Enhancing the Indoor-Outdoor Visual Relationship: Framework for Developing and Integrating a 3D-Geospatial-Based Inside-Out Design Approach to the Design Process

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ABSTRACT

This research study aims to enhance the effectiveness of the architectural design process regarding the exploration and framing of the best visual connections to the outside environment within built environments. Specifically, it aims to develop a framework for developing and integrating an inside-out design approach augmented and informed by digital 3D geospatial data as a way to enhance the explorative ability and decision-making process for designers regarding the visual connection to the outside environment. To do so, the strategy of logical argumentation is used to analyze and study the phenomenon of making visual connections to a surrounding context. The initial recommendation of this stage is to integrate an inside-out design approach that operates within the digital immersion within 3D digital representations of the surrounding context. This strategy will help to identify the basic logical steps of the proposed inside-out design process. Then, the method of immersive case study is used to test and further develop a proposed process by designing a specific building, specifically, an Art Museum building on the campus of Virginia Tech. Finally, the Delphi method is used in order to evaluate the necessity and importance of the proposed approach to the design process and its ability to achieve this goal. A multi-round survey was distributed to measure the consensus among a number of experts regarding the proposed design approach and its developed design tool. Overall, findings refer to a total agreement among the participating experts regarding the proposed design approach with some different concerns regarding the proposed design tool.
Enhancing the Indoor-Outdoor Visual Relationship: Framework for Developing and Integrating a 3D-Geospatial-Based Inside-Out Design Approach to the Design Process

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GENERAL AUDIENCE ABSTRACT

Achieving a well-designed visual connection to one’s surroundings is considered by many philosophers and theorists to be an essential aspect of our spatial experience within built environments. The goal of this research is to help designers to achieve better visual connections to the outside environment and therefore create more meaningful spatial experiences within the built environment. This research aims to enhance the ability of designers to explore the best possible views and make the right design decisions to frame these views of the outdoors from the inside of their buildings. Of course, the physical presence of designers at a building site has been the traditional method of determining the best views; however, this is not always possible during the design process for many reasons. Thus, this research aims to find a more effective alternative to visiting a building site in order to inform each design decision regarding the quality of its visual connection to the outdoors. To do so, this research developed a proposed inside-out design approach to be integrated into the design process. Specifically, it outlines a process that allows the designers to be digitally immersed within an accurate 3D representation of the surrounding context, which will help designers to explore views from multiple angles both inside the space and in response make the most suitable design decision. For further developing the proposed process, it was used during conducting this research to design an Art Museum on Virginia Tech Campus.
Dedication

I would like to dedicate this work to my mother Haifaa, my father Mohammad, and my brothers and my sister, who always support and encourage any academic achievement.

Also, I would like to dedicate this work to the people who have been the most positive, supportive, and inspirational to me at all times, including our adventures and surprise trip—my lovely wife Heba and my great and sweet children Lara and Kareem.

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1. Chapter One: Introduction

1.1. Introduction

Achieving a meaningful spatial experience within the built environments is an essential goal of architecture. It is widely agreed that any work of architecture essentially seeks to provide a meaningful spatial experience in which its inhabitants can truly “dwell.” Also, the phenomenon of the indoor-outdoor relationship is an inseparable part of this spatial experience and has a great influence on achieving this goal. Many philosophers and architectural theorists have developed several hypotheses and interpretations that emphasize the essential role of the indoor-outdoor relationship in achieving those meaningful spatial experiences that meet basic human needs. For example, Martin Heidegger emphasizes, in his seminal essay “Building, Dwelling, Thinking,” that the fourfold of sky, earth, divinity, and mortality are essential for true “dwelling” (Heidegger, 1977). In other words, to dwell is to bring the essence of our surroundings into our being. He also emphasizes the essential importance of the in-between boundary between the indoors and outdoors. He argues that “a boundary is not that at which something stops but as Greeks recognized, the boundary is that from which something begins its essential unfolding” (Heidegger, 1977). Christian Norberg-Schulz (1980) also addressed this issue when he argues that “it is meaningless to imagine any happening without reference to a locality. Place is evidently an integral part of existence” (Norberg-Schulz, 1980). He also believes that “man dwells when he can orient himself with an environment” (p. 5). These views—and the related views of other architects and architectural theorists who addressed this issue such as Juhani Pallasmaa, Tadao Ando, Kenneth Frampton—are discussed in more detail in the next sections.

For many architects, a well-designed visual connection to the outside is pivotal for the
indoor-outdoor relationship. Moreover, several studies indicate that there are many benefits of establishing a well-designed visual connection to the outside for the health, well-being, and productivity of a space’s inhabitants (C. O. Ryan, Browning, Clancy, Andrews, & Kallianpurkar, 2014). Neuroscientific studies indicate the importance of natural views on human health and productivity. A study by Brown, Barton, and Gladwell (2013) shows the impact of the man-nature connection on stress reduction by lowering blood pressure and heart rate. Another study by (Biederman & Vessel, 2006) shows the positive impact of a strong man-nature connection on cognitive performance by improving mental engagement, attentiveness, concentration, and memory restoration of the people in a built environment.

Even though there have been a number of buildings designed with meaningful spatial experiences emphasized by well-designed visual connections to the outside environments, these cases are still the exception, not the rule. Likewise, there are still many buildings found around the world that have poorly designed visual connections to the outside environment and therefore, poor spatial experiences. Cross (2006) refers to the distinctive features of the traditional architectural design process, where designers deal with an ill-defined problem within a limited frame, often requiring that they respond with only a quick approach to solve one problem within a large range of possible satisfactory solutions. Moreover, Franck and Lepori (2007) refer to another distinctive feature of the design process, which they describe as mainly an outside-in process and that therefore, designers deal with design problems through an outside perspective.

In light of these identified features of the design process, this research assumes that the inability of many architects to achieve a well-designed visual connection may be due to some essential drawbacks inherent in the design process itself. Accordingly, this research examines
this problem through multiple intertwined methods to further analyze these flaws and their impacts on the design process’ ability to achieve a well-designed visual connection. In doing so, this research could develop a framework for modifying and enhancing the traditional design process to make it more explorative, synergetic, and therefore, more context-based. Moreover, this research considers and introduces various related theories, concepts, and factors to develop its framework—such as the moving image theory, biophilia, geo-design, digital immersion, “placemaking,” “critical regionalism,” digital architecture, building boundary (building envelope), etc. As a better way of conducting this research, this research relied upon a kind of divergent and convergent thinking approach to allow for as much exploring and synthesizing of these various elements as possible to contribute to building the proposed framework.

1.2. Architecture of Resistance: From Frampton To Tadao Ando

1.2.1. Critical Regionalism: Kenneth Frampton

The phenomenon of universalization, while being an advancement of mankind, at the same time constitutes a sort of subtle destruction, not only of traditional cultures, which might not be an irreparable wrong, but also of what I shall call for the time being the creative nucleus of great cultures.


The approach of “critical regionalism,” developed by the historian-theorist Kenneth Frampton, seeks to deal with architecture in a way that counters the “placelessness” and lack of identity inherited in the international style of modern architecture. Modern architecture’s main approach focuses on the “repeatability of the buildings in space and repeatability of space in buildings,” which replaces the creation of the “place” in favor of the production of a
homogeneous and repeatable “space” (Fernàndez-Galiano, 2000, p. 106). However, critical regionalism is unlike vernacular architecture, which acts against the modern tradition; rather, it seeks to provide an architecture rooted in modern tradition, but tied to the place and to its geographical and cultural context. In other words, the fundamental strategy of critical regionalism is to “mediate the impact of universal civilization with elements derived indirectly from the peculiarities of a particular place” and to achieve “a self-conscious synthesis between universal civilization and world culture” (Foster, 1983, p. 22).

Frampton further discusses the conception of critical regionalism through six main points that revolve around a paradox raised by Paul Ricoeur (1965): “how to become modern and return to sources”? (qtd. in Frampton, 1983, p. 17). Here, Ricoeur invokes Frampton to refer to the importance of the visual and tactile of human senses in creating tangible and intangible experiences within a building. Frampton (1983) also indicates that one of the main problems of a modern building is that “it is now so universally conditioned by optimized technology that the possibility of creating significant urban form has become extremely limited” (p. 17). As one of his main points, in a section he called “The Resistance of the Place-Form,” Frampton refers to Heidegger’s critical vantage point to look at the phenomenon of “universal placelessness.” Here, Frampton supports Heidegger’s (1954) argument from his essay “Building, Dwelling, Thinking” that a concrete and clearly defined boundary of a space/place is essential for its phenomenological essence of being.

In terms of relating to one’s surrounding context, Frampton argues that critical regionalism necessarily involves a more directly dialectical relation between the indoors and the outdoors. This relation includes factors like topography, context, climate, light, and tectonic
form. In line with Frampton, Hal Foster (1983) refers to the essential role of the building boundary (building envelope) and the innate capacity of its fenestration (arrangement of windows) to “inscribe architecture with the character of a region and hence to express the place in which the work is situated” (Foster, 1983, p. 22). Therefore, Frampton believes that the building boundary is the most basic and essential element to counter a placeless quality of an architectural space and to achieve critical regionalism. As such, the goal of this research intended to simultaneously benefit from and contribute to the concept of critical regionalism. In other words, my aim is to show how the quality of a spatial experience could be greatly influenced and promoted by the indoor-outdoor relation in modern architecture, and thus contribute to the realization of critical regionalism.

1.2.2. A Form Cut off from the Outside World: Tadao Ando

In order to bring out and make apparent the invisible logic of nature, one must oppose it with the logic of architecture.

Tadao Ando, Complete Works (1995)

The exterior-interior relationship within the built environment has been a central matter of interest for many architects and architectural theorists. For example, Tadao Ando is one of the leading architects who emphasizes the concept of sensation and physical experience. Ando’s philosophy is influenced by the evolution of Japanese architecture as “the fusion of the man-made and the natural, out of the reading of topography and an awareness of nature” (Ando, 1995b). Ando believes that architecture alone, without paying attention to the surrounding context, cannot provide a fulfilling environment. For him, architecture should be designed to enable humans to sense the presence of nature. However, he does not mean raw nature, but rather
a “domesticated nature”—one that has been “given order by man and is in contrast with chaotic nature” (Ando, 1995b). The involvement of natural elements is essential in Ando’s design approach; he believes that natural elements become meaningful when they are introduced into the architectural space in “a form cut off from the outside world” (Ando, 1995). In turn, architectural form needs natural elements to become manifest and provide a meaningful spatial experience that reveals dynamic natural phenomena—such as the passing of time and the seasonal changing throughout the year. For instance, Ando describes his own experience inside the Pantheon building, where the architectural space truly becomes manifest only when it is illuminated from its oculus at the top of its dome.

More specifically, Ando’s architecture has been influenced by traditional Japanese Sukiya style. He describes how Sukiya buildings are connected to nature as: “The Sukiya tradition takes the loose natural scene and recreates it artificially in a tense composition. It uses Shoji panels to contain light, and simultaneously separates and connects the inner and outer garden walls by means of fences” (Ando, 1995a). In this vein, Ando considers the building boundary, especially its exterior walls, to be the most powerful, basic, and enriching building parts that influence the interior-exterior relationship, evoke an architectural space, and regulate the urban structure. In other words, exterior walls have the power to “divide space, transfigure place, and create new bounded domains” (Ando, 1995, p. 449). Ando believes that there should be a level of tension present on both sides of this confrontation, or the area where the internal world and external world meet. He argues that “those places where the internal order meets the external order, that is, the area of fenestration in a building, are of extreme importance” (Ando, 1995, p. 449). This area of fenestration allows walls to play the dual role of acceptance and
rejection of the immaterial and amorphous elements of wind, sunlight, sky, and landscape. This role mainly occurs through, as Ando describes, the act of cutting as a “ceremonial act symbolizing a new disclosure” where the “walls ‘cut’ into sky, sunlight, wind and landscape at every instant, and the architecture reverberates to this continual demonstration of power” (Ando, 1995a, p. 449).

In fact, Ando’s intertwines conceptions of “shintia” (the union of human body and mind), architecture, a place, and the world. This has influenced his credo of the necessary fusion of nature within the man-made built environment. He believes that architecture should articulate the world in a similar way as man articulates the world. In other words, architecture should bring the world together through geometry, and man should create his world through his shintia. The asymmetrical physical structure of the human body makes him articulate a place not as a universal or a Newtonian absolute space, but as a space with “meaningful directionality and heterogeneous density” (Ando, 1995a). In the same manner, architecture brings the world into being not as homogenous spaces, but as “concrete and heterogeneous spaces related to the totality of history, culture, topography, and urbanity” (Ando, 1995a).

Relatively speaking, the goal of my research is also to enhance the experience of human shintia by achieving the best possible visual connection with the surrounding nature through, as Ando puts it, “the skillful manipulation of rejection and acceptance” of the building form and boundary (Ando, 1995b).

1.2.3. Placemaking and Phenomenology of Place: Christian Norberg-Schulz

Norberg-Schulz indicates that the basic property of a man-made environment is concentration and enclosure with the main function of gathering. Consequently, buildings are
“insides” or *internal foci* that emphasize the basic function of gathering and need openings to fulfill the function of dwelling (Norberg-Schulz, 1980). Moreover, Norberg-Schulz (1980) defines place as a qualitative “total” phenomenon made up of concrete things and cannot be reduced to any of its single properties. He argues that it is highly recommended to analyze a place’s structure by means of the categories “space” and “character.” “Space” indicates the three-dimensional organization of the elements that make up a place, and “character” indicates the general “atmosphere” that is the most comprehensive property of any place (Norberg-Schulz, 1980). The building boundary, as the space-defining element, is the main element responsible for giving otherwise similar spatial organizations different characters. These two categories are essential to man’s “dwelling.” Norberg-Schulz posits that to achieve "dwelling," man should be located in ‘space’ and exposed to a certain environmental ‘character’ simultaneously” (Norberg-Schulz, 1980). Norberg-Schulz also states that there are two psychological functions, “orientation” and “identification,” involved in man’s dwelling. These two psychological functions are important to man for gaining an existential foothold in a place. “Orientation” is necessary for man to know where he is, whereas “identification” is necessary to know how he is in a certain place. To achieve meaningful and true dwelling, Norberg-Schulz believes that man should experience these functions in a fully developed manner.

In the end, according to Norberg-Schulz, nature is usually available as reliable local reference for man-made environments, or “settlements.” The main focus of this research is how architects can then connect man inside a space with his local surroundings by framing direct views of that nature through the building boundary as a main space-defining medium. Accordingly, connecting man with his surrounding context through direct framed views may
help to achieve the functions of “orientation” and “identification,” and therefore emphasize his existential foothold and meaningful dwelling. In other words, when a person inside a space has a well-established visual connection with the outside environment, their feelings of where they are and how they are in this place might be satisfied and, therefore, their spatial experience becomes meaningful.

1.2.4. From Unstructured Nature into an Ordered Nature through the Building Boundary

Juhani Pallasmaa defines architecture as that which “domesticates limitless space and enables us to inhabit it, but it should likewise domesticate endless time and enable us to inhabit the continuum of time” (Pallasmaa, 2012). Indeed, this philosophical definition reveals complex issues regarding the relationship between surrounding context (the limitless space) and the built environment (the domesticated outcomes). One’s spatial experience inside these materialized domesticated spaces is greatly influenced by the nature of its domestication process. This is to say, we need a critical vantage point to look at the nature of the domestication process in a way that produces a space/place that inherently belongs to and emerges from its context. The philosopher Martin Heidegger (1977), in his essay “Building, Dwelling, Thinking,” identifies the essence of building: to let “dwelling,” as the basic character of “being,” represent our being in the world, and to bring the essence of the fourfold of earth, sky, divinities, and mortality into our lives. In other words, to dwell is to bring the essence of nature into our being. He argues that a clearly defined boundary is essential to bringing the essence of nature into our being: “a boundary is not that at which something stops, but as Greeks recognized, the boundary is that from which something begins its essential unfolding” (Heidegger, 1977). Foster (1983) agrees
with Heidegger, stating, “the condition of ‘dwelling’ and hence ultimately of ‘being’ can only take place in a domain that is clearly bounded” (Foster, 1983).

Robert Venturi looks at the building boundary as a basic and rich medium to achieve man’s being. He states that at this boundary, a state of tension has emerged and this kind of tension is essential for making architecture (Arnheim, 1977). In this same vein, Ando (1995b) considers the building boundary, especially exterior walls, to be the most powerful, basic, and enriching building part that influences the interior-exterior relationship, by both evoking the architectural space and regulating the urban structure. In other words, exterior walls have the power to “divide space, transfigure place, and create new bounded domains” (Ando, 1995a). Ando (1995a) refers to this boundary as a medium at which “the inside and outside are not separate things but instead form one continuous place”.

