path to the past and searching for the origins might not sound like a convincing method. However, if the goal of the past and the present is both to find a way to bring creativity and innovation to design, these two points should meet. Type study will always be criticized if it maintains the status of an exclusive search for original forms: it will stagnate and may never be more useful than a stuffed specimen in a museum. Likewise, mere search for innovation ignoring the innate power of the malleable
structure of archetypes may face the problem of deficiency or stagnation in a pool of banal imitations of trendy styles. For me this study was a curious and revealing journey from deep thoughts about archetypes and finally to pleasant observations of some auspicious clues to the unknown future. I hope this research provides a rendezvous point where type theorists and creativity researchers collaborate.

This study also was an illustration of my insatiable interest in a connected network of multiple disciplines influenced by Johnson’s (2010) liquid network theory. Broadly speaking, in this study an integral biological concept inspired the understanding of the archetypes design theory, and computer science offered a way for the implementation of the biology inspired archetypes design theory to be actualized. Finally, high-end technology reinforced the plausible embodiment of the conceptual framework developed throughout the study.
APPENDIX A
CONSENT FORM
Consent to Participate in Research Study

You are invited to participate in a research study about design archetypes. This research aims at examining the potential benefit of using design archetypes in design education. The purpose of this study is to determine whether typological thinking based on the proposed understanding of archetypes could enhance students' understanding of archetypes, attitudes including creative confidence, and creativity in design projects.

If you agree to be part of the research study, you will be asked to answer survey questions, participate in a museum archetypes lecture, archetype exercises designed for this study, and two design ideation workshops. During archetype exercises, one of the three groups will occasionally view virtual environments via head-mounted display. It is possible that you may experience visual discomfort or motion sickness, such as dizziness and nausea.

The researchers hope that the information you provide will assist the researcher in making informed decisions in the development of effective instructional materials and techniques to enhance students’ creative ideation. You may earn extra credit if you are taking a class that offers credit for research studies. The class instructor will assign credit according to class policy. You will be provided a certificate that proves your participation in this research and a $10 gift card if you complete the two-day design workshop.

Participating in this study is completely voluntary. Even if you decide to participate now, you may change your mind and stop at any time. You may choose not to answer any survey question for any reason. The information you provide about yourself is needed for research purposes only and will be treated as strictly confidential. The workshop process will be videotaped and will be used for analysis only. Some of students’ works from the workshop may appear in the researcher’s scholarly activities such as academic publications. If you have any questions about this research study, you may contact Joori Suh, principal researcher at joorisuh@iastate.edu.

We appreciate your cooperation and time shared with us.

Iowa State University Institutional Review Board has determined that this study is exempt from IRB oversight.

I agree to participate in the study.

_________________________
Signature [optional]            Date
APPENDIX B
IRB EXEMPT APPROVAL DOCUMENT

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 1/13/2015
To: Joori Suh
CC: Dr. Mikesch Muecke

From: Office for Responsible Research

Title: Archetypes study in design education

IRB ID: 14-654
Study Review Date: 1/13/2015

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (1) Research conducted in established or commonly accepted education settings involving normal education practices, such as:
  - Research on regular and special education instructional strategies; or
  - Research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.

- You shall carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other
colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4586 or IRB@iastate.edu.
APPENDIX C

PATTERN RECOGNITION EXERCISE
(Examples of Student Work)
PATTERN RECOGNITION EXERCISE

INSTRUCTION
In this exercise, we ask you to try to recognize shared common traits among a certain group of archetypes. Please look at the images in the package coded "P" first. You may see something similar among a few of the examples. Start collecting the images that share characteristics (up to 5) to create a group. That is how you create an archetype. Remember, each group should have unique characteristics that make the group distinct from other groups.

How would you name this group: [Student response]

What are the main characteristics or principles? (In other words, what makes this group unique and distinguishable from others?)

THE MAIN IDEA IS TO ENCOURAGE DESIGN, CREATING A NEW SPACE FOR THE

How did you make a space?