I believe, as a designer and researcher, that the building boundary plays an essential role in this domestication process as the only building part shared between the domesticated space (inside) and the limitless outside space (outside). Therefore, the building boundary has great potentials to achieve a sense of being and dwelling inside the built environment. This makes it the central medium in the confrontation condition between a raw and chaotic nature and a more domesticated or man-ordered nature (see Figure 1.1 and Figure 1.2).
Figure 1.1 Carefully placed the openings to frame the surrounding vistas; Photo of the Aperture House in Bangkok, Thailand taken by (Ketsiree Wongwan, 2007) and Chaichoompol Vathakanon; Image downloaded from https://www10.aeccafe.com/blogs/arch-showcase/2017/05/17/aperture-house-in-bangkok-thailand-by-studo in February 2020

Figure 1.2. Framed the surrounding vista; Photo of Jørn Utzon’s Can Lis house, Majorca, Spain taken 8 Jul 2016; Image downloaded from https://artchist.wordpress.com/tag/jorn-utzon/ in February 2020
1.2.5. Biophilia and Biophilic Design

Man, both consciously and unconsciously, has built memories that are stored and transcended in his body through prolonged encounters with nature (Arnheim, 1977; Norberg-Schulz, 1980; Pallasmaa, 2012). These memories, in one way or another, influence his relationship with various aspects of nature. They establish a common sense of dealing with and a way to judge various natural aspects, regardless of the culture or society to which people belong (Kellert, 2012). A connection with nature, which had several forms, has helped man throughout time to develop the necessary skills to survive, perform his daily tasks, encounter potential challenges he might face, and ultimately achieve dwelling. Nowadays, several research studies about the man-nature connection provide evidence of its benefits for our well-being, health, and productivity in the built environments—be it educational, healthcare, residential, or commercial. Neuroscientific studies indicate the importance of natural views on human health and productivity. The results of these studies show that looking at complex, dynamic natural views potentially triggers more pleasurable mental reactions, as it stimulates many interactions of the receptors in the visual cortex (Biederman & Vessel, 2006). Biederman and Vessel (2006) also show its positive impact on cognitive performance by improving mental engagement, attentiveness, concentration, and memory restoration. Also, Don Auman, Lisa Heschong, Roger Wright, and Ramona Peet conducted a series of studies about the impact of daylight and natural view on performance and productivity inside different learning spaces (I. Heschong Mahone Group, 2003), 2003). The general outcomes of these studies show that better performance and productivity were achieved in the spaces that had a better daylight design and better view out of a window.
In response, a design trend is becoming more desirable at different levels in urban areas, which are growing exponentially and causing people living there to unconsciously lose contact with surrounding nature. This trend, known as biophilia or biophilic design, is the “designing for people as a biological organism, respecting the mind-body systems as indicators of health and well-being in the context of what is locally appropriate and responsive” (C. O. Ryan, Browning, William D., Clancy, Joseph O., 2014). Studies show that such a design trend could help greatly in reducing the stress of urban life, while also increasing cognitive function and creativity in our living places. Many businesses and employers worldwide believe that this design strategy can solve the problems of low productivity due to stress-related illnesses. For example, the paper titled “14 Patterns of Biophilic Design” identifies three main strategies that might be used to achieve biophilic design within built environments: “Nature in the Space,” “Nature of the Space,” and “Space Analogy.” Each strategy addresses different aspects of the human-nature relationship within the built environment, and each strategy can be achieved through several design patterns.

- **Nature in the Space**: addresses “the direct, physical and ephemeral presence of nature in a space or a place” (p. 10). It can be achieved through seven design patterns: 1) “visual connection with nature”, 2) “non-visual connection with nature”, 3) “non-rhythmic sensory stimuli”, 4) “thermal & airflow variability”, 5) “presence of water”, 6) “dynamic & diffuse light”, and 7) “connection with natural systems.”

- **Natural Analogues**: addresses “organic, non-living and indirect evocations of nature” (p. 10). It can be achieved through three design patterns: 1) “biomorphic forms & patterns,”
2) “material connection with nature”, and 3) “complexity & order.”

- Nature of the Space: addresses spatial configurations in nature. It can be achieved through four design patterns: 1) “prospect”, 2) “refuge”, 3) “mystery”, and 4) “risk/peril.”

Of the three, this research is more concerned with the strategies of “Nature in the Space” and “Nature of the Space.” These two strategies are dependent, to a great extent, on visual connections with one’s surroundings and their need for visual connection to be achieved. (C. O. Ryan et al., 2014) define the strategy of “Nature in the Space” as one that “addresses the direct, physical and ephemeral presence of nature in a space or place” (p. 9). Also, they define the strategy of “Nature of the Space” as one that “addresses spatial configurations in nature. This includes our innate and learned desire to be able to see beyond our immediate surroundings, our fascination with the slightly dangerous or unknown; obscured views and revelatory moments; and sometimes even phobia-inducing properties when they include a trusted element of safety” (p. 10). These strategies can be applied singularly or collectively to achieve any of these outcomes. Again, only the two aforementioned strategies are considered alongside other relevant theories in the scope of this research, as they rely the most on the visual connection to the surrounding context (see Figure 1.3). These two strategies are discussed in more detail in the literature review.
1.3. **Design Frameworks: Force-based Design Framework and Stages of Design**

This aim of this study is to enhance the architectural design process’s ability to provide the best possible visual connections to the surrounding environment, which in turn may help to achieve a true and meaningful “dwelling.” To this end, this research should be positioned within a flexible design framework that allows designers to look for quality in response to a variety of
complex forces. First of all, it will be helpful to understand design frameworks and how they are used to produce architecture. In general, the simplest way to define design frameworks is to look at them as “containers of thinking that scale content, pre-select tools, and identify points of decision-making” (Plowright, 2014). Design frameworks should be flexible without predetermined outcomes; rather, any decision made by the designer and the outcomes depend mainly on the types of inputs (Plowright, 2014).

There are three main architectural design frameworks: pattern-based, force-based, and concept-based (Plowright, 2014). The pattern-based framework is defined as “series of rulesets and best practices” communicated among architects (Plowright, 2014, p. 227). The force-based framework is built upon the conception of systems thinking. It deals with complex forces conceptualized as pressures, assets, constraints, and flaws. It aims to make these complex forces accessible and ordered within the design process. In a design process, designers deal with systems that consist mainly of a built environment, a natural environment, social interactions, financial structures, and human bodies in space. The force-based framework produces architecture as “the result of the resolution of forces … [or] the direct manifestation of forces, flows or pressures” (Plowright, 2014, p.42). Finally, the concept-based framework is based on the idea that architecture expresses something beyond its own materiality (Plowright, 2014).

Because of the characteristics that best support my main objectives, this research study has been positioned within the force-based framework. First, the force-based framework does not approach the architectural design as a problem-solving activity, so any environmental complexity will not be reduced or limited. Second, it allows for the translation of non-physical forces—such as qualities, desires, and requirements, into decisions that are made to define
form—such as constraints, assets, pressures, and opportunities. The force-based approach seeks to engage spatial qualities as a direct resolution of formal, environmental, and social qualities. In other words, the force-based approach tests and analyzes all things for better spatial qualities rather than a pattern, shape, or object (Wright, 1954). Finally, similar to other frameworks, it has the same pattern of exploratory and evaluative thinking throughout discrete phases, which are processed in strong iterative way, with loops and parallel lines of exploration within phases (Plowright, 2014). Accordingly, this research considers the force-based design framework as the most suitable in order to develop a framework for enhancing visual connections and decision-making abilities in the design process.

1.4. The Discipline of Architecture and Architectural Research

Schön (1991) argues that architecture is a context-dependent discipline and it is better to deal with through a “reflection-in-action” approach. He claims that such an approach helps designers deal well with ill-structured situations characterized of uncertainty, instability, uniqueness, and conflicted values. (Schön, 1991). Therefore, handling an architectural design through a reflection-in-action approach is more suitable than utilizing a problem-solving approach. However, I believe that this reflection-in-action approach has some essential shortcomings that limit a designer’s ability, especially novice ones, from designing for quality. Because of the lack of the necessary information, experience, and time required throughout the design process, designers cannot always respond effectively. For example, they may not be able to effectively evaluate the spatial quality of the space—such as the quality of visual connections to the surrounding environment. Consequently, designers usually tend to treat architecture not as an act of discovery, but rather as an economic activity where the goal is usually to create a
“mistake-free architecture.” In some ways, a designer’s way of responding to design problems contrasts the scientist’s or scholar’s way of solving scientific problems (Table 1.1). Whereas the designer is constrained to produce a design within a limited timeframe, the scientist can suspend his/her final judgment or decision until more is known. In other words, design activity seeks to generate a quick and satisfactory solution instead of a prolonged analysis of the problem. Simon (1969) describes this strategy as “a process of ‘satisficing’ rather than optimizing; producing any one of what might well be a large range of satisfactory solutions rather than generating the one hypothetically optimum solution” (p. 7).

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<thead>
<tr>
<th>Designer</th>
<th>Scientist</th>
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<tr>
<td>• Ill-defined problem</td>
<td>• Well-defined problem</td>
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<td>• Limited timeframe</td>
<td>• Suspend final judgment or decision until more is known</td>
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<td>• Quick and satisfactory solution</td>
<td>• Prolonged analysis of the problem</td>
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<td>• Process of ‘satisficing’</td>
<td>• Process of optimizing</td>
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<tr>
<td>• Produce a solution out of a large range of satisfactory solutions</td>
<td>• One hypothetically optimum solution</td>
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1.5. **Design Process from the Inside-Out**

Franck and Lepori (2007) describe the role of architects in the existing design process as outsiders, where most of their contributions come from the position of a maker and spectator rather than of a space occupant. Even if this view is a bit extreme, I do agree with it for some extent. Frank and Lepori (2007) attribute this to the emphasis in architectural education (i.e., design studios) on professional language and the abstract presentation of drawings and models. The outcomes of such design education mostly breed architects who are more concerned with “the designing forms and [pay more attention] to the manipulation of materials…often with no indication of how spaces are intended to be [experienced]”. One of the main reasons behind this trend, the objective-oriented design process, is that architectural education does not effectively help students to emphasize themselves as authentic subjective entities in the design process. As an alternative, developing and integrating an inside-out design approach to the design process allows architects, clients, and users to combine their inputs and participate in the design decision within a collaborative design process. This collaboration process has the potential to serve as a “combinatorial activity,” which is necessary for the act of discovery through the design process. According to Jerome Bruner (1979), a combinatorial activity combines different spheres of experiences and knowledge, which is the essential characteristic of the creative enterprise and places things in new perspective. I think that designing from inside-out greatly supports the concept of combinatorial activity as it designs for a variety of experiences in terms of time, activities, events, and inhabitants.

According to (Franck et al., 2007), the hallmark of designing from the inside-out is not only to reveal what is already there, but to find what is hidden, or the inspiring factors for the
design process. These factors might stem from anything related to the design process such as the
experience of clients, the users, and the architects or from the pattern of activities supported by
the design; or from the building site and surrounding context (Franck et al., 2007). For example,
Tadao Ando (1995a) emphasizes the importance of movement to maximize perceive objects
around us:

In order to perceive an object in all its diversity, the distance between the self and object
must be changed in some way. This change is brought about through the movement of
shintai. Spatiality is the result, not of a single, absolute direction of vision, but of
multiplicity of directions of vision from a multiplicity of viewpoint made possible by the
movement of the shintai. Not only the movement of the shintai but the natural movement
such as that of light, wind, or rain can change the (phenomenal, as opposed to physical)
distance between the self and the object. (p. 453)

In conclusion, these objects are not always physically hidden, most often they have been present
but neglected or remain unclear, and they need new perspectives of looking to be revealed and
combined.

1.6. Digital Continuum from Design to Construction

Since the late twentieth century, digital technologies have allowed for the design and
construction of complex forms in new ways within a reasonable budget—enabled by the
effective flow and use of information, or the “digital continuum from design to production.” In
short, by using digital technologies, design information has become construction information.
Now, it is more about the process rather than the formal change itself. According to Kolarevic
(2003), the goal of using digital technologies is to develop “a four-dimensional model with all
qualitative and quantitative dimensional information necessary for design, analysis, fabrication,
and construction” (p. 11). Moreover, adopting digital modeling (3D) and animation (4D)
software in the architectural discourse enables designers to design in unconventional ways that unfold new dimensions of formal exploration in architecture. Novel generative processes based on new concepts (e.g., topological space, isomorphic surfaces, dynamic systems, keyshape animation, parametric design, and genetic algorithms) leads to new shapes and forms. The digitally-driven process that interconnects each step (design, analysis, representation, fabrication, and assembly) into a relatively seamless collaborative process gives architects greater control over the design process because of the effective extraction and exchange of the digitally-generated design information.

However, and in light of my research goal, I believe that there is still a gap in the design process regarding (1) identifying the non-formal forces of a given context and (2) extracting the necessary information to design the best possible visual connections to the outside environment. Digital technologies provide internal computational logical concepts for the morphogenesis processes of creating a building form, but it does not provide information extraction or input tools for any external non-formal forces—such the indoor-outdoor visual relationship. Architects using digital technology as a part of the traditional design process are not able to extract the necessary information to support exploring visual connection and make the best design choices during the design process. Therefore, I think that there should be a prior step before applying the digital continuum at the “design to production” stage, which I might call the “digital continuum from context to design” stage, through which designers could extract spatial information and interactively integrate it into the digital modeling process throughout the design process (see Figure 1.4). For this research, the aim specifically is to achieve this regarding building boundary to achieve the best possible connection to the outside environment.
Figure 1.4. Digital continuum from design to production and from context to design
1.7. **Problem Statement**

Overall, the problem that this research seeks to resolve is complex for several reasons. First, there are spatial and temporal differences or separations between the actual context of designing and the actual context of building. In other words, designers cannot be present at the two locations at the same time. This might potentially lead to loss or poor management of the spatial data and relevant visual information necessary, resulting in a failure to achieve a well-designed visual connection with the outside context. Moreover, this issue cannot be resolved within the limited timeframe within which designers should respond to a design problem.

Second, the current design process is dominated by the outside-in design approach. As mentioned earlier, most contributions to the design process come from the position of a maker and spectator rather than of a space occupant. Digital techniques have advanced the design process by introducing unconventional ways that unfolded new dimensions of formal exploration in architecture, thus offering a digital continuum from design to production. However, the design process’s explorative ability and designers’ cognitive ability to extract information from a given context and make informed design decisions is still limited.

In light of these intrinsic features, the design process does not support an effective and informative decision-making process to design for the best possible indoor-outdoor visual relationship. This is especially true, considering that it also does not provide designers with the ability to explore and design for the best possible visual connection to the surrounding context. The traditional representation media used by designers to explore a visual connection to the outside design and inform their decisions is not effective in light of the various possible scenarios of the indoor-outdoor visual relationship. Currently, the common traditional
representation media (which might be used individually or combined) are manual and digital sketches, physical models, abstract explorations, and digital photography. Each of these representation media has its own limitations that prevent both conducting an effective exploration of the connection to the outside environment and therefore, achieving a meaningful spatial experience. This is because they rely heavily on the physical visit and a physical exploration of the building site, which is not always (easily) accessible at the time of design. Also, these media do not support a comprehensive exploration process for many assigned points within the spatial boundary of the proposed design—especially for elevated points. Moreover, they do not effectively support dynamic representative or iterative actions for exploring and updating the inside-out relationship throughout the design process (Table 1.2). In brief, the central problem with the traditional design process stems from its limited ability to inform designers’ decisions when exploring and framing the best possible views or when modifying the design accordingly within the allocated timeframe.

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<th>Representation Media</th>
<th>Dynamic Representation</th>
<th>Exploration accuracy</th>
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</thead>
<tbody>
<tr>
<td>Physical Models</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Sketches</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Abstract Exploration</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Digital Model with manual photo-integration</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
1.8. **Research Objective**

Based on the identified research problems, this main objective of this research is to develop a framework for developing and integrating an interactive and explorative inside-out design approach. The proposed inside-out design approach aims to augment and enhance decision making during the traditional design process in terms of exploring, evaluating, and framing the best possible visual connection to the outside context. In doing so, the research seeks to bridge the existing temporal and spatial gap between the actual context of designing and actual context of building by integrating 3D geospatial data into the digital design process. The 3D geospatial data is used as a primary information source for exploring visual connections and informing the decision-making process throughout the design process. For a more effective integration of the proposed inside-out design approach, the general workflow of the traditional design process was considered. In other words, the proposed framework suggests having multiple steps that support different levels of exploration and evaluation of the visual connection that therefore, inform multiple design decisions during different conceptual and development stages of the design process.

Also, the proposed approach requires immersing designers inside three-dimensional digital models of proposed buildings and exploring the connection to an outdoor context within 3D digital model. More specifically, designers will explore the digital 3D context model and the 3D representation of the real world from within the digital 3D model of the building and then modify it accordingly to achieve the best possible connection to the outside environment (see Figure 1.5).
This study relies on the availability of 3D city models such as the 3D Blacksburg project, the 3D Berlin project, the 3D Paris project, and other 3D city models that have been developed across the world. According the website of the Center for Geospatial Information Technology (CGIT) at Virginia Tech, the 3D Blacksburg project is “a comprehensive three-dimensional model of the town of Blacksburg, Virginia.” This project is one of several 3D projects being developed by the Open Geospatial Consortium for different cities throughout the world, providing 3D portrayal services such as Web 3D Service (W3DS) and Web View Service (WVS). The services also provide views of the surrounding nature, which can be captured from any point determined by its geographic coordinates. The user can then control the position of a virtual camera by using a 4x4 transformation matrix (see Figure 1.6). In fact, for the purpose of
this research, the available 3D city models were not used; rather, a 3D context model was specifically built to conduct this research. The main reason for not using these 3D city models was because of an issue of interoperability, which needed specialized technical development to resolve. Instead, this research developed a framework to provide a conceptual solution to this interoperability issue by building and using a compatible 3D context model. More details about developing and using this model are discussed in the methodology chapter.

Figure 1.6. The internal steps to process a Web View Service (WVS) request,

In general, the proposed framework for developing and integrating an inside-out design approach to the design process consists of multiple steps of exploration and evaluation that are distributed throughout the design process. To implement any of these steps, points of exploring
and evaluating the visual connection to the outside must be assigned at spatially analyzed locations within the building location. The numbers, types, and locations of the assigned exploring and evaluating points may vary from one step to another according to its temporal position in the design process. Accordingly, each step will yield different design decisions. For example, exploring steps at early stage will inform major design decisions, such as the building’s form origination, transformation, and orientation, while steps at later stages will inform more specific design decisions, such as the design of openings on the exterior walls. In general, as the design process progresses, the points of exploration and evaluation will inform more detailed design decisions.

Also, the number of the assigned exploring points will increase as the design process progresses and more defined spaces will be created. More specifically, as the number of viewing points increases across the space, visual information will increase, and design decisions might become more accurate and reliable, helping to achieve a stronger indoor-outdoor relationship. The increase in the number of exploration points could also provide visual information as the designer moves inside the space and looks from several perspectives (see and Figure 1.8). This allows a designer to perceive objects around them in all their diversities and therefore, increase the accuracy of their design decisions throughout the design process. Sheena Rogers refers to the important role of movement, either the movement of the perceiver (the designer) or the objects in experience of perception, as moving through a space increases the information perceived by the perceiver (designer) regarding the quality of the explored and framed visual connection to the outside the world (William Epstein, 1995).
Figure 1.7. Different fields of view can be captured from the virtual positions of the designer located any at specific point.

Figure 1.8. Several points distributed selectively across the architectural space to provide designers with more explorative positions and increase the relevant visual information.
Accordingly, the cognitive ability of designers might be greatly enhanced, therefore, designers would have ability to evaluate and redesign spaces for better visual connections to the surrounding context. Designers will use this visual exploration (the captured views) to inform his/her different level of design decisions to be applied back on the 3D digital model of the proposed spaces. This process can be iterative during the design process (see Figure 1.9). This proposed process has the potential to be developed through future research into an actual stand-alone design tool used in conjunction with a Computer Aided Design (CAD) application.

Figure 1.9. How the inside-out representation approach might be integrated with the design process
1.9. **Research Methodology Overview**

The non-objectively measurable aspects of a phenomenon such as visual connection to the outside environment can best be investigated through a qualitative approach that allows the researcher to deeply understand the phenomenon (Creswell, 2009). In response, my research objectives focus on developing a framework for enhancing the decision-making process of the design process and its explorative ability in order to help designers achieve the best possible visual connections to the outside environment. This research calls attention to normative thinking about the traditional design process regarding its explorative, evaluative, and decision-making abilities in order to explore and frame the best possible visual connections to the outside context. To better meet the research objectives, this research was conducted using a qualitative-dominant mixed-methods design combining three research tactics: logical argumentation, immersive case study, and the Delphi (Figure 1.10). The logical argumentation strategy was mainly used to identify, describe, and combine apparently disparate factors to build an overarching conceptual framework that would more effectively contribute to developing and integrating an interactive and informative inside-out approach for the design process. This strategy, powered by using first principle thinking, helped to discover and develop relations between several known, unknown, and/or unappreciated factors involved in achieving the best possible visual connection to the surrounding (D. Wang & Groat, 2013). Accordingly, related literature about these factors was reviewed, which included topics like the human-nature relationship, biophilic design, the design process, dynamic digital representations in architecture, moving image theories, the 3D modeling process, building envelopes, 3D geospatial data, and others. Ultimately, the aim of this phase of the research was to build and develop the initial conceptual framework to be developed and
enhanced in the successive phases. Next, and because of the potential of the outcomes of the logical argumentation to deviate from reality, a case study method (namely, the immersive case study) was conducted. As a researcher and a designer, I believe that the way to better develop and adjust a conceptual framework should not be separate from the way to use it. Consequently, the generated logical framework in the previous stage was used and therefore, further developed to design a building on the campus of Virginia Tech. This phase helped to identify deficiencies and gaps that might emerge during future use of the framework. To a great extent, conducting the immersive case study relied upon my personal experience and accumulated knowledge in the field of architectural design and design education.

Since this research is a critique of normative thinking in the design process, there was a need to question or evaluate the framework that resulted from the first phases of this research. The ideal scenario to do that is to test it for prolonged period of time by many designers or design students to design various design projects. However, this scenario is not applicable within the timeframe for conducting this dissertation. Instead, a three-round Delphi survey was conducted. The main goal of conducting the Delphi survey was to build consensus among a panel of experts who were purposefully selected for this study. In the first round, experts responded to and interacted with an open-ended questionnaire about several related aspects of this research and the developed framework. In the second and third rounds, the experts responded to closed-ended questionnaires based on their responses from the first round. The responses were statistically analyzed to measure for consensus among all expert responses.
Figure 1.10. Workflow for conducting the used research method

**Logical Argument** *(Initial Conceptual Framework)*
- Analyze the phenomenon of indoor-outdoor visual relationship
- The rationale for developing the proposed framework
- Position the research in a broader theoretical context
- Develop more relevant critical questions
- Discover and develop relationships among several known/unknown and/or unappreciated elements
- Identify potential limitations

**Immersive Case Study** *(Developed Framework)*
- Test the effectiveness of the proposed process
- Identify the deficiencies and gaps that might emerge during the use of the proposed process
- What are the main steps of the proposed process
- What is the operational workflow of the proposed design approach in relation to the design process

**Delphi Method** *(Develop Consensus)*
1.10. **Research Questions and Contribution**

This research aims to answer several intertwined questions in order to resolve the identified research problem:

- What are the steps, in terms of software, hardware, and exploration levels, for the design process to augment and enhance the decision-making process and achieve the best possible connection to the outside environment?

- How much integration of the 3D geospatial data and 3D city models into the design process is needed to bridge the temporal and spatial difference between the actual contexts of designing and building?

- What is the most effective order for conducting the exploration and evaluation steps of the proposed inside-out design approach?

- What is the influence of the proposed inside-out design approach on the cognitive ability of designers to explore and evaluate several scenarios regarding a connection to the outside environment?

1.11. **Objectives and Goals of the Study:**

By answering the previous questions, the study will achieve its main objectives:

- To build a framework that integrates a 3D geospatial data-based inside-out design approach into the design process

- To augment designer’s decisions regarding the exploration and framing of the best possible visual connection to the surrounding environment

Moreover, achieving this study’s main objectives may achieve some relevant secondary goals:
• To narrow the gap in the design process between the theoretical domain and practical domain in terms of achieving true “dwelling” and having a meaningful spatial experience as a result of a well-designed visual connection to the outside context

• To emphasize the architectural design process as a context-dependent one

• To enhance the architectural design practice and design education in a way that better recognizes man as a central concern of the built environment and meets his complex needs inside the architectural space

• To encourage designers to consider cultural and environmental contexts as influential forces on the design process

• To encourage designers to consider and use architectural representations as generative tools, not only as visualization tools

• To bridge potential gaps between architects and interior designers and between master designers and novice designers

• To raise designers’ awareness about the importance of a multidisciplinary approach and the act of exploration and discovery in the architectural design process

• To help designers apply and achieve architectural theories that contribute to creating meaningful spatial experiences as called for in Heidegger’s “True Dwelling,” biophilic design practices, Frampton’s critical regionalism, and Norberg-Schulz’s genius loci and man’s existential foothold.
1.12. Assumptions and Limitations

The study faced several kinds of limitations related to the investigated phenomenon, the methodology used, and the final findings. The first limitation is related to the nature of the investigated phenomenon; the visual connection of man to the outside within the built environment. Since this is a mainly subjectively measurable phenomenon, developing an explorative- and evaluative-based decision-making process might not be enough. Such subjective-based explorations and evaluations of the visual relationship quality could lead to biased findings. However, it could be justified that this is an inherent aspect of the design process and the proposed process might potentially mitigate or balance the influence of this natural bias.

The second category of limitation is related to the employed research methods. For example, regarding conducting the logical argumentation strategy, it can be difficult for only one researcher to thoroughly identify the fundamental categories and the first principles of the identified disparate elements related to the central phenomenon. Moreover, the resulting logical system may not be an accurate representation despite its internal consistency from a logical point of view. Moreover, there are some limitations related to the relationships between any identified logical blocks of the proposed logical framework. For example, achieving a high level of interoperability between the available 3D geospatial models such as the 3D Blacksburg model on one hand and Computer Aided Design (CAD) applications such as Revit, 3Ds Max, Google Sketchup on the other has been an annoying limitation that requires a great effort and an expanded knowledge base in other fields, such as computer science.

Also, conducting the strategy of case study faced a central limitation, since only one case study was conducted in which the researcher documented his observations and actions as the
only source of data collection. It is much more common for a case study strategy to have multiple sources of data (Yin, 2003). To overcome this limitation, the Delphi survey was conducted. However, a Delphi survey has inherent limitations due to its nature. These limitations include: identifying the optimum number of rounds to reach consensus, developing the appropriate criteria for identifying and recruiting qualified participants, the long time needed to conduct the survey, and the potential withdrawal of any participating expert at any time of conducting the survey. One of the most significant limitations of the Delphi method is the time and effort it takes, which is antithetical to a large enough number of participants necessary for the random distribution requirement in statistical analysis.

Moreover, the final findings may face some limitations that can weaken the possibility of generalization and development into an actual design tool. This research is based primarily on the availability of three-dimensional geospatial models for the context and the surrounding environment of an architectural project—such as the 3D Blacksburg project. At present, these kinds of projects are not widely available and they may not provide a very accurate representation. Accordingly, the proposed framework will not be tested widely by various users in different environments or settings. It should be noted that the aforementioned projects continue to be enhanced and there are many other projects have been or are being developed for several towns and cities in the United States and other countries in the world.
1.13. The Researcher’s Stance

Generally, my interest in doing this research has been gradually shaped throughout my experience in studying, teaching and practicing architecture. I have a bachelor’s degree in architectural engineering and a master’s degree in interior architecture, adaptive reuse/intervention from the Rhode Island School of Design (RISD). I have taught architectural design studios for two years in the College of Architectural and Design at the Jordan University of Science and Technology (JUST). The opportunity to experience design through different perspectives has allowed me to identify some design issues and challenges that designers might face during the design process. Specifically, my interest in enhancing our explorative ability and decision making in the design process has been motivated by my interest in the theories and philosophies of achieving true “dwelling” and meaningful spatial experiences within the built environment. When reviewing such philosophical and theoretical views, I concluded that there is a gap between these aspects of the design process, which prevents designers from applying these theories effectively during the design process. Moreover, my experience in teaching and studying architecture has led to my hypothesis that transferring design knowledge during the design process lacks a solid epistemological platform. In my opinion, the structure of the architectural design process lacks effective communication channels for transferring information among design team members or between designers and clients. Therefore, I assume that this topic needs to be researched more to help designers, especially novice designers, to overcome these challenges and save effort and time throughout the design process.

1.14. Future Research Work

The future goal of this research study is to develop a stand-alone digital design tool that
facilitates the dynamic exploration of the visual indoor-outdoor relationship throughout the design process. In order to facilitate using this tool during the design process, designers should be able to use the tool inside the environments of architectural design applications such as Revit, SketchUp, or similar programs. Moreover, for an optimum utilization of the tool, future research will consider using the tool through mixed reality media, such as virtual reality (VR). Over the last two decades, these media have been developing exponentially and it is expected that they will play a significant role in the design process in the near future. Through their display tools such as head-mounted displays (HMD), these kinds of media provide designers with the ability to effectively navigate and explore spaces to be designed in terms of their visual relation with the surrounding context. Moreover, in future work, this research may look more closely at the principles of cinematography and how they can be involved in capturing and framing more meaningful and engaging visual fields of the surrounding nature. Moreover, this research represents a starting point toward more integration and utilization of the 3D geospatial data and models to support the design process. The future work aims to go beyond its primary and secondary objectives to include more social, cultural, and environmental aspects. The future work of this research may need to change in response to the partnership between two leading companies, ESRI in 3D geographic information system (GIS) and Autodesk in building information modeling (BIM).
2. Chapter Two: Literature Review

This section addresses two main topics related to potential logical blocks of the conceptual framework and to the rationale for conducting this research. In fact, some of these topics were preemptively addressed in the introduction section in order to give the reader an early understanding of the problems and objectives that this research aims to address (see Figure 2.1). In this section, these topics are discussed in more detail.

2.1. Man-Nature Relationship in Context

Much evidence of the man-nature connection can been found in ancient civilizations—for example, the stylized animals of Neolithic Göbekli Tepe, the Egyptian sphinx, or Acanthus
leaves in Greek temples (Browning, 2014). For the most part, these representations of animals or plants were used for either decorative and symbolic ornamentation or the actual bringing of nature into the built environment. History presents many examples of man’s creative interventions in bringing nature into his built environment—such as the garden courtyards of the Alhambra in Spain, porcelain fish bowls in ancient China, the cottage garden in medieval Germany, bonsai in Japanese homes, or the hanging garden of Babylon (Browning, 2014).

The significance of the human-nature connection within the built environment has been emphasized in history, the arts, and sciences (especially the neural sciences). As described by the American landscape architect Frederick Law Olmsted, in his report on Yosemite Valley in 1865, “the enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquillizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system” (Dilsaver, 1994). The Victorian painter and art critic John Ruskin believes that architecture should be shaped by the energies of the natural world. During the design of the History of Science Museum in Oxford, England, he asked the masons to find inspiration in the surrounding countryside; as a result, nature was introduced as hand-carved flowers and plants decorating the walls and ceilings. As another example, the columns’ capitals and corbels were carved into plants representing all the botanical orders (Kellert, Finnegan, Miller, & Bullfrog Films., 2011). The mid-nineteenth century witnessed an obvious shift toward nature in Europe and the United States. For instance, spending vacations and holidays among nature in the mountains and along the seashore became more common; at the same time, winter gardens became highly desirable in wealthy homes. Moreover, a view of nature and natural sunlight became a high priority in hospital design such as at St. Elizabeth’s in
Washington, D.C. (built in the 1850s). In the late-nineteenth century, specifically for art nouveau designs, the inspiration from nature is also readily observable. For example, Antoni Gaudi’s buildings are explicitly biomorphic forms. In Chicago, Louis Sullivan created elaborate ornamentation with leaves and cornices that represented tree branches. Moreover, modernists—despite stripping much excess ornamentation—used wood grain and the veining of stone as decorative elements and were also concerned with indoor-outdoor relations. As another example, Mies van der Rohe tried through the design of Farnsworth House to juxtapose the sleek, streamline design of modernist structure with the organic environment of the surrounding nature (see Figure 2.2). Le Corbusier’s unbuilt project, Radiant City, was designed to connect city dwellers with nature as well (Browning, 2014).
Figure 2.2. Photo of the Farnsworth House by Mies van der Rohe, with sleek, streamline design of a modernist structure with the organic environment of the surrounding nature; Images downloaded from https://www.pinterest.com/831mgb/ludwig-mies-van-der-rohe/ in February 2020
2.1.1. Human Values of Nature – Naturalistic Tendency

Biophilia has been defined as “humankind’s innate biological connection with nature” (C. O. Ryan et al., 2014, p. 4). The notion of biophilia asserts that man has been deeply dependent upon and rooted in his relationship with nature to survive and achieve a fulfilling, coherent, and meaningful existence. Conversely, any degradation of this dependence on nature will lead to a deprived and diminished existence. Stephen R. Kellert and E.O Wilson, in their book *The Biophilia Hypothesis* (1993) describe nine fundamental values that indicate this biophilia tendency, or man’s deep dependence on nature. Kellert describes these categories or fundamental values—utilitarian, naturalistic, ecologistic-scientific, aesthetic, symbolic, humanistic, moralistic, dominionistic, and negativistic—as essential for a meaningful and fulfilling human existence (see Table 2.1). These fundamental values help man to develop a range of adaptational advantages including enhanced physical skills, greater awareness, increased protection and security, improved knowledge and cognitive capacity, and communication and expressive skills (Kellert & Wilson, 1993).