What are the differences found among 5 examples you collected? (e.g. materials, size, etc.)

THE DIFFERENCES ARE THE TYPE OF GLASS, THE MATERIALS IN CONTACT WITH THE

THE TYPE OF DISPLAY.

You may find 6 groups. Do your best!

PASTE THE PHOTOS OF A GROUP ON EACH ARCHETYPE PAGE AND ANSWER THE QUESTIONS BELOW.

P-2

P-3
THE ARTIST : David Barnett

BACKGROUND INFORMATION

I begin much the way Auden envisioned an author starting a "piece of fiction. A character is born, and a storyline begins. If you listen carefully enough, the subject will help you to travel through the entire journey. Whether it is a literal piece of metal, branches from an oak tree, or a torn strip of typography, the right juxtaposition can always find its way into my constructions—this more absurd, the better. The end results happen when these various found or created elements come together to form a believable vision.

With a desire to express myself creatively, I explored alternate methods of visual communication. Finding inspiration in the works of Warhol, Yoko Ono, Robert Rauschenberg, and the Fluxus movement, I began to experiment with collage. This print page is in its original form, ink and watercolor manipulations, edges obtained, transparency exploited; these are my pens and pencils. However, the two-dimensional surface exists at times limiting. Because of my fascination with materials, my influences broadened from the poetic boxes of Joseph Cornell, to the metaphorical machines of Arthur Ganson, and of course, Leonardo Da Vinci—most specifically his ideas on human flight and combining the study of anatomy and mechanics. Using found objects coupled with original structural supports—using soldered brass, glazed rice paper and other various visual components—I found my artistic palette unlimited.

Beginning a new piece of art at times the hardest part. The initial concept is usually inspired by my observations. The design and design fun to be clear, details have to be envisioned. Once the concept, a majority of the rigour falls into place. However, at times, halfway through the process the piece can take a 180-degree turn. Letting go of my initial thought is never easy, but being flexible and resilient is a necessity.

My work speaks to a few recurring themes:

One: The battle between society and automation for man’s soul. To comment on humanity and technology, I try to depict the interplay between the two—see attachment 1. While man can stop and the other begins something totally new with similar connections between the past and present, the object can take on the form of a conceptualized novel-needs construction such as the one depicted (see attachment 2). This model flying machine is a comment on man’s comparison to media nature through industrialization. It’s created from hundreds of tiny turquoise feathers supported by a complex brass structure—embellished with patterns and fans that suggest a mechanical function that exists only in my imagination.

Two: Our current state of visual overload. Today’s "information age" and the modernization that has emerged on the horizon along with it. I illustrate the point in a number of ways. For example, (see attachment 3) Traditional images—the bird and the Renaissance man—have been surpassed by technological elements. The bird’s mechanical elements are, in fact, too pointy. Cyclopedia combines traditional collage with bits of typography; old newspaper, found objects, and discarded wire mesh have been brought together to form a new machine—presumably a vessel to transport the elderly—include an aircraft type propeller powered by a 120-volt motor. The moving metallic blades suggest a mechanical function that exists only in my imagination. If this assembly is impossible, it is certainly impossible. If this assembly is impossible, it is certainly impossible. The elaborate design has been added on for a reason other than its creator’s ability to do so.

THE ARTIST : David Barnett

Theme One: The battle between society and automation for man’s soul

Men’s need to take flight—this notion has always triggered my imagination; where the human enters leaves off and the technical aspect begins. It seems as if technology is so overwhelming it swallows man’s identity. My career as a graphic designer, filled with tight deadlines, demanding clients, and limited budgets, the concept of flight has taken on a personal meaning: a freedom of artistic expression.

Top Story, 2004, Mixed Media, 27.5 x 16 x 6 in.