This research addresses many of these tendencies especially the naturalistic tendency as it is simply defined as “the satisfaction derived from direct contact with nature” (Kellert & Wilson, 1993, p. 45). The mental and physical benefits associated with this tendency have been among the most ancient motivating forces behind the human-nature relationship. In industrial modern societies, this tendency has gained greater significance. The naturalistic tendency motivates and develops an intense curiosity and urge for exploring the natural world. Nature, as a great diverse and complex system, stimulates human curiosity to explore and discover—which in turn will let
him acquire valuable information and knowledge to understand nature and himself.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilitarian</td>
<td>Practical and material exploration of nature</td>
<td>Physical sustenance/security</td>
</tr>
<tr>
<td>Naturalistic</td>
<td>Satisfaction from direct experience/contact with nature</td>
<td>Curiosity, outdoor skills, mental/physical development</td>
</tr>
<tr>
<td>Ecologistic-Scientific</td>
<td>Systematic study of structure, function, and relationship in nature</td>
<td>Knowledge, understanding, observational skills</td>
</tr>
<tr>
<td>Aesthetic</td>
<td>Physical appeal and beauty of nature</td>
<td>Inspiration, harmony, peace, security</td>
</tr>
<tr>
<td>Symbolic</td>
<td>Use of nature for metaphorical expression, language, expressive though</td>
<td>Communication, mental development</td>
</tr>
<tr>
<td>Humanistic</td>
<td>Strong affection, emotional attachment, “love” for nature</td>
<td>Group bonding, sharing, cooperation, companionship</td>
</tr>
<tr>
<td>Moralistic</td>
<td>Strong affinity, spiritual reverence, ethical concern for nature</td>
<td>Order and meaning in life, kinship and affiliation ties</td>
</tr>
<tr>
<td>Dominionistic</td>
<td>Mastery, physical control, dominance nature</td>
<td>Mechanical skills, physical prowess, ability to subdue</td>
</tr>
<tr>
<td>Negativistic</td>
<td>Fear, aversion, alienation from nature</td>
<td>Security, protection, safety</td>
</tr>
</tbody>
</table>

2.2. Biophilia and Biophilic Design

The term biophilic was first coined by the social psychologist Eric Fromm, and later it was popularized by biologist Edward Wilson (Wilson, 1984). All its various connotations refers to the “desire for a (re)connection with nature and natural systems” (Browning, 2014, p. 7). The definition of biophilic design is the “designing for people as a biological organism, respecting the mind-body systems as indicators of health and well-being in the context of what is locally
appropriate and responsive” (Browning, 2014, p. 7).

Three strategies have been identified for implementing biophilic design within the built environment: “Nature in the Space,” “Natural Analogues,” and “Nature of the Space,” and each strategy could be achieved through one or more of its design patterns (Browning, 2014, p. 7):

In light of this research’s objective, exploring and framing the best connection to nature is one of the main desired forms of connecting to the outside context—especially in metropolitan areas where natural contexts are limited and not easily connected to visually. Accordingly, the outcome of this research will greatly help designers to apply the identified patterns of the biophilic design strategies that rely on the phenomenon of visual connection to the surrounding environment – namely “Nature in the Space” and “Nature of the Space” strategies. The table below describes the patterns that rely mainly on visual connection to be achieved (Table 4) (Browning, 2014).

<table>
<thead>
<tr>
<th>Strategy</th>
<th>“Nature in The Space”</th>
<th>“Nature of The Space”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pattern 3. Non-Rhythmic Sensory Stimuli: Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely</td>
<td>Pattern 12. Refuge: A place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead</td>
</tr>
</tbody>
</table>

Table 2.2. The potential design patterns to be applied and achieved by the proposed framework of the study
Table 2.2 cont

<table>
<thead>
<tr>
<th>Strategy</th>
<th>“Nature in The Space”</th>
<th>“Nature of The Space”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pattern 5. Presence of Water:</strong></td>
<td>A condition that enhances the experience of a place through the seeing, hearing, or touching of water</td>
<td>The promise of more information achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment</td>
</tr>
<tr>
<td><strong>Pattern 6. Dynamic &amp; Diffuse Light:</strong></td>
<td>Leveraging varying intensities of light and shadow that change over time to create conditions that occur in nature</td>
<td>Pattern 14. Risk/Peril: An identifiable threat coupled with reliable safeguard</td>
</tr>
<tr>
<td><strong>Pattern 7. Connection with Natural System:</strong></td>
<td>Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem</td>
<td></td>
</tr>
</tbody>
</table>

2.2.1. Nature-Health Relationships

As mentioned earlier, humans can obtain enormous benefits from their interactions with nature. Many studies, either laboratory or field ones, provide significant evidence of nature’s positive impact on human health and well-being. These impacts on a human’s mind-body system can be described under three categories: “cognitive functionality and performance”; “psychological health and well-being”; and “physiological health and well-being” (C. O. Ryan et al., 2014). Directed attention is considered one of man’s main cognitive functions that may cause mental fatigue over time (Kellert, Heerwagen, & Mador, 2008). However, a regular connection with nature can potentially give the mind periodic breaks from being stressed from high cognitive-
demanding tasks and give the mind a chance for restoration and revitalization. Regarding psychological health and well-being, studies consistently show a better response for emotional restoration in natural environments compared to urban environments (Alcock, White, Wheeler, Fleming, & Depledge, 2014). Also, studies show that different physiological systems of the human body (e.g., aural, musculoskeletal, respiratory, and circadian systems) function much better when man is exposed to a natural scene. These physiological responses range from muscle relaxation to reducing blood pressure and stress hormone levels (Park & Kagawa, 2009). Table 2.3 below presents the biophilic design patterns that might be achieved by using this study’s proposed framework. The table contains only the patterns that rely to some extent on successfully achieving a visual connection with the surrounding context. It includes objectives, design considerations, examples, and some positive impacts for each design pattern.
Table 2.3. Some of biophilic design patterns that might be integrated and applied by using the proposed decision-support framework (Browning, 2014).

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Objective</th>
<th>Design Considerations</th>
<th>Examples</th>
<th>Health Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visual Connection With Nature:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| • Grabs one’s attention and can be stimulating or calming | • Can convey a sense of time, weather, and other living things | • Helps the individual shift focus to relax the eye muscles and temper cognitive fatigue | • Prioritizes biodiversity over acreage, area, or quantity | • Natural flow of a body of water
• Vegetation, including food bearing
• Plants
• Animals, insects
• Fossils
• Terrain, soil, earth
• Mechanical flow of a body of water
• Koi pond, aquarium
• Green wall
• Highlly designed landscapes | • Increases positive emotional functioning and improved concentration and recovery rates
• Reduces attentional fatigue, sadness, anger, and aggression
• Improves mental engagement/attentiveness |
| Non-Rhythmic Sensory:             |                                                                           |                                                                                       |                                               |                                                                                                         |
| • Momentarily fresh, interesting, stimulating, and energizing distraction | • Encourages the use of natural sensory stimuli that unobtrusively attract attention, physiological stressors. | • Should occur approximately every 20 minutes for 20 second from a distance of more than 20 feet away | • Cloud movement
• Breezes
• Babbling brooks
• Insect and animal movement
• Birds chirping
• Fragrant flowers, trees, and herbs | • Supports physiological restoration
• Provides a periodic distraction for >20 seconds at a distance (of >20 feet), which allows for short mental breaks where the muscles relax and the lenses flatten (Lewis, 2012; Vessel, 2012) |
| Presence of Water:                |                                                                           |                                                                                       |                                               |                                                                                                         |
| • Fluidity, sound, lighting, proximity, and accessibility each contribute to whether a space is simulating, calming, or both | • Enhances the experience of a place in a manner that is soothing,
• Prompts, contemplation, enhances mood, and provides restoration from cognitive fatigue | • Prioritizes a multi-sensory water experience to achieve the most beneficial outcome
• Prioritizes naturally fluctuating water movements over predictable movements or stagnancy | • River, stream, ocean, pond, or wetland
• Visual access to rainfall and flows
• Seasonal arroyos
• Water wall
• Constructed waterfall
• Aquarium
• Fountain
• Constructed stream | • Enhances perception and psychological and physiological responsiveness when multiple senses are stimulated simultaneously |
<table>
<thead>
<tr>
<th>Pattern</th>
<th>Objective</th>
<th>Design Considerations</th>
<th>Examples</th>
<th>Health Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dynamic &amp; Diffuse Light:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Conveys expressions of time and movement to evoke feelings of drama and intrigue, buffered with a sense of calm</td>
<td>• Provides users with lighting options that stimulate the eye and hold attention in a manner that engenders a positive psychological or physiological response, and helps maintain circadian system functioning</td>
<td>• Provides dynamic lighting conditions can help transition between indoor and outdoor spaces</td>
<td>• Daylight from multiple angles</td>
<td>• Induces more positive moods and significantly less dental decay among students attending schools with quality daylight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Includes circadian lighting, which will be especially important in spaces the people occupy for extended periods of time</td>
<td>• Direct sunlight</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>• Diurnal and seasonal light</td>
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<td>• Firelight</td>
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<td>• Moonlight and star light</td>
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<td>• Bioluminescence</td>
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<td><strong>Connection with Natural System:</strong></td>
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<tr>
<td>• Evokes a relationship to a greater whole, making one aware of seasonality and cycles of life.</td>
<td>• Heightens both awareness of natural properties and hopefully environmental stewardship of the ecosystems within which those properties prevail</td>
<td>• Provides visual access to existing natural systems will be the easiest and most cost-effective approach.</td>
<td>• Climate and weather patterns (rain, hail, snow; wind, clouds, fog; thunder, lightning)</td>
<td>• Enhances positive health responses</td>
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<td>• Seeing and understanding the processes of nature can create a perceptual shift in what’s being seen and experienced</td>
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<td>• Hydrology (precipitation, surface water flows and resources; flooding, drought; seasonal arroyos)</td>
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<td></td>
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<td>• Geology (visible fault lines and fossils, erosion, shifting dunes)</td>
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<td>• Animal behaviors (predation, feeding, foraging, mating, habitation)</td>
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<td>• Pollination, growth, aging and decomposition (insects, flowering, plants)</td>
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<td>• Diurnal patterns (light color and intensity, shadow casting; plant receptivity, animal behavior, tidal changes)</td>
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<td>• Night sky (stars, constellations, the Milky Way) and cycles (phases of the moon, eclipses, etc)</td>
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<td>• Seasonal patterns (freeze-thaw, light intensity and color, plant cycles, ambient scents)</td>
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Table 2.3. cont.

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Objective</th>
<th>Design Considerations</th>
<th>Examples</th>
<th>Health Benefits</th>
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<tr>
<td><strong>Prospect:</strong></td>
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<td>• Feels open and freeing, yet imparts a sense of safety and control, particularly when alone or in unfamiliar environments.</td>
<td>• Provides users with a condition suitable for visually surveying and contemplating the surrounding environment for both opportunity and hazard.</td>
<td>• Help optimize visual access to indoor or outdoor vistas by orienting building, fenestration, corridors, workstations, activity hubs or destinations</td>
<td>• Views including shade trees, bodies of water or evidence of human habitation</td>
<td>• Reduces stress, boredom, irritation, fatigue and perceived vulnerability, as well as improved comfort.</td>
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<td></td>
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<td>• Provides focal lengths of ≥20 feet, preferably 100 feet because if a space has sufficient depth, spatial properties can be leveraged to enhance the experience by removing visual barriers</td>
<td>• Transparent materials</td>
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<td></td>
<td></td>
<td>• Locates stairwells at building perimeter with glass façade and interior glass stairwell</td>
<td>• Focal lengths ≥ 20 feet (6 meters)</td>
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<td><strong>Refuge:</strong></td>
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<tr>
<td>• Provides a sense of retreat and withdrawal – for work, protection, rest or healing – whether alone or in small groups</td>
<td>• Provide users with an easily accessible and protective environment that support restoration</td>
<td>• Differs light levels in refuge space from adjacent spaces and user lighting controls to broaden functionality as refuge space</td>
<td>• Weather/climate protection</td>
<td>• Improves concentration, attention and perception of safety</td>
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<td></td>
<td>• Limits visual access into the refuge space</td>
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<td>• Speech or visual privacy</td>
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<td>• Reflection or meditation</td>
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<td>• Rest or relaxation</td>
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<td>• Reading</td>
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<td><strong>Mystery:</strong></td>
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<td>• Experiences a sense of anticipation or of being teased to further investigate the space</td>
<td>• Provide a functional environment that encourages exploration in a manner that support stress reduction and cognitive restoration</td>
<td>• Curves edges that slowly reveal, which are more effective than sharp corners in drawing people through the space</td>
<td>• Views are medium (≥ 20 ft) to high (≥ 100 ft) depth of field</td>
<td>• Supports stress reduction and cognitive restoration</td>
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<tr>
<td>• Heightens curiosity</td>
<td>• Enhances the mystery experience through dramatic shade and shadows</td>
<td>• At least one edge of the focal subject is obscured, preferably two edges</td>
<td>• Auditory stimulation from an imperceptible source</td>
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<td>• Increases interest in gaining more information</td>
<td></td>
<td>• Peek-a-boo windows that partially reveal</td>
<td>• Curving edges</td>
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<tr>
<td></td>
<td></td>
<td>• Curving edges</td>
<td>• Winding paths</td>
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2.2.2. View through a Window May Influence Recovery from Surgery: A Study by Ulrich

Roger S. Ulrich (1984) conducted a study to examine the restorative effect of natural views on surgical patients in a suburban Pennsylvania hospital. In the study, he compared the recovery rates between 46 patients grouped into 23 pairs. For each pair, one member was assigned to a room that looked out onto a brown brick wall, and the other member was assigned to a room that looked out onto a small stand of deciduous trees. Otherwise, all rooms were almost identical in terms of dimension, window size, and other major characteristics (the only thing that distinguish each room from another was the view seen out of its window). The record shows that the patients assigned to rooms with a tree view had shorter lengths of hospitalization than the patients assigned to rooms with brick wall view. Moreover, the patients with the tree view had fewer negative comments recorded by the nurses and took fewer analgesic (either strong or moderate doses). However, it is important to notice that natural views are not always better than built views. Although the study findings suggest that natural views had comparatively better therapeutic influence than built views, it is important to recognize that this could not be generalized to all built views. Roger suggests that, sometimes, “a built view such as a lively city street might be more stimulating and hence more therapeutic than many natural views” (Ulrich, 1984, p. 421).
2.2.3. The Auman et al. (2003) Study: The impact of Daylight and View the Health and Performance

In 2003, Auman et al. conducted a series of studies on human performance built environments. The series includes studies about different aspects of the indoor environment, such as the impact of daylight on human performance along with other aspects such as view and ventilation. They conducted two studies related to the aspect of view in the built environment—a study of students’ performance in the classrooms and a study of worker performance in offices.

2.2.3.1. Windows and Offices: A Study of Office Worker Performance

This study focuses on the potential contribution of windows and daylight on offices workers performance. The whole study consists of two different studies conducted at the same organization, the Sacramento Municipal Utility District. The first study measured the performance of 100 workers in an incoming call center according to the factor of time needed to handle each call. The second study examined the performance of 200 other office workers individually through short cognitive assessment tests. The studies found that “having a better view out of a window, gauged primarily by the size of the view and secondarily by greater vegetation content, was most consistently associated with better worker performance” (l. Heschong Mahone Group, 2003). The performance of workers in the call center improved by 6% to 12% when they had the best possible views. Moreover, the results of the office workers’ cognitive tests were 10% to 25% better when they had the best possible view compared to when they did not have a view. The study also found that office workers with the best possible views were the least likely to report negative health symptoms. Conversely, negative health symptoms such as fatigue were mostly associated with a lack of view (l. Heschong Mahone Group, 2003).
2.2.3.2. Windows and Classrooms: A Study of Student Performance

This study aims to measure the impact of daylight and other aspects of the indoor environment on students learning performance according to the factor of their improvements on standardized math and reading tests. Overall, the study examined the relationship between students’ test improvement and the availability of daylight in their classrooms in combination with other physical attributes such as: ventilation, indoor air quality, and quality of the views out of the windows. The study’s statistical models show that physical conditions of classrooms—and specifically the characteristics of the window—are as important as, or more than, many other factors with much more public attention. The findings emphasize the importance of having a view of the surrounding context and show that there is a strong relation between a sufficient and pleasant view out of window and the outcomes for student learning (I. Heschong Mahone Group, 2003).

2.3. Architectural Design Process

2.3.1. Introduction

According to John Christopher Jones (2004), the goal of a design process, through rational criteria, is to make a decision and try to optimize it. Although the design process is always experienced in every design project, its exact nature is often vague (Bayazit, 2004). In the application, methods (when applied by others) tend to be simplified and distorted from the original intention. This makes them less than useful and consequently highly criticized for a lack of relevance in practice (Plowright, 2014). There have been two camps who have adopted opposing approaches to handling design issues: the rational problem-solving and reflection-in-
action. According to the reflection-in-action approach, the designer “adapts and shifts his or her approach based on experience and need but without any explicit understanding of methods” (Plowright, 2014). In this approach, architecture is considered a context-dependent discipline rather than product-focused one, with multiple stakeholders. This nature of architecture makes the reflection-in-action approach more suitable than the traditional problem-solving approach to include quality as part of the human ecosystem.

Often, in learning environments, the structure of the architectural design process lacks clear communication or documentation to transfer knowledge from a master to an apprentice—such as an office principal or studio critic to an inexperienced designer. Designers need to know that they deal with types of knowledge, including tactic knowledge, that can be difficult to document or transfer. Therefore, novice designers may be not able to develop design decisions independently of expert designers. In the case of this research, to design for man’s best possible visual connection to the surrounding environment, the proposed process could help designers to overcome the difficulty of transferring relevant knowledge and decentralizing the process.

2.3.2. Design Frameworks

In general, architects and designers over time, consciously or unconsciously, have used one of the three design frameworks to create design. The three main architectural design frameworks as identified by (Plowright, 2014) are: pattern-based framework, force-based framework, and concept-based framework. The simplest way to define design frameworks is to look at them as “containers of thinking that scale content, pre-select tools, and identify points of decision-making” (Plowright, 2014). Design frameworks should be flexible without predetermined outcomes; any decision made by the designer and the outcomes depend mainly on
the types of the designer’s input. Several designers can use the same structure of a design process and obtain different outcomes depending on the starting bias, content, and philosophical approach. In other words, frameworks do not make a decision by themselves, instead, they help designers to make decisions through the design process (Plowright, 2014). For instance, they are used as filters to help designers apply particular types of information to outcome desires and specify what and when to do certain kinds of thinking, the disciplinary devices to use, the optimum timing to apply judgment, and how to do scale thinking. In any discipline, be it architecture, engineering design, or industrial design, the design framework always has two types of thinking: (1) exploratory, divergent, or expansive thinking (creative) and (2) reductive, convergent, evaluative thinking (analytical) (Plowright, 2014).

2.3.2.1. Pattern-based Framework

The origin of patterns as a source of architectural design traces back to the earliest architectural treaties of Vitruvius and could be defined as “a series of rulesets and best practices” communicated among architects (Plowright, 2014). The pattern-based framework was theoretically developed by Quatremère de Quincy at the end of the eighteenth century and introduced to the use in architectural design early in the nineteenth century (Plowright, 2014). Patterns seen by designers as identifiable structures combine parts together and are capable of holding almost any type of information to achieve relevant outcomes for the final design. Compositional rules can then be extracted from those patterns. For example, they can provide social information extracted from the formal composition, allowing one to gather information about how the space is used from its shape, volume, adjacency, qualities (e.g., light, sound, textures, atmosphere), and distribution (Hanlon, 2009). The use of patterns in architectural
design can be supported by Quatremère’s notion that “everything must have an antecedent; nothing whatsoever comes from nothing, and this cannot but apply to all human inventions” (Plowright, 2014). In other words, any invention keeps its elementary principles visible and evident despite any changes that occur over time. The pattern-based framework operates internally without the need to transfer content between domains of knowledge. It should be noted that the use of composition and typological approaches and rulesets in the contemporary architectural practice has become uncommon because its limited ability to deal with the cultural and social content of a space.

2.3.2.2. Force-based Framework: Approaching Design in Terms of Qualities

This type of design framework is built upon the conception of “systems thinking,” which deals with complex forces conceptualized as pressure, assets, constraints, and flaws. It aims to make these complex forces accessible and ordered within the design process. However, it does not deal with objects being reduced to the sum of their parts; objects are “parts of a system which has structural and behavioral relationships as well as interconnectivity” (Plowright, 2014). In a design process, designers deal with systems that consist mainly of a built environment, natural environment, social interactions, financial structures, and human bodies in space. Accordingly, these elements can be looked at either as assets or obstacles to the final proposal. Since this framework is very flexible, it produces various outcomes depending on the initial contents and the types of forces selected and emphasized by designers. Viollet-le-Duc is one of the earliest architects that introduced and used systems thinking in his design process. He considered that “human activities and environmental events as pressures or forces interconnected on an environment” (Plowright, 2014) Forces in a force-based framework can be interpreted in a very
similar manner to those which Louis Sullivan used to interpret the phrase “form follows function,” since in his opinion, “function is a force or pressure that shapes form to make it a little clearer” (qtd. in Plowright, 2013, p.42). Frank Lloyd Wright as a disciple of Sullivan, also interpreted the forces in similar but broader way, as summarized by Plowright (2014):

“architectural form is the result of the resolution of forces … [or] the direct manifestation of forces, flows or pressures” (Wright, 1954).

Therefore, an architectural designer can use the force-based framework to approach their architectural design to avoid seeing it as a problem-solving activity that reduces and limits the environmental complexity. This is because the forces approach translates non-physical elements such as qualities, desires, and requirements, into constraints, assets, pressures, and opportunities to be used to make decisions that define form. In contrast to the pattern-based framework, the forces-based approach seeks to engage spatial qualities as a direct resolution of formal, environmental, and social qualities. In other words, the forces-based approach looks for “qualities in all things rather than the pattern, shape, or object” (Wright, 1954).

2.3.2.3. Concept-based Framework

A concept could be defined as an “abstract idea used to order the elements of an architectural design project” (Plowright, 2014, p. 370) The concept-based framework used today as an architectural design method developed from the idea that architecture expresses something beyond its own materiality. The main advantage of this design framework over pattern and forces approaches is in its ability to introduce and address knowledge from non-architectural domains into the architectural syntax early in the design process. Conversely, there is the possibility of not dealing with non-architectural content, such as external sources, in an
appropriate way. A concept-based framework mainly relies on the metaphor operation to translate the material from outside of the core syntax of the discipline into an architectural response. Metaphor in the context of the architectural design process can be defined as any movement of content from specific discipline(s) to be mapped as an explainable device in the architectural discipline. During the mapping process, the core information, values, and relationships of the source domain are maintained while non-essential characteristics are dropped (Plowright, 2014).

2.3.3. Thinking Styles and Tools in Design Process

The various and extended content of information that can be accessed for use in the architectural design process makes it very complex and requires some limitations on the scope of that content. To this end, any design framework is associated with certain tools, conceptual and physical, that allow designers to focus and filter content. There are two main styles of thinking in the design process that are associated with these tools: exploratory thinking with divergent techniques and evaluative thinking with convergent techniques. Frameworks are responsible for focusing on a specific thinking style and the necessary context for them to work. It should be mentioned that thinking styles are not phases or steps in the design process, but they operate within phases as conceptual tools (Plowright, 2014).

2.3.3.1. Exploratory Thinking Style

The exploratory thinking style aims to extend the boundaries of potential solutions by using divergent techniques for a more creative and imaginative process. It is needed to avoid premature decision-making, or presupposing answers before investigation. Deferring judgment, allowing more explorations, and generating a wide range of options and possibilities are
hallmarks of the exploratory thinking style. Techniques of exploratory thinking include 
*brainstorming, variable brainstorming, and asking questions.* Brainstorming is the most common technique of exploratory thinking. It is usually performed by using mind-mapping, which is a diagrammatic technique. Typically, mind-mapping involves the free association of ideas around a central topic, problem, issue, or position.

2.3.3.2. Evaluating Thinking Style

The results of exploratory thinking always need to be organized, analyzed, and clarified by using evaluative thinking applied through convergent techniques. In general, the purpose is to narrow the number of possible solutions and identify paths to move forward in the decision-making process. Making decision during the design process and choosing the perfect option among many can be problematic; the designer often has a limited timeframe to examine every alternative and search every aspect of his design decision. Instead, he often makes decisions that are good enough or, so to speak, *satisficing.* This strategy of decision making is considered significant since designers do not know all consequences of any decision to be made, and there is no single correct answer. Using a satisficing strategy and stopping rules make the design process completable and realistic within the available timeframe, and help achieve coherence of the whole (Plowright, 2014).

2.3.4. First Principles Reduction

The *first principles* reduction tool is one of the most important thinking tools used in the design process. Its main use is to break things down into fundamental activities and operations. Moreover, it can be used to avoid automatic responses to a situation and allow for more alternative ways of thinking about the situation or the object. This can therefore help designers to
approach a situation without predetermined assumptions since it connects designers’ attention to deeper factors underlying forms rather than the forms themselves. Using the first-principles reduction in the architectural design process occurs at multiple scales, such as during the program analysis, volume organization, and reconsidering relationships among architectural objects and forms.

2.3.5. Conclusion

Since this research deals with a non-formal force, the phenomenon of visual connection to the surrounding context, it might be best conducted within the force-based design framework. By doing so, the proposed framework (along with explorative and evaluative thinking) would inform the decision-making process, yield better outcomes, and help resolve the problem of making decisions, especially, for novice ones. As previously mentioned, designers often have a limited timeframe to make all of their decisions. Therefore, the proposed framework, supported by the complementary relationship between the explorative and evaluative thinking styles and based on the role of the first principle reduction tool, can help connect designers’ attention to deeper factors underlying forms. Consequently, the proposed framework will help expand the designing cognitive ability of designers.
2.4. Building Boundary: A Medium for Environmental Control and Defining Atmosphere for a Place

There are two distinct approaches to thinking of the role of the building boundary in architecture. First, from the perspective that it is a medium for protection. Second, the perspective that it is a medium for achieving placemaking and meaningful existential foothold in place. In fact, this research focuses on the second approach, building boundary is a medium for achieving placemaking and meaningful existential foothold in place. For example, Robert Venturi describes the building boundary as a state of tension that is essential for making architecture (Arnheim, 1977). Also, Heidegger (1977) was a true proponent of the potential of the building boundary, stating that, “A boundary is not that at which something stops but, as the Greeks recognized, the boundary is that from which something begins its essential unfolding” (Heidegger, 1977). Accordingly, the building envelope should be dealt with as a medium for continuity, openness, and unfolding. However, one approach deals with building boundary as a multi-component physical separator between the interior and exterior of a building consisting of walls, roofs, floors, and fenestrations (e.g., windows and skylights). According to Machi Zawidzki (2016), in his book *Discrete Optimization in Architecture: Building Envelope*, a building envelope has several main functions:

- “To protect from external factors, especially to provide security and to alleviate the external pollution and noise.
- To protect from climate factors, e.g.: the temperature and humidity outside the comfort range, glare, etc.
- To provide and control natural light.
• To control, i.e., to allow or block the visual connection with the environment” (p. 3). Apparently, the first two points mentioned above emphasize the building boundary as a physical separator, and the last two points emphasize it as a medium for achieving placemaking and meaningful existential foothold in place.

2.4.1. External Wall Climatic Responsive Zoning

The external wall of a building envelope is the most critical component that is responsible for achieving a harmony with nature and connection with the surrounding environment. In his book *Climate Responsive Design*, Richard Hyde (2000) distinguishes between different zones that extend inward and outward from the external wall as the line of enclosure. He believes that understanding these different zones and their effects is necessary to design a building envelope with the optimum climatic response for the building. In his interpretation, the inward zones are the main active and passive zones. The active zone is “the area of the building not influenced by the environmental effects of the external wall or openings in the roof, normally conditioned by active systems” (Hyde, 2000, p. 164). The passive zone is defined by the extent to which the internal environment is affected by the external environment and is not conditioned by the active systems. The area in the passive zone that is immediately adjacent to the enclosure line is called the enclosure zone. It is approximately one to two meters from the enclosure line. Its depth depends to a great extent on the level of transparency in the line of enclosure.

Conversely, the outward zones include the buffer zone and the environmental zone. The buffer zone is immediately adjacent to the line of enclosure. This zone gives a level of protection to the line of enclosure depending on depth and transparency. Effects of adjacent buildings and the landscape can also affect the response of the wall (see Figure 2.3). Indeed, there are several
designs of an external wall that respond differently: thin skins, inclined skins, thick skins, buffering, and valve effects (Hyde, 2000).

![Diagram of different responsive zones on both sides of a building enclosure line.](image)

Figure 2.3. Different responsive zones on both sides of a building enclosure line

In light of the proposed design approach, building envelopes (and especially their external walls) are considered very important building components that play the key role in the quality of the visual connection to the outside context. Accordingly, the proposed framework of integrating the inside-out approach considers augmenting the design decisions regarding the
exterior walls’ configuration. Also, it will provide designers with the necessary cognitive ability to explore and evaluate several scenarios of a visual connection to the outside through exterior walls. Accordingly, knowing the different responsive zones on both side of the building enclosure line might give designers deeper insight regarding the configuration of the external walls to achieve a better connection to the outside environment.

2.4.2. Literal Boundary as Existential Devices

This section discusses the role of building boundary as an existential device in context of discussing the phenomenon of placemaking explained by Christian Norberg-Schulz. A good point of departure is to refer to Christian Norberg’s statement that “a concrete term for environment is place….In fact, it is meaningless to imagine any happening without reference to a locality. Place is evidently an integral part of existence” (Norberg-Schulz, 1988, p. 414). He also holds that “different actions need different environments to take place in a satisfactory way” (p. 8). Norberg-Schulze refers to the importance of phenomenology as “return to the things” to solve the problem of loss of everyday life-world—one of the main sources that philosophers have used to use to obtain “information” about everyday life-world are language and literature. Poetry has the potentials to concretize the totalities that science could not. For example, the poem “A Winter Evening” by Trakl, used by Martin Heidegger and reexamined by Norberg-Schulz (1988) to explain the origins of language, refers to many aspects of “place” through experiencing everyday life-world:

A Winter Evening

Window with falling snow is arrayed,
    Long tolls the vespers bell,
The house is provided well,
The table is for many laid,  
Wandering ones, more than a few,  
Come to the door on darksome courses,  
Golden blooms the tree of grace  
Drawing up the earth’s cool dew.  
Wanderer quietly steps within;  
Pain has turned the threshold to stone.  
There lie, in limpid brightness shown,  
Upon the table bread and wine.  
(p. 8)

Reading through Trakl’s poem, one can notice that there are common concrete images of our everyday life-world used in poetry such as “snow,” “window,” “house,” “table,” “door,” “tree,” “threshold,” “bread and wine,” “darkness,” and ‘light.” One of the clearest aspects of the everyday life-world present in the poem is the distinction between the inside and outside and the role of boundary in determining the nature of this relationship. For example, the outside is present by using either natural or man-made elements and events such as falling snow. Moreover, the word ‘falling’ creates “a sense of space or rather: an implied presence of earth and sky.” (Norberg-Schulz, 1988). For a more satisfactory experience, the house has a window, or in Norberg-Schulz’s words, “an opening which makes us experience the inside as a complement to the outside” (p. 8). In conclusion, man-made places have the basic function of concentration and enclosure fulfilled and related to the outside by fenestration (the arrangement of openings on the building lateral boundary).