Theme Two: Our current state of visual overload

A play on the diagrams and charts of Edward Tufte and the vintage illustrated works collected by Willem Sand by Galerie of Lambert Crouzet. At first glance they all appear to convey serious information. Upon closer inspection the actual work is not at all as it first appears. It speaks to "misinformation" and distortion in today’s society. Not unlike the communication we are bombarded with daily, from advertising to politics.

Artworks introduced for Workshop 1

Toy Story, 2004, Mixed Media, 27.5 x 16 x 6 in.

Two sculpture pieces selected for the exhibit

Two collage pieces selected for the exhibit

Apachment #1
Sanctuary, Flight #4, 2010, Mixed Media, 24 x 36 x 2 in.

Apachment #2
Cyclopedia

Apachment #3
Machine for Lazy Bones
THE ARTIST : David Barnett

Theme One: The battle between society and automation for man’s soul

Man’s need to take flight—this notion has always triggered my imagination, where the human element leaves off and the technical aspect begins. It seems at times technology is so overwhelming it swallows man’s identity. In my career as a graphic designer, filled with tight deadlines, demanding clients, and limited budgets, the concept of flight has taken on a personal meaning: a freedom of artistic expression.

Two sculpture pieces selected for the exhibit

Two collage pieces selected for the exhibit

Artworks introduced for Workshop 2

PROJECT DESCRIPTION

DESIGN PROBLEM: You are invited to redesign a 12’ x 12’ museum gallery space in a large open museum space at the Bronx, New York. A museum curator came up with the idea to display David Barnett’s four artworks. The museum director stated, “The proposal does not effectively tell the story. The intention of this exhibit is to convey the artist’s imagination. Let’s invite a designer and give freedom to utilize the whole 12’ x 12’ space and enhance detailed aspects of David Barnett’s artistic imagination. The design should enrich multisensory exhibition experience.” You are hired to redesign the space for this mission. The designer’s artistic reproduction, manipulation, and transformation of the selected artworks are permitted for this exhibition; therefore, you have options to display (or not to display) the original artwork as part of your exhibit design.

Judging criteria:

Final Design: Creativity + Variation in shapes + Novel use of materials + Novel idea + Novel use of color + Complexity + Effective execution + Idea to enhance multisensory experience

Design Process: Variation + Combination + Transformation

The curator’s proposal (rejected).

Project Description for Ideation Workshop
Step 1: Initial brain storming sketches

Step 2: Variation phase sketch
Step 3: Combination phase sketch

IDEATION - Combination

INSTRUCTION
Using the blank square boxes below, combine some of previously created sketches to explore your ideas (horizontal sketches). Sketch combined ideas as many as you can. You can use as many ideation sheets as you want. Please let the workshop facilitator know whether you need more papers.

Step 4: Transformation phase sketch

IDEATION - Transformation

INSTRUCTION
By using the blank square boxes below, transform some of previously created sketches to explore your ideas (horizontal sketches). Sketch transformed ideas as many as you can. You can use as many ideation sheets as you want. Please let the workshop facilitator know whether you need more papers.
Final Ideation Workshop Design
APPENDIX E
SURVEY ONE

Introduction

This survey is part of a research project aimed at evaluating students’ learning experiences with archetype exercises. The word archetype derives from the Greek for "original model." The purpose of this survey is to obtain feedback on your general understanding of archetypes and how you evaluate learning experience and attitude before and after the workshop. We hope that the information you provide will assist the researcher in making informed decisions in the development of effective instructional materials and techniques to enhance students’ creative ideation.

The questionnaire is not a test, and so no answer is considered wrong. However, we seek your honest opinions, which we anticipate will be reflected in the answers you provide.

The information you provide about yourself is needed for research purposes only and will be treated as strictly confidential. We appreciate your cooperation and time shared with us.

Yours sincerely,
Joori Suh (principal researcher)

Index No.

Section A: Demographic data

The following background information about you is needed for classification purposes. By checking the appropriate box please indicate the classifications that best describe you.

1. Please indicate your gender.
   - Female
   - Male

2. Which range includes your age?
   - 18 – 20
   - 21 – 23
   - 24 – 26
   - 27 – 29
   - 30 – 32
   - 33 – 35
3. In what year of study are you currently enrolled?
   - Freshmen
   - Sophomore
   - Junior
   - Senior
   - 5th year
   - Graduate school ( ___ year)

4. Please indicate your current major.
   - Interior Design
   - Architecture
   - Graphic Design
   - Landscape Design
   - Integrated Studio Art
   - Others _______________

5. Is English your first (primary) language?
   - Yes
   - No

6. Do you play interactive adventure, strategy, combat, simulation games (e.g., Starcraft, The Sims) on the Internet (or video)?
   - Yes
   - No

7. During an average week, how many hours do you spend playing video (or Internet) games?
   - Never
   - Less than 1 hour
   - 1 to 3 hours
   - 3 to 5 hours
   - 5 to 7 hours
   - More than 7 hours
Section B: Understanding of Archetypes and Typological Thinking

The following questions concern your general understanding of the attributes of archetypes and typological thinking approach in design.

8. Please indicate how you feel about relationships between the words listed and archetypes by marking the numbers on the right. (For example, if you feel archetypes and “sameness” are closely related, mark 7).

<table>
<thead>
<tr>
<th>ARCHETYPES</th>
<th>Not related</th>
<th>Closely related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sameness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Similarity</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Diversity</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

9. Please indicate how you feel about typological thinking in design by marking the numbers on the right. (For example, if you strongly agree that typological thinking is for categorizing, mark 7).

<table>
<thead>
<tr>
<th>TYPOLOGICAL THINKING is for</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorizing</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Imitation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Variation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Combination</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Transformation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Invention</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
Section C: Attitudes towards high-end technology

In this section, we want to find out YOUR opinion of high-end technology, such as advanced computer programs, apps, devices, 3-D printers, or virtual reality simulation.

10. Please answer the questions and let us know what you think of high-end technology. There are no right or wrong answers, so just mark the number that comes closest to what YOU think. Please answer all items.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology is very important in life.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-end technology makes design more interesting.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I positively do NOT want to have a job that uses a lot of high-end technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would like to learn more about new technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am NOT interested in high-end technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think technology is a little scary.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I usually feel comfortable working with high-end technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like playing with new technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can do a good job using high-end technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. Do you have motion sickness (cyber sickness)?

- [ ] Yes
- [ ] Somewhat
- [ ] No
### Section E: Attitude Towards Ideation Workshop

The following questions are concerned with your feeling about your creative confidence in the ideation workshop.

12. Please rate the following items on the left based on your attitude toward the workshop you will participate.

<table>
<thead>
<tr>
<th></th>
<th>Not at all true of me</th>
<th>Very true of me</th>
</tr>
</thead>
<tbody>
<tr>
<td>I consider myself to be a creative person.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel designing is a playful activity.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel that I have a good imagination</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in the workshop.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in coming up with multiple options.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in combining variations.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in transforming variations.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

- END OF SURVEY -
APPENDIX F
SURVEY TWO

Section F: Workshop Experience

The following questions concern your feeling about your experience in the ideation workshop W1.

1. Please rate the following items on the left based on your behavior in the exercise you participated.

<table>
<thead>
<tr>
<th></th>
<th>Not at true of me</th>
<th>Very true of me</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I liked the design problem.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>During the course of designing, I felt as if the task was like a game and that designing was a playful activity.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>I feel confident that I was creative during the course of designing.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>I feel that I have had many good ideas and good design intentions that I did not apply and include in the final design.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>During the course of designing, I was able to come up with multiple ideas or variations.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>During the course of designing, I was able to combine multiple ideas or variations.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>During the course of designing, I was able to transform multiple ideas or variations.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>During the course of designing, I considered more aesthetic aspects than practical and applied aspects.</strong></td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

2. Please describe how you felt about your experience during the ideation workshop W1.
Section G: Self Evaluation

The following questions concern your evaluation of your project in the ideation workshop W2.