Norberg-Schulz (1980) describes the structure of place in terms of “landscape” and “settlement,” and analyzed by means of the categories of “space” and “character.” The “space,” which according to Norberg-Schulz, is “the three-dimensional organization of the elements which make up a place,” and “character,” which is “the general atmosphere which is the most comprehensive property of any place” (p. 11). This accentuates the fundamental role of building
boundary, mainly, the exterior walls, as space-defining elements in relation to the outside-inside relationship. However, Norberg-Schulz also points out, “Similar spatial organizations, ‘space,’ may possess very different characters according to the concrete treatment of the space-defining elements” (p. 11). Heidegger, in a similar fashion, refers to the role of building boundary in defining the character of “space,” as he believes that “spaces receive their being from locations [through the building boundary] and not from ‘space’, [the three-dimensional organization of the elements]” (Norberg-Schulz, 1980, p. 45). In this way, the building boundary determines the quality of inside-outside relationship as the primary aspect of concrete space. Boundary has the primary role of defining any enclosure, or as Heidegger says: “A boundary is not that at which something stops but, as the Greeks recognized, the boundary is that, from which something begins its presencing” (qtd. in Norber-Schulz, 1980, p. 13). Norberg Schulz refers to the role of openings in determining the enclosing properties of a boundary: “in general, the boundary, and in particular the wall, makes the spatial structure visible as continuous and/or discontinuous extension, direction and rhythm” (Norberg-Schulz, 1988). Therefore, the experienced general comprehensive atmosphere depends on the “space” (i.e., structure or treatment) of the place-defining elements (boundary). Different treatments and actions for a place give it different “characters”; a dwelling has to be protective, an office practical, a ball-room festive, and a church solemn. Moreover, Norberg-Schulz holds that “place is the point of departure as well as the goal of our structural investigation; at the outset, place presented as a given, spontaneously experienced totality, at the end it appears as structured world, illuminated by the analysis of the aspects of ‘space’ and ‘character’” (Norberg-Schulz, 1988).

In contrast to “space,” “character” denotes the quality of our relation to the
comprehensive environment we live in. In order to consider “character” one should try to answer several basic questions: “how is the ground on which we walk, how is the sky above our heads, or in general; how are the boundaries which define the place” (Norberg-Schulz, 1980, p. 14).

Repeatedly, the answer should be found by giving more particular attention to a building’s lateral boundary or walls. Accordingly, we can conclude both that “character” is a result of “space” and that they come together. Except for the intuitions of Venturi and few other architects, the problem of “character” has not been adequately considered in the current architectural theory and design process. As a result, current theories may not produce works of architecture who design contact with a concrete life-world.

Norberg-Schulz (1980) holds that deep understanding of the structure of place, or the distinction between “space” and “character,” helps to understand and achieve the phenomenon of “dwelling.” The relation of dwelling to “space” and “character” described by Norberg-Schulz as follows: “when man dwells, he is simultaneously located in space and exposed to a certain environmental character” (p. 19). Moreover, Norberg-Schulz refers to two important psychological functions involved in “dwelling” called “orientation” and “identification.” The main role of “orientation” function is “to gain existential foothold” through helping man to orient himself with an environment and know “where he is” (p. 19) On the other hand, “identification” function helps man “to identify himself with the environment, that is, he has to know how he is in a certain place” (p. 19). For this research, achieving these two functions are underlying for achieving its ultimate goal of the true “dwelling.” Norberg-Schulz refers to of Kevin Lynch’s concept of “node,” “path,” and “district” to resolve the issue of “orientation” function within outside environments. Lynch’s theory suggests organizing the world in relation to focal points,
named regions, or remembered routes (Norberg-Schulz, 1980, p. 45). In conclusion, I think that these functions are not adequately considered in light of the traditional design process. I think that the functions of “orientation” and “identification” inside are underestimated or not fully achieved and need to be investigated further. As in the case of urban design, the psychological functions of “orientation” and “identification” in designing the special experience of being inside should be based on or derived from the surrounding environments or the everyday life-world. In a similar way to Lynch’s ideas, interior spaces and their spatial experience should be organized in reference or relation to localities (man-made and natural environments) and the best medium to achieve this is through the building boundary. Therefore, this research argues that the building boundary is the primary medium that differentiates between “settlement” and “landscape,” and adds a certain “character” to the “space,” while also helping achieve the functions of “orientation” and “identification” necessary for the phenomenon of place.

2.4.3. Framing the View to Outside: Windows as Mediators and Framing Device between Indoor and Outdoor Environments

In light of the above, a building boundary should be dealt with as an essential medium to achieve the phenomenon of place and true “dwelling.” Exploring views of the outside surrounding environment and framing it as part of the spatial experience is necessary to determine the general atmosphere to be experienced (i.e., “character”) and achieve the psychological functions of “orientation” and “identification.” I believe that this is the underlying rationale and motivation for conducting this research. In fact, there are many scenarios for the design of windows that could provide several relationships between the indoors and what is outside.
There are many questions to be answered related to the effect of the shape, material quality, and sensory aspect of a window on the man's connection to the outside. For example, Pierre von Meiss (2011) considers windows as an “eye, mouth, nose, and ear concurrently, it is not only a determining feature in the building’s appearance, but also the intermediary which allows the occupants of a building to see, hear, and feel the place of which they are part” (Meiss, 2011). Also, (Kellert et al., 2008) refer to the role of the window as “arguably, the moment of divide is the most charged, ambivalent, and negotiable for belonging to both sides of the psychological boundary that informs our reaction to the environment” (p. 256). The inherent characteristic of windows, in their ability to frame views, gives windows an important role in determining the nature of the indoor-outdoor relationship. However, there are different windows shapes that produce different framed views and develop different existential feelings. For example, according to Neil Levine, a square window functions in a similar way to an eye, whereas a vertical window develops a “homologous relationship with the body standing in front of it” (Mohney & Easterling, 1991). Conversely, the horizontal window allows a distanced, more abstract field of vision. In Levine’s view, “the vertical window establishes a more coherent, multisensory relationship between the two sides of the window by placing an empathic, anthropomorphic shape into the threshold, while a horizontal or picture window alienates the viewer from what is outside, reducing it to a mere view for consumption” (Mohney & Easterling, 1991). On the other hand, Le Corbusier advocated using horizontal strip windows. In addition to the two main orientations of windows (horizontal vs vertical), other architects such as Mies van de Rohe used frameless ceiling-to-floor glass windows, lending the illusion of complete transparency and openness at the same time that they weaken the existence of man in the total
picture. Also, architects Christopher Alexander, Sara Ishikawa, and Murray Silverstein strongly believes that careful framing of a view is essential to maintain a framed view function for most occupants of a space. In their coedited volume *A Pattern Language: Towns, Buildings, Constructions* (1977), he says “gradually it will become part of the building, like the wallpaper; and the intensity of its beauty will no longer be accessible to the people who live there” (Alexander, Ishikawa, & Silverstein, 1977). Alexander et al. advocate for a special framing process of the desired and beautiful views. On contrary to what Le-Corbusier and Mies believe, Alexander et al. believe that views of nature and outside should not fully enter the space to keep a sense of mystery and curiosity in exploring the space. Instead, “they should be framed as part of a narrative each time that is seen” (Alexander et al., 1977). Moreover, Alexander et al. believes that windows should do something more than to openings in the wall. They refer to the important paradox regarding using clear plate window, pointing out that despite the common belief that the clear plate window put us in a more contact with the exterior view, in fact, it does the opposite. They point out:

> Our contact with the view, our contact with the things we see through windows is affected by the way the window frames them. When we consider a window as an eye through which to see a view, we must recognize that it is the extent to which the window frames the view, that increases the view, increase its intensity, increase its variety, even increase the number of views we seem to see---and it is because of this that windows which are broken into smaller windows, and windows which are filled with tiny panes, put us intimately in touch with what is on the other side. It is because they create far more frames: and it is the multitude of frames which makes the view. (p. 1106)

Therefore, Alexander et al. advocate for multiple small windows more than using a single large sheet of glass. Also, they recommend thinking of windows together with interior spaces configuration at the threshold (i.e., “window place”) in way that allows for sitting and social
interaction. They believe that this way makes space generate more meaningful spatial experiences than connecting inhabited areas to the views on the same level (Alexander et al., 1977). Moreover, Alexander et al. discusses how Kent Bloomer adds another dimension to the function of openings beyond framing clear views of the outside, going beyond the threshold and give a window more spatial power. Interestingly, Thomas Markus who studied windows for a long time reached the same conclusion. According to Alexander et al., Markus concludes that having small windows instead of one large window provides more interesting views, claiming that “small and narrow windows afford different views from different positions in the room, while the view tends to be the same through large windows or horizontal ones” (Alexander et al., 1977, p. 1109). In other words, “the view becomes alive because the small panes make it so” (Alexander et al., 1977).

Alexander et al. (1977) refer to another issue regarding the use of small pane windows: “Modern architecture and building have deliberately tried to make windows less like windows and more as though there was nothing between you and outdoors” (p. 1110). This actually emphasizes the credo of modern architecture, that of making homogeneous extensions in all direction. Alexander et al. critique this approach in the context of a window’s function to give occupants a sense of enclosure and protection in addition to the function of offering views and connecting people with the exterior context at various level. They argue that “it is uncomfortable to feel that there is nothing between you and the outside, when in fact you are inside a building” (Alexander et al., 1977).

In light of the various fenestration configurations used by architects, the question that should be raised is: what is the best fenestration configuration option among several that can
create the desired connection to what is outside, and to weave a spatial story about it? I believe that there is no correct answer to this question, since the answer could be influenced by several factors—the personal preference of the space’s designer or its users, the prevailing architectural thoughts and views, the functionality of the designed space, the available materials and construction techniques, or, which could be the most important one, the lack of or a poor decision-making process and limited cognitive ability of designers to make the right decision. In other words, the cognitive ability of designers may be limited for testing all the connection scenarios. Because of the complexity of decision-making, the proposed design approach in this research could help greatly.

2.4.3.1. Case Studies

This section presents various architectural case studies about the configuration of windows. One good example to start with is accommodation buildings (i.e., lodgings) built at the beginning of the twenty century in the National Parks of the United States. The purpose of these buildings is to offer places for tourists to stay and enjoy the magnificent landscape. For example, the Ahwahnee Hotel in Yosemite National Park, designed by Gilbert Stanely Underwood, with its tall windows that frame a view of the surrounding forest and mountains. For its central views, the architect used tall windows with central clear glass panes, which “the central part of the window directs the seeing on the landscape with the most actions while the other parts on the sides and enhance seeing the sky (Semenov, 2017), see (Figure 2.4).

Figure 2.4. Ahwahnee Hotel in Yosemite National Park; Photo taken by Skip Moore, taken 25 Aug 2013; Image downloaded from https://www.flickr.com/photos/skipmoore/9805482045/in February 2020

The same treatment used at the Old Faithful Lodge in Yellowstone. Windows similar to
those in the Ahwahnee Hotel were used to frame the geyser, and there is one central clear glass pane surrounded by smaller segmented panes. The central view of the geyser is framed and highlighted by the thick mullions and its natural surroundings are pixelized by a fragmented frame (Figure 2.5).

![Figure 2.5. Old Faithful Lodge in Yosemite National Park; Image downloaded from https://www.hotels.com/ho1038210560/old-faithful-lodge-cabins-yellowstone-national-park-united-states-of-america/ in February 2020](image_url)

Finally, the Lake Crescent Lodge in Olympic National Park features its sunroom with full-glazed wall offers a panoramic view to the lake outside. To emphasize the horizontal line of the lake, which occupies the entire view, the designer used a horizontal thick bar at head height (Figure 2.6). In these three case studies, the main strategy was to use different pane sizes to accentuate particular parts of the scene and fragmentize other parts. This treatment can be found
more elaborately deployed in Lyndhurst Castle, designed by Alexander Jackson Davis.

Figure 2.6. Lake Crescent Lodge in Olympic National Park; Image downloaded from https://www.olympicnationalparks.com/lodging/lake-crescent-lodge in February 2020

Some architects have been able to mitigate using a modern full-wall window by using different framing strategies, such as adding framing elements beyond the basic framing layer. An excellent example of this strategy is what the Finnish architect Alvar Aalto did in designing Villa Mairea. He added vertical elements in the living room in a way that precisely mirrors the rhythm of pine trunks on the other side of the window (Figure 2.7). These interior vertical elements serve as a framing medium of the outside scene, which can be seen from the living room and creates a unity between inside and outside (Semenov, 2017).

Figure 2.7. Villa Mairea living room peaceful atmosphere, photo by Misha Semenov (Semenov, 2017)

It is not always framing a view that is the desired quality from a fenestration configuration. Sometime, fenestration is configured to offer a different kind of interface with the exterior. For example, mashrabiyas, as a feature element of North Africa and Middle Eastern
architecture, are mainly used to provide shade and privacy for the space with only very fragmented views of the outside environment. However, their interactions with weather elements, specifically, daylight give the space’s users a sense of time and dynamic change throughout the day and the whole year (Figure 2.8).

![Mashrabiya windows](https://ecoempathyproject.wordpress.com/2017/12/17/framing-the-view-to-nature-windows-as-empathic-mediators-between-indoor-and-outdoor-ecology/)

In a similar context to the function of the mashrabiyas, windows can be used as a “translation and empathic communication devices for information from nature” (Semenov, 2017)

An interesting example of this type of window is the stained glass sundial window that was common in Europe before using the analogous clocks (Figure 2.9 and Figure 2.10). These windows partially or entirely block the view to the outside and instead, translate environmental elements such as directional light and shadow into visual effects (opaque field of information), which inform the space occupant about the passing of time. For example, the Goldfinch Dial
window does permit some view outside (Figure 2.9). Because of the high placement of the window, the view can only be seen through the window is the sky, some high branches, and some flying birds. Accordingly, the center of the window is where the sundial sits in the form of a bird as allegory, whereas the side panes are transparent for the view.

Figure 2.9. Goldfinch Dial, England, 17th Century. Photos are courtesy of John Carmichael (2004).
2.5. Architectural Representations and Motion-based Representation

2.5.1. Architectural Representations

History shows that man has always invented and developed different visual tools and forms to express his thoughts, feelings, and ideas. These tools, whether very primitive ones (such as cave drawings) or advanced ones (such as motion-graphics) are considered architectural representations. Representations based on Euclidean’s projective geometry have been central in the architectural design process since the European Renaissance. Projective geometry is defined as “a branch of geometry dealing with the properties that are invariant under projective transformations” (Tepavčević & Stojaković, 2014). However, graphical representations are an inseparable part of any design process; without them, any architectural idea will be trapped in the designer’s mind without any development or physical implementation. In short, architectural emergence depends on representational techniques (As & Schodek, 2008). Thus, traditional
representations, especially when designers started to deviate from classical architecture principles, have revealed deep deficiencies in dealing with experiential and sensual qualities. Rather, the emergence of the computer and digital technologies has helped designers to develop and systematize traditional architectural representations based on projective geometry via the triumvirate of plan, section, and elevation in axonometric and perspective drawings. However, this systemization process has not resolved their inability to visualize phenomenal experiences.

Despite the many trials of architects and artists to liberate themselves from traditional representational techniques—whether hand-drawn or computer-aided, projective geometry has been the most dominant means of architectural representations. As a case in point, both Filippo Brunelleschi in the fourteenth century and Zaha Hadid in the twenty-first century have used projective geometry. At the same time, we should admit that digital technologies are at least leading architectural representation techniques in a new direction, as they give architects multiple angles of observation and evaluation. In comparison to digital representation technologies, traditional techniques will eventually become unable to communicate the information load of non-traditional design approaches. In other words, “the more a building deviates from the traits of classical architecture – basic frontality, symmetry, right angles and axiality – the more difficult it is to represent it with Euclidean geometry” (As & Schodek, 2008). These emerging technologies offer designers powerful tools that extend the possibilities for the complex manipulation of space and form. Also, they yield new and more advanced representational techniques and applications, based on the juxtaposition of mental images. As and Schodek (2008) refer to the central influence of digital representation media on the architectural discipline in the following manner:
Certainly, digital technologies caused deep changes of medium, content, and representation, and enabled us to broaden our understanding through a more diverse spectrum of information. New modes of dynamic representation are well-suited to accommodate a multitude of interpretations. In the future, the role of representations will increasingly shift from projective means to generative means of architecture; in other words, from tools of visualizing design aspirations to tools for generating these very aspirations. (p.137)

Thus, it can be said that these new digital techniques greatly enhance designers’ ability to study invisible forces that might have an impact on the designed spatial experience (As & Schodek, 2008). Designers who use representations in a form of motion-graphic will be exposed to a broader spectrum of information compared to those who use traditional architectural representations. Consequently, the opportunities of being exposed to more information will potentially enhance the outcomes of a design process.

2.5.2. Architecture in the Digital Age

Architecture depends upon its time. It is the crystallization of its inner structure, the slow unfolding of its form. That is the reason why technology and architecture are so closely related. Our real hope is that they will grow together, that someday the one will be the expression of the other. Only then will we have architecture worthy of its name: architecture as a true symbol of our time.

Ludwig Mies van der Rohe, “Technology and Architecture” (1950)

Digital technologies such as 3D modeling software, generative systems, and CAD/CAM fabrication have been the main media to evolve and change architectural teaching and practicing in the last 50 years, namely after the Second World War. Since then, a paradigm shift from a mechanical paradigm to an electronic one has taken place, which has had a profound effect on architecture. In his essay “The Effects of Singularity,” Peter Eisenman (1992) explains the shift by comparing the ability of the mass reproduction process using the photograph in the
mechanical paradigm with the fax in the electronic paradigm.