G.1 FINAL DESIGN

3. Please rate the following items on the left.

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Variation in shapes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Novel use of materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Novel idea</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Novel use of colors</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Detail</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Effort evident</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Novel Idea to enhance Sensory Experience</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>
**G.2 DESIGN PROCESS**

*Please see IDEATION pages to rate your design process. Please rate each dimension based on the design process, including the final project.*

<table>
<thead>
<tr>
<th></th>
<th>Poor ---------------------------------</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variation</strong> (Evidence of producing variations of similar ideas is apparent in the process)</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>Combination</strong> (Evidence of producing combinations of different ideas is apparent in the process)</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td><strong>Transformation</strong> (Evidence of producing transformation of previously generated ideas is apparent in the process)</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

- END OF SURVEY -
## APPENDIX G
### SURVEY THREE (M)

### Section B: Understanding of Archetypes and Typological Thinking

The following questions concern your general understanding of the attributes of archetypes and typological thinking approach in design.

1. Please indicate how you feel about relationships between the words listed and archetypes by marking the numbers on the right. (For example, if you feel archetypes and “sameness” are closely related, mark 7).

<table>
<thead>
<tr>
<th>ARCHETYPES</th>
<th>Not related</th>
<th>Closely related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sameness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Similarity</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Diversity</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

2. Please indicate how you feel about typological thinking in design by marking the numbers on the right. (For example, if you strongly agree that typological thinking is for categorizing, mark 7).

<table>
<thead>
<tr>
<th>TYPOLOGICAL THINKING is for</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorizing</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Imitation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Variation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
Section D: Learning Experience of Archetypes Exercise in Lesson Plans

The following questions are concerned with your feeling about your learning experience with Archetypes exercise in the specific lesson plan you participated in.

3. Please rate the following items on the left based on your behavior in the lesson you participated.

<table>
<thead>
<tr>
<th></th>
<th>Not at all true of me -------------------------------------- Very true of me</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe understanding typological thinking is important.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>I am certain I understood the ideas practiced in the lesson plan.</td>
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<td>It was hard for me to decide what the main ideas were in the lesson plan.</td>
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</tr>
<tr>
<td>I feel what I learned from the lesson plan is useful.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>The exercise in the lesson plan encouraged me to think about various options that can be created with each archetype.</td>
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<tr>
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<tr>
<td>The exercise in the lesson plan encouraged me to think about how I may combine various archetypes to create a new one.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>The overall lesson plan was fun and enjoyable.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>The overall exercise gave me a lot of ideas I can use in the workshop.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>I feel confident that I can be creative in the workshop.</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>
4. Please describe your opinion of the archetype exercise you experienced.

5. Which part of the lesson plan was most useful? (Mark all that apply)
   
   - Lecture about Archetypes
   - Pattern Recognition Exercise
   - Exercise M: manual sketching

Section E: Attitude towards Ideation Workshop

The following questions are concerned with your feeling about your creative confidence in ideation workshop.

6. Please rate the following items on the left based on your behavior towards the workshop you will participate.

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<thead>
<tr>
<th></th>
<th>Not at all true of me</th>
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<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in coming up with various different options of ideas.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in combining different variations.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in transforming different variations.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

- END OF SURVEY -
APPENDIX H
SURVEY THREE (IGATY-S)

Index No. 

Section B: Understanding of Archetypes and Typological Thinking

The following questions concern your general understanding of the attributes of archetypes and typological thinking approach in design.

1. Please indicate how you feel about relationships between the words listed and archetypes by marking the numbers on the right. (For example, if you feel archetypes and “sameness” are closely related, mark 7).

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</thead>
<tbody>
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<tr>
<td>Sameness</td>
</tr>
<tr>
<td>Similarity</td>
</tr>
<tr>
<td>Flexibility</td>
</tr>
<tr>
<td>Diversity</td>
</tr>
</tbody>
</table>

2. Please indicate how you feel about typological thinking in design by marking the numbers on the right. (For example, if you strongly agree that typological thinking is for categorizing, mark 7).

<table>
<thead>
<tr>
<th>TYPOLOGICAL THINKING is for</th>
<th>Strongly Disagree</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Categorizing</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
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<td></td>
</tr>
<tr>
<td>Imitation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
Section C: Attitudes towards high-end technology

In this section, we want to find out YOUR opinion of high-end technology, such as advanced computer programs, apps, devices, 3-D printers, or virtual reality simulation.

3. Please answer the questions and let us know what you think of high-end technology. There are no right or wrong answers, so just mark the number that comes closest to what YOU think. Please answer all items.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology is very important in life.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-end technology makes design</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>more interesting.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I positively do NOT want to have a</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>job that uses a lot of high-end</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>technology.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would like to learn more about</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>new technology.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am NOT interested in high-end</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>technology.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think technology is a little scary.</td>
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<td></td>
</tr>
<tr>
<td>I usually feel comfortable working</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with high-end technology.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like playing with new technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel confident that I can do a</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>good job using high-end technology.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section D: Learning Experience of Archetypes Exercise in Lesson Plans

The following questions are concerned with your feeling about your learning experience with Archetypes exercise in the specific lesson plan you participated in.

4. Please rate the following items on the left based on your behavior in the lesson you participated.

<table>
<thead>
<tr>
<th>I believe understanding typological thinking is important.</th>
<th>Not at all true of me ----------------- Very true of me</th>
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<tr>
<td></td>
<td>1  2  3  4  5  6  7</td>
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5. Please describe your opinion of the archetype exercise you experienced.
6. Which part of the lesson plan was most useful? (Mark all that apply)

- Lecture about Archetypes
- Pattern Recognition Exercise
- IGATY–S: Using IGATY Software

Section E: Attitude towards Ideation Workshop

The following questions are concerned with your feeling about your creative confidence in ideation workshop.

7. Please rate the following items on the left based on your behavior towards the workshop you will participate.

<table>
<thead>
<tr>
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</tr>
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<td></td>
<td>1 2 3 4 5 6 7</td>
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<td></td>
<td>1 2 3 4 5 6 7</td>
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</tr>
</tbody>
</table>

- END OF SURVEY -
APPENDIX I
SURVEY THREE (IGATY-VE)

Section B: Understanding of Archetypes and Typological Thinking
The following questions concern your general understanding of the attributes of archetypes and typological thinking approach in design.

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<td></td>
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<td></td>
</tr>
<tr>
<td>Imitation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>Variation</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Combination</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Transformation</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Invention</td>
<td>1</td>
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</tr>
</tbody>
</table>

**Section C: Attitudes towards high-end technology**

*In this section, we want to find out YOUR opinion of high-end technology, such as advanced computer programs, apps, devices, 3-D printers, or virtual reality simulation.*

3. Please answer the questions and let us know what you think of high-end technology. There are no right or wrong answers, so just mark the number that comes closest to what YOU think. Please answer all items.

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<tr>
<td>I positively do NOT want to have a job that uses a lot of high-end technology.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>I feel confident that I can do a good job using high-end technology.</td>
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<td></td>
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</table>
Section D: Learning Experience of Archetypes Exercise in Lesson Plans

The following questions are concerned with your feeling about your learning experience with Archetypes exercise in the specific lesson plan you participated in.

4. Please rate the following items on the left based on your behavior in the lesson you participated.

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</tbody>
</table>

5. Please describe your opinion of the archetype exercise you experienced.
6. Which part of the lesson plan was most useful? (Mark all that apply)

- Lecture about Archetypes
- Pattern Recognition Exercise
- IGATY–VE: IGATY Software and Virtual Environment experience

Section E: Attitude towards Ideation Workshop

The following questions are concerned with your feeling about your creative confidence in ideation workshop.