Electronic technologies since the early 1990s have been changing almost every aspect of daily life. Some architects thought that architecture should change too. Also, some expected that cyberspace would replace physical space for many activities and functions (Carpo, 2013). This change has unfolded new dimensions, aspects, approaches, and methods in architecture. For example, Mario Carpo (2013) defines the meaningful building of the digital age as a building that could not either be designed or built without using digital technologies. However, the term “technology” is still used widely, from a simple material object such as machines, to include wider themes such as systems. It also can be applied to specific areas such “medical technology” or “industrial technology” (Borgmann, 2006).

Using digital media to generate 2D and 3D visualizations and drawings has been increasingly adopted by almost all designers across the world. The uses of digital media are not limited to only visualization purposes for the final outcomes of the design process, as it might also include more spatial exploration and form generation roles of architectural projects during the design process. Kolarevic (2003) refers to the main influences of the digital age on design domain. He holds that the most important contributions that digital media introduced to contemporary architecture are the digital morphogenesis and digital production. First, digital morphogenesis includes some different approaches, morphogenesis, and tectonic concepts in digital media and computational technologies to develop building forms in contemporary architectural design. Second, digital production is what has reconfigured the relationship between the conception stage and production stage by creating a direct link between these two stages, or the “file-to-factory” processes (Kolarevic, 2003). According to Kolarevic, this process
holds that the digital information of construction can be sent directly to computer-controlled machinery; therefore, much of the time-consuming production of drawing has become unnecessary. Also, architects become able to produce scale models of their designs in a very similar way to industry, as “a valuable feedback mechanism,” which allow them to make relatively informed design decisions during the design process (Kolarevic, 2003).

In architecture, morphogenesis is often used as an inspiration for a built form as a group of methods realized in digital media. It works not only as a representational tool, but also as a generative tool for the derivation of form and its transformation (Roudavski, 2014). Consequently, and as a result of the digitally-driven design process, morphogenesis is characterized by “dynamic, open-ended and unpredictable but consistent transformations of three-dimensional structures” (Kolarevic, 2003). Likewise, Peter Zellner suggests that designers become able to produce new tectonic formations. He describes this paradigmatic shift in the practice of architecture as “recasting itself, becoming in part an experimental-investigation of topological geometries, partly a computational orchestration of robotic material production and partly a generative, kinematic sculpting of space” (Zellner, 2000). On the other hand, digital production refers to the process of extracting and exchanging the construction information from the design information.

Finally, Kolarevic (2003) disccusses how contemporary architectural practice has been influenced and changed by digital technologies in terms of design and construction. The common departure point is that the digital age has facilitated the emergence of different kinds of architecture and redefined the role of architects in the design process (Kolarevic, 2003). The most important aspect that digital technologies has emphasized and brought to the realm of
architecture and construction new information, through which a connection between what can be designed and what can be built is made in much more direct, accurate, and faster manner. This includes the issues of “production, communication, application, and control of information in the building industry” (Kolarevic, 2003).

2.5.2.1. **Digital Continuum from Design to Construction**

According to Kolarevic, the ultimate goal of using digital technologies is to develop “a four-dimensional model with all qualitative and quantitative dimensional information necessary for design, analysis, fabrication, and construction, plus based-time information necessary for assembly sequencing” (p. 11). In other words, it is about producing a cohesive and complete model with all information necessary for designing and construction. By doing this -- developing a single source of information -- architect will play a leading role in the design and construction process, in a similar manner to the absolute power of master builders in the medieval time.

Moreover, adopting digital modeling (3D) and animation (4D) software in the architectural discourse enable designers to design in unconventional ways that unfolded new dimensions of formal exploration in architecture. Novel generative processes based on new concepts (topological space, isomorphic surfaces, dynamic systems, keyshape animation, parametric design, and genetic algorithms) leads to new shapes and forms. The digital technologies allow the design and construction of complex forms in new ways within a reasonable budget enabled by the effective flow and use of information, In short, by using digital technologies the design information becomes the construction information. It is more about the process itself rather than the formal change itself. The digitally-driven process that interconnects each of the design, analysis, representation, fabrication, and assembly into a relatively seamless collaborative
process, gives the architects a greater control over the design process because of the effective extraction and exchange of the digitally-generated design information.

2.5.2.2. Digital Morphogenesis

As mentioned earlier, in contemporary architectural design, digital media’s role in design practice is increasingly used as “a generative tool for derivation of form and its formation” rather than as representation tool for visualization (Kolarevic, 2003). Accordingly, the forms are generated automatically according to “internal generative logic,” developed by designers. Based on this logic, the designer can choose one among the many produced alternatives for further development. Digital media changes the design process to be a more consistent, continual, and dynamic transformation process of the architectural form. The digital generative processes now shift the emphasis from “making form” to “finding form” achieved by opening new areas for “conceptual, formal, and tectonic exploration,” and “articulating an architectural morphology focused on the emergent and adaptive properties of form” (Kolarevic, 2003, p. 17).

Consequently, the variable and multiple forms have replaced the stable and singular forms. Kolarevic (2003) posits that “[c]omputational, digital architectures are based on processes of digital morphogenesis of form origination and transformations” (p. 17). He continues:

[T]he plural (“architectures”) emphasizes multiplicities inherent in the logics of the underlying computational concepts [used in digital morphogenesis], such as topological geometries, isomorphic polysurfaces (“blobs”), motionkinematics and dynamics, keyshape animation (metamorphosis), parametric design, genetic algorithms (evolutionary architectures), [and] performance, etc. . . . (p. 17)

This means that the inherent feature of multiplicities in the computational concepts raises another issue of how to choose what form(s) among the many generated forms for further development—depending on the basis of what relevant decision has been made. The preliminary answer
provided in this research seeks to explore the designed spaces or generated form within its actual spatial context (i.e., digital immersion)

**Topology:**

As described by Kolarevic (2003), the concept of topology in architecture emphasizes the shift from typological-based expression into “relations that exist between and within an existing site and the proposed program ... as underlying structuring and organizing principle for the generation and transformation of form” (Kolarevic, 2003).

**Dynamics and Fields of Forces:**

Kolarevic also cites Greg Lynn (1999) who, in his book *Animate Form*, observed that it is essential to recognize that the architectural form is manifest of both the “internal, parameter-driven rational logics,” as well as the “response and engage to dynamic, often variable influences from its environmental and socio-economic context” (qtd. in Kolarevic, 2003, p. 28). In doing so, Kolarevic emphasizes the influence of external and gradient forces on the architectural form through its transformative interactions. This is because, as outlined by Kolarevic, Lynn refers to one of the main drawbacks in traditional architecture compared to other design fields that “abstract space of design is conceived as an ideal neutral space of Cartesian coordinates,” but in other design fields, “design space is conceived as an environment of force and motion rather than as a neutral vacuum” (Lynn, 1999). Kolarevic continues citing Lynn, who argues that “while physical form can be defined in terms of static coordinates, the virtual force of the environment in which it is designed contributes to its shape,” thus making the forces present in the given context is fundamental to the form making in architecture (Lynn, 1999). Lynn attributes to this
position the significance of a paradigm shift “from a passive space of static coordinates to an active space of interactions,” which he describes as “a move from autonomous purity to contextual specificity” (Lynn, 1999). Thus, a key tool for this conceptual shift is the use of digital media, such as animation and special effects, described by Lynn as design tools rather than devices for rendering, visualization and imaging (Kolarevic, 2003).

**Parametrics:**

Kolarevic (2003) also discussed how parametrics have improved the process of generating the architectural form by providing a range of possibilities and replacing the features of stability and singularity with variability and multiplicity. In parametric design, the design form’s origination and transformation are determined according to the different values assigned to the parameters of the design. In other words, different objects and forms are created by assigning different values (Kolarevic, 2003).

**Metamorphosis:**

Digital modeling software offers a rich repertoire of transformations a designer could use to further explore formal potentialities of an already conceived geometry. According to Kolarevic (2003), simple, topologically invariant transformations, such as twisting and bending, are particularly effective means for creating alternative morphologies. However, by adding a fourth, temporal dimension to the deformation processes, animation software adds the possibility to literally express the space and form of an object’s metamorphosis. In keyshape (keyframe) animation, different states of an object (i.e., keyshapes or keyframes) are located at discrete points in time, and the software then computes by interpolating a smooth, animated, time-
encoded transition between them. A designer could choose one of the interpolated states for further development or could use the interpolation as an iterative modeling technique to produce instances of the object as it transitions (i.e., morphs from one state to another). Again citing Lynn (1999), Kolarevic (2003) describes a particularly interesting temporal modeling technique, or morphing, in which dissimilar forms are blended to produce a range of hybrid forms that combine formal attributes of the “base” and “target” objects.

2.5.2.3. Digital Production

As mentioned earlier, the digital age has formed a new relationship between conception and production by creating a direct link between them. Building projects have become both digitally designed and realized through “file-to-factory” 3D digital models (Kolarevic, 2003). These digital technologies provide opportunities for architects to redefine this relationship by integrating the domains of architecture, engineering, and construction. This integration enables a relatively seamless digital collaboration between these domains in which architects could be the key players, or “information master builders” (Kolarevic, 2003).

In fact, the great impact of digital technologies on the Architecture, Engineering And Construction (AEC) industry—such as computer-aided design (CAD) and computer-aided manufacturing (CAM)—has increased exponentially within the last two decades. More specifically, the impact of digital technologies on building design and construction practices are profound, as it has unfolded new opportunities for designing and building architectural projects, which were previously very difficult and expensive to realize. Kolarevic (2003) believes that the consequences of the new digitally-driven processes of design, fabrication, and construction will be huge on the historical relationship between architecture and its means of production. In his
opinion, digital technologies unify digital architects, designers, and thinkers through providing “an enabling apparatus that directly integrates conception and production in ways that are unprecedented since the medieval times of master builders”

2.6. The Ecological Theory of Meaning in Film

According to Sheena Rogers (2005) in her chapter, “Through Alice’s Glass: The Creation and Perception of Other Worlds in Movies, Pictures, and Virtual Reality,” a filmmaker creates a world like ours that is somehow familiar, yet intrinsically different. Roger refers to the basic tenets of ecological psychology to develop an ecological theory of meaning in film. According to Roger’s theory, we, as observers, “become immersed in the world of the motion pictures because it shares its natural (non-symbolic) meaning with the real world it depicts” (Anderson & Anderson, 2005). According to the ecological approach, motion and still pictures can provide the observer’s eye with optical structures very similar to those in nature. Rogers refers to the important role of movement in the experience of perception, since it increases information perceived by the perceiver about the world. This movement includes movement of objects, in the real world or film, and movement of the perceiver. In Roger’s ecological theory of meaning in film, “the viewer is an active explorer, constantly in search of information, and the filmmaker as ‘auteur’ of information’ takes on the formidable responsibility of providing the information needed to understand the world being portrayed on the screen” (qtd. in Anderson & Anderson, 2005, p. 215). However, the filmmaker is not responsible for developing new symbols and new language, but rather to guide the available information. Citing Kepes (1994), Rogers reminds us: “Just as letters of alphabet can be put together in innumerable ways, so the optical measures and qualities can be brought together in innumerable ways, and each relationship generates a
different sensation of space. The variation to be achieved are endless” (qtd. in Rogers, 2005, p. 218). In other words, movement is an essential action to gain needed information about the world out there and our relation to this world (Anderson & Anderson, 2005).

Based on the ideas of Erwin Panofsky (1991), Rogers (2005) continues to explain how images contain two levels of meaning, the natural or primary meaning and the secondary or conventional meaning. Like Panofsky, she believes that primary or natural meaning is available for and detectable by everyone who has experienced the real world; in turn, the secondary or conventional meaning is not available to everyone as this secondary meaning requires special knowledge and is beyond the bounds of proper perception. Likewise, the ecological approach does not deny the importance and existence of symbolic meaning of motion picture, but it reclaims its abundant natural meanings that have been ignored in favor of symbolic meanings. In this way, the natural meaning in the form of information is the core of the ecological theory of moving images. However, the moving and changing of objects or observers in the optical flow are essential in the ecological theory of film. Despite any similarities between still image and moving images, moving images have a much greater capacity to capture natural meanings in the form of information with much less ambiguity than still images. Since some informative structures require movement, not all informative structure can be available in still pictures. As Rogers (2005) describes, “There are some things about the world that simply cannot be known from information available in frozen array although many things can be. Some informative structures require movement, these structures are necessarily, in principle, be made available in a still picture” (p. 224).

Moreover, since the proximity to life and reality depends, to a great extent, on the amount
of informative structures available, motion picture or movies (which provide more informative structures compared to still pictures) are closer to life and reality. Consequently, virtual reality is the closest to reality and life yet, and has the potential to exceed video’s ability to provide informative structures. Moreover, in addition to having many characteristics of motion pictures, virtual reality also resolves the issue of missing the ecological imperative of action in still and motion pictures, as more information can be obtained as the observer makes various moves and directs the camera through the artificial environment to produce optical-flow patterns. The key advantage of virtual reality over motion-pictures, then, is that the relation between informative structures and the observer’s eye is very like actual reality (in which the observer through his movement can create his own informative structures). Thus, virtual reality can help the observers by himself to create meaning instead of relying on filmmakers to do this task.

According to the ecological theory and contrary to the claim of symbolic theorists, when humans interact with their surroundings, they become continuously engaged in different spatial and temporal patterns of optical flow. These patterns in optic arrays are rich in informative structures that provide various kinds of information about objects, surfaces, people, places, and events, and about human relations to these things and about the various possibilities of one’s interactions with them.

2.7. Mixed Reality and digital immersion in Architecture

2.7.1. Introduction

Architecture, Engineering, and Construction (AEC) industries benefit from developments in computing, visualization, and modeling technologies, which allow media to merge real-life situations with computer-generated visual information (Anders, 2003). These technologies have
expanded the range of realities that humans might exist in or interact with—from real environments to virtual ones. Mixed Reality (MR) covers all kinds of reality-based experiences that exists between reality and virtuality as shown in Figure 2.11. The design process can effectively be enhanced by this kind of merging, where it can be used to enrich the process through “different perceptions, comprehension and conceptions of the spatial volumes within both physical and virtual environments” (Schnabel & Kvan, 2016). Designing through a mixture of realms, virtual and real, helps to dismantle the limits of each environment and leads to alternative design outcomes (X. Wang, Schnabel, & SpringerLink (Online service), 2009).

![Reality-Virtuality (RV) Continuum](image)

Figure 2.11. Reality-Virtuality (RV) Continuum

### 2.7.2. Virtual Reality

The term Virtual Reality (VR) can be defined in several ways and applied in various situations, from partially immersive environments to completely immersive environments. In other words, the difference in the definitions of MR and VR comes from the various levels of immersion that VR systems provide to their users—such as a partial immersion experienced on an ordinary desktop monitor to a complete immersion experienced with a head-mounted display (HMD).
Sherman & Craig (2003) identify four key elements that are required to experience virtual reality: a virtual world, immersion, sensory feedback and interactivity. According to the authors, the virtual world is defined as “the content of a given medium” (p. 6). A virtual world is like the script to a play or a film; it cannot exist without being experienced through a virtual reality system (i.e., an integrated collection of hardware, software, and content). In other words, a virtual world can only be experienced via a system that presents these objects and interactions in a physically immersive and interactive medium called virtual reality. Immersion is also essential to the definition of VR as an “immersion into an alternate reality or point of views” (p. 7). This definition refers to two ways that one can perceive something in addition to the world that the participant currently lives in: first, by perceiving an alternate world and second, by perceiving the normal world from another point of view. An alternate world could be either a representation of the actual world or a completely imaginary one. Immersion per se is not enough for experiencing virtual reality, as several media can mentally immerse people in alternate worlds—like a novel. So, immersion should be a physical one to begin a virtual reality experience. (Sherman & Craig, 2003) define physical immersion as “bodily entering into a medium; synthetic stimulus of body’s senses via the use of technology; this does not imply all senses or that the entire body is immersed/engulfed” (p. 9).

Through sensory feedback, virtual reality systems provide participants with information about their positions in the environment. This sensory feedback comes from tracking the movement of the participant’s body or some part(s) of his body. Interactivity is therefore necessary to produce an authentic virtual reality experience, which is one that responds to the participant’s actions. In turn, the response to action occurs either by changing a computer-based
world or by changing one’s viewpoint within the world. When combining all of the key elements of VR, Sherman and Craig (2003) suggest a more suitable definition of VR as: “a medium composed of interactive computer simulations that sense the participant’s positions and actions and replace or augment the feed-back to one or more senses, giving the feeling of being mentally immersed or present in the simulation (a virtual world)” (p. 13).