7. Please rate the following items on the left based on your behavior towards the workshop you will participate.

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<td>I feel confident that I can be creative in coming up with various different options of ideas.</td>
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<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in combining different variations.</td>
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<td></td>
</tr>
<tr>
<td>I feel confident that I can be creative in transforming different variations.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

- END OF SURVEY -
APPENDIX J
SURVEY FOUR

Index No.

Section F: Workshop Experience

The following questions concern your feeling about your experience in the ideation workshop W2.

1. Please rate the following items on the left based on your behavior in the workshop W2 you participated.

<table>
<thead>
<tr>
<th></th>
<th>Not at all true of me</th>
<th>Very true of me</th>
</tr>
</thead>
<tbody>
<tr>
<td>I liked the design problem.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I felt as if the task was like a game and that designing was a playful activity.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel confident that I was creative during the course of designing.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>I feel that I have had many good ideas and good design intentions that I did not apply and include in the final design.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I was able to come up with multiple ideas or variations.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I was able to combine multiple ideas or variations.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I was able to transform multiple ideas or variations.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>During the course of designing, I considered more aesthetic aspects than practical and applied aspects.</td>
<td>1  2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

2. Please describe how you felt about your experience during the ideation workshop W2.
Section G: Self Evaluation

The following questions concern your evaluation of your project in the ideation workshop W2.

G.1 FINAL DESIGN

3. Please rate the following items on the left.

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Variation in shapes</td>
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<td></td>
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<tr>
<td>Novel use of materials</td>
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<tr>
<td>Novel idea</td>
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<tr>
<td>Novel use of colors</td>
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<td>Complexity</td>
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<td>Detail</td>
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<td>Effort evident</td>
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<td></td>
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<tr>
<td>Novel Idea to enhance Sensory Experience</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
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</tbody>
</table>
G.2 DESIGN PROCESS

*Please see IDEATION pages of to rate your design process. Please rate each dimension based on the design process, including the final project.*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Poor</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variation</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Evidence of producing variations of similar ideas is apparent in the process)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td><strong>Combination</strong></td>
<td></td>
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</tr>
<tr>
<td>(Evidence of producing combinations of different ideas is apparent in the process)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td><strong>Transformation</strong></td>
<td></td>
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</tr>
<tr>
<td>(Evidence of producing transformation of previously generated ideas is apparent in the process)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

- END OF SURVEY -
APPENDIX K
CRITERIA FOR CAT

Introduction

Please follow the randomly assigned order to rate student projects. First, find the Index No. from the first page of student work and write the number in the box below. Keep the different dimensions of judgment as separate from one another as possible. Rate student projects relative to one another on each dimension instead of rating them against some absolute standard of art.

Creativity: In terms of your own subjective definition of creativity, the degree to which the design is creative.

<table>
<thead>
<tr>
<th>Index No.</th>
</tr>
</thead>
</table>

EVALUATION OF CREATIVITY
Using your own subjective definition and judgment, please rate student projects on each dimension.

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>1</th>
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<th>3</th>
<th>4</th>
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<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
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<tr>
<td>Variation in shapes</td>
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<td>Organization</td>
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<td>Novel use of materials</td>
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<tr>
<td>Aesthetic appeal</td>
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<td></td>
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<tr>
<td>Novel idea</td>
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<tr>
<td>Novel use of colors</td>
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</tbody>
</table>
### Evaluation of Design Process

*Please see IDEATION pages of to rate the student’s design process. Please rate each dimension based on the student’s design process.*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Poor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variation</strong> (Evidence of producing variations of similar ideas is apparent in the process)</td>
<td></td>
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</tr>
<tr>
<td><strong>Combination</strong> (Evidence of producing combinations of different ideas is apparent in the process)</td>
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<tr>
<td><strong>Transformation</strong> (Evidence of producing transformation of previously generated ideas is apparent in the process)</td>
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</tbody>
</table>

Please write any other comments about this student’s project.
REFERENCES