2.7.3. Augmented Reality

In the past, the experience of augmented reality was entirely through physical media and not easily to implement or alter. Consequently, the amount of information that might be provided in a specific location was limited. However, the technological revolution in the twenty-first century—with the ability to store, manipulate, retrieve, and display information—allows for more interactive and flexible experiences, through which man can experience an augmented physical environment with more digital information and virtual objects. Indeed, augmented reality has been defined by many specialists in several ways, but all definitions emphasize the essence of augmented reality as “the combination of virtual objects and real-world environment, so that users can experience a realistic illusion when using the interactive virtual object to explore the real-world environment” (Furht, 2011, p. 340). Thus, the core of an augmented reality experience can be described as experiencing and interacting with a physical environment with additional layers of various digital information about this physical environment (Furht, 2011).

(Azuma, 1997) identifies the three primary characteristics of augmented reality as: a combination of real and virtual, interactive in real time, and registered in 3D. Another definition of augmented reality provided by (Craig & Books24x, 2013) as a “medium in which digital
information is overlaid to the physical world that is in both spatial and temporal registration with the physical world and that is interactive in the real time” (p. 20). Craig (2013) explains the key aspects of AR in more detail:

- “The physical world is augmented by digital information superimposed on a view of the physical world.
- The information is displayed in registration with the physical world.
- The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world.
- The augmented reality experience is interactive, that is, a person can sense the information and make changes to that information if desired” (p. 16)

In the paper “An Augmented Reality System for the Treatment of Acrophobia—The Sense of Presence Using Immersive Photography,” Juan, Baños, Botella, and Pérez (2003) show that the sense of presence during a user’s experience in immersive photography environments is like one being felt in real environments. The authors use a comparison between two scenarios where a participant looked down from a balcony towards a staircase to make their point. In the first scenario, the participant stood in the real space and looked down from a terrace; in the second scenario, the same participant stood in an immersive photography environment of the same place looking down wearing a video see-through HMD. Their results suggest that the immersive photography environment induces a sense of presence for a place just like the user physically experiences in the actual place.

### 2.7.4. Visual Displays: Head-Mounted Displays
The primary classes of visual displays used in VR or AR include: 1) stationary visual displays such as a computer monitor and 2) visual displays that move with the participant’s head or with other parts of his or her head.

2.7.4.1. Head-Mounted Projection Display Technology and Applications

There are two scenarios for how the user sees the real world through HMDs. The user can see the world either in a direct way through optical means (referred to as optical see-through) or in an indirect way through video technology (referred to as video see-through). Contact lenses are a clear example of an optical see-through display, where the user can directly see the real-world through these lenses (Craig & Books24x, 2013). HMD technology has improved the experience of augmented and virtual reality at different levels. It allows for achieving an optical combination between computer-generated virtual information and the real world in augmented environments. Moreover, it reduces the cognitive barriers that may exist between the real and virtual world, such as through improving the design of the Tangible User Interface (TUI). Also, it enhances the sense of “being there” and controlling for remote users (Furht, 2011).

2.8. The 3D Blacksburg Project

The project of 3D Blacksburg is a “comprehensive three-dimensional model of the town of Blacksburg, Virginia” (Tech, 2017). The model was created by the 3D Blacksburg Collaborative – described on the website as “an open community effort launched by the Center for Geospatial Information Technology (CGIT) and the Visual Computing Group at Virginia Tech (VT).” The project aims to develop spatial data infrastructure for the campus of VT and the town of Blacksburg that “enables interactive 3D visualization in a variety of real-world applications and display venues” (Tech, 2017). It includes data from topography, aerial
photography, and buildings in a 3D environment that can be used to visualize related spatial information such as building interiors, utilities, and networks (see Figure 2.12). The 3D Blacksburg project, through private and public models, addresses domains such as community resilience, emergency management, town planning, social networking, crowd sourcing, and economic development. 3D Blacksburg was published using an ESRI ARC-GIS backend to a set of file directories for Keyhole Markup Language (KML) / (COLLAborative Design Activity) COLLADA and extensible 3D (X3D) clients. Students and researchers from diverse academic disciplines can benefit from this project as an educational and outreach tool in their research (Tech, 2017). For this research, the 3D Blacksburg model was involved indirectly. Specifically, some spatial data sources used to build the 3D Blacksburg, namely, the LiDAR data file, was used to build an accessible 3D digital model of the surrounding context inside Infraworks 360 used for conducting the immersive case study. The reason for not using 3D Blacksburg directly is the issue of interoperability (see Chapter 1.7) with the design software used to conduct the immersive case study to design a given building on Virginia Tech campus.
2.8.1. Open Geospatial Consortium 3D Portrayal Interoperability Experiment

The Open Geospatial Consortium (OGC) conducted an Interoperability Experiment (IE) on the portrayal of 3D geospatial data in which different mechanisms were tested for the portrayal, delivery, and exploitation of 3D geodata based on open standards-based formats and services. Its main intention was to identify, test, and further develop “technologies and workflows that may be the foundation of spatial data infrastructures with a requirement for rapid visualization of very large and complex 3D geodata” (Consortium, 2012) (Figure 2.13). The focus of the IE was on “the proposed Web 3D Service (W3DS) and Web View Service (WVS) interfaces” (Global, 2013).
2.8.1.1. **Web 3D Service (W3DS):**

A good working definition of Web 3D Services (W3DS) can be found in the book *Image Processing: Concepts, Methodologies, Tools, and Applications* by IGI Global (2013):

The Web 3D Service (W3DS) is a portrayal service for three-dimensional geodata delivering graphical elements from a given geographical area such as: landscape models, city models, textured building models, vegetation objects, and street furniture. Geodata is delivered as scenes that are comprised of display elements and optimized for efficient real time rendering at high frame rates. 3D Scenes can be interactively displayed and explored by internet browsers with 3D plugins or loaded into virtual globe applications (http://w3ds.org). (p. 1413)

2.8.1.2. **Web View Service (WVS):**

A good working definition of Web View Services (WVS) can be found in the same book (Global, 2013).

The Web View Service (WVS) is a portrayal service for three-dimensional geodata such as landscape models, city models, vegetation models, or transportation infrastructure models. A WVS server mainly provides 2D image representing a 3D view on a scene constructed from 3D geodata that is integrated and visualized by the WVS server. (p. 1413)
2.8.1.3. Data encodings and bindings

The actions of describing, exchanging, and visualizing 3D (geographic) data require a standardization process among the variety of data formats such as CityGML, KML/COLLADA, X3D, X3DOM, HTML5/WebGL and OpenStreetMap data format (Consortium, 2012) (see Figure 2.14).

- **CityGML**: “The City Geography Markup Language (CityGML) is an open data model and XML-based format for the representation and exchange of virtual 3D city models.”

- **KML/COLLADA**: “The Keyhole Markup Language (KML) is an XML-based 3D graphics format used to visualize geographic data in 3D virtual globes and 2D web browser or mobile mapping application.”

Figure 2.13. Example of W3DS workflow; Image from OCG (2012), *OGC 3D portrayal interoperability experiment final report*, p. 39; Retrieved from https://portal.opengeospatial.org/files/?artifact_id=49068
• **X3D:** X3D is “the successor of the Virtual Reality Modeling Language (VRML) and is standardized as ISO/IEC 19775 (architecture and abstract capabilities), 19776 (encodings), and 19777 (API).

• **X3DOM:** it is “an adaption of the X3D standard to (X)HTML, ensuring declarative 3D can be used inside a standards-compliant browser.”

• **HTML5/WebGL:** HTML5 is the next revision of the Hypertext Markup Language (HTML). It ensures “the interoperability among browsers so that web applications and documents behave the same no matter which HTML 5-compliant browser is used to access them.”

• **OpenStreetMap (OSM) data format:** OSM uses “the XML format to define and convey models. There are only a few simple data primitives in OSM, namely nodes, ways, and relations.”
Figure 2.14. 3D Portrayal of the Interoperability Experiment (IE), including data flows of all experiments; Image downloaded from https://www.ogc.org/projects/initiatives/3dpie in February 2020
3. Chapter Three: Research Methodology

3.1. Introduction

The complex nature of studying non-objectively measurable aspects of the phenomenon of visual connecting to the outside environment requires a qualitative approach that allows the researcher to deeply understand the phenomenon (Creswell, 2009). As previously mentioned, this research’s objectives focus on developing a framework for enhancing decision making in the design process and its explorative ability to help designers achieve the best possible visual connections to the outdoors.

To better meet the research objectives, this study was conducted using a qualitative-dominant mixed-methods design combining three research methods: logical argumentation, immersive case study, and Delphi method. The logical argumentation strategy was mainly used to identify, describe, and combine seemingly disparate factors to build an comprehensive conceptual framework that may more effectively contribute to developing and integrating an interactive and informative inside-out design approach to the design process. Next, and because it is possible that the outcomes of the logical argumentation may deviate from reality, a case study method, namely, the immersive case study was conducted. As a researcher and a designer, I believe that the best way to develop and adjust the resulting framework should not be separate from the way of using it. Consequently, the generated logical framework from the logical argumentation was used, and therefore further developed, to design a building on the campus of Virginia Tech. This phase helped to identify deficiencies and gaps that might emerge during the use of the proposed process. To a great extent, conducting the immersive case study relied upon my personal experience and knowledge in the field of architectural design and design education.
As a consequence, this research questions normative thinking regarding the current design process and the proposed modification to the design process regarding designers’ cognitive exploration of inside-outside visual connections and making design decisions to frame the best possible visual connection. Consequently, there was a need to question the resulted framework. As mentioned earlier, the ideal scenario to do that is to test it for prolonged period of time by many designers or design students to design various design projects. However, this scenario is not applicable within the timeframe for conducting this dissertation. Instead, a three-round Delphi survey was conducted (Figure 3.1). The main goal of conducting the Delphi survey is to build consensus among a panel of experts who were purposefully selected for this study regarding the need for this proposed process and its effectiveness in achieving its goal.
Figure 3.1. Overview of the used method for conducting this research

- Analyze the phenomenon of inoor-outdoor visual relationship
- The rationale for developing the proposed framework
- Position the research in a broader theoretical context
- Develop more relevant critical questions
- Discover and develop relationships among several know/unknown and/or unappreiated elements
- Identify potential limitations

- Test the effectiveness of the proposed process
- Identify the deficiencies and gaps might emerge during the use of the proposed process
- What are the main steps of the proposed process
- What is the operational workflow of the proposed design approach in relation to the design process

Logical Argument (Initial Conceptual Framework)

Immersive Case Study (Developed Framework)

Delphi Method (Develop Consensus)
3.2. Logical Argumentation Strategy

3.2.1. Introduction

Logical argumentation can be implicitly used in any research design. The decision to choose a logical argumentation strategy in this research study stems from its hallmark and basic trait of “the enumeration of first principles.” This trait allows researchers to think freely and thoroughly about potential elements of the investigated phenomenon and synthesize them into one conceptual system at the paradigmatic level. Linda Groat and David Wang (2002) define the first principle as “a fundamental proposition that is so self-evident that it needs not be derived from more elemental proofs” (Groat & Wang, 2002, p. 379). The authors continue, arguing that they are rather best perceived as “logical building blocks by which, or upon which, broad explanatory theories can be constructed” (Groat & Wang, 2002, p. 379). It is noteworthy that these logical blocks are demarcated from each other, irreducible, and do not overlap conceptually. This strategy, powered by using first principle thinking, helped to discover and develop relations between known and unknown and/or unappreciated factors regarding the exploring and achieving the best possible visual connection to the surrounding (D. Wang & Groat, 2013). For doing so, logical argumentation used to place the research in a broader theoretical framework and enable explorative (divergent) thinking style. Accordingly, many relevant questions were developed and related literature were reviewed such the human-nature relationship, biophilic design, design process, dynamic digital representations in architecture, moving image theories, the 3D modeling process, building envelope, 3D geospatial data, and other related topics. Ultimately, the aim of this phase is to build and develop the initial conceptual framework to be enhanced in the successive phases.
3.2.2. Logical Argumentation Strategic Traits

Related to the trait of first principle, the logical argumentation strategy has several traits that make it very helpful for this research strategy, such as paradigmatic innovation and its interdisciplinary nature. For example, because of the trait of paradigmatic innovation, logical argumentation strategy helps to “take a set of previously disparate factors, or previously unknown and/or unappreciated factors, and interconnect them into unified frameworks that have significant and sometimes novel explanatory power” (Groat & Wang, 2002, p. 379). This trait could play a significant role in building an explanatory system that allows the researcher to look at existing objects from a new perspective and may shape discourse at the paradigmatic level.

The second trait is the tendency of logical frameworks to be interdisciplinary, which is mainly supported by the ability of the a priori principle of logical argumentation to transcend disciplinary boundaries. Its implementation in this study helped the researcher to include apparently non-related elements to build the framework and consider this project as a stepping stone into a broader application of its findings in the field of built environment design (Groat & Wang, 2002, p. 379).

Implementing a logical argumentation framework as a paradigmatically innovative strategy requires the researcher to develop skills to discover the connections between disparate elements in a field of information. John Zeisel argues that research is a creative activity, and “[c]reative researchers invent and discover …. In the beginning of a project, emerging concepts are visions defining what data to gather” (Groat & Wang, 2002, p. 379). Therefore, logical argumentation has some strengths and weaknesses that should be considered by any researcher who uses this strategy. Some of these, as outlined by Groat and Wang (2002), are as follows:
“Strengths:

- Logical Argumentation identifies first principles as the common denominator(s) for a wide variety of seemingly disparate factors and provides an underlying framework that ties them together into a conceptual system that can describe, explain, and predict within its area of concern.

- First principles are part of any research design; hence the principles of logical argumentation can help identify them and organize them in understandable manner.

Weaknesses:

- It is not easy to identify fundamental categories; examples abound in the literature of unclear categories. It is also easy to fall into the trap of wishing for well-accepted numbers of categories.

- A logical system may in fact not be an accurate representation of the reality it tries to explain and yet still be internally consistent from a logical point of view. For this reason, logical systems must be tested.” (p. 410)

3.3.  Case Study Strategy

3.3.1.  Introduction

A case study strategy was used to further develop the logical framework by identifying deficiencies and determining gaps that may emerge while using the framework. This stage mainly depends on my experience and accumulated knowledge in the field of architectural design to use the framework within the design process. Also, this stage helped to collect and
analyze necessary data to conduct the Delphi survey.

As a research strategy, case study helps an investigator to understand “the holistic and meaningful characteristics of real-life events” (Yin, 2003, p. 2). Yin defines a case study as “an empirical inquiry that investigates contemporary phenomenon within its real-life context, especially when the boundary between phenomenon and context are not clearly evident (Yin, 2003, p. 13). In general, there are three types of case study research strategies: explanatory case study, exploratory case study, and descriptive case study (Yin, 2003). (D. Wang & Groat, 2013) expanded on Yin’s definition to fit more appropriately with architectural research, defining it as “an empirical inquiry that investigates a phenomenon or setting” (p. 346). More importantly, Groat and Wang also identify and explain five characteristics of the case study strategy:

- A focus on either single or multiple cases, studied in their real-life context.
- The capacity to explain causal links, which means that the case study strategy can identify causal links among elements of events or a socio-physical system.
- Determining if the case study is explanatory, exploratory, descriptive, or combination is the responsibility of the researcher through the framing the research question(s).
- The importance of theory development in the research design phase.
- A reliance on multiple sources of evidence, with data converging in a triangular fashion.
- The power to generalize to theory, since Yin (2003) claims that “the case study strength is in its capacity to generalize to theory, much the way a single ‘experiment’ can be generalized to theory” (p. 18).
3.3.2. Immersive Case Study

The case study strategy used in this research has a combination of exploratory and explanatory strategies. These were used to test and further develop the logical conceptual framework developed through the logical argumentation strategy and to provide an approximate explanation of using the proposed process. These strategies allowed for collecting the data required to examine—as much as possible—how the proposed framework could be integrated with the design process in order to produce an architectural space that provides a strong visual connection to the surrounding environment. It also allowed me, as a researcher and designer, through applying explorative and evaluative thinking to explore solutions for and answers to potential challenges and questions that might be faced while using the proposed process.

The main data source for this strategy was my own observations and reflections on my experience using the proposed process to design an actual building (art museum). (Marshall & Rossman, 1999) define the observation technique of data collection as “the systematic description of events, behaviors, and artifacts in the social setting chosen for study” (p. 68). DeWalt and DeWalt (2011) provide another definition as “a method in which a researcher takes part in the daily activities, rituals, interactions, and events of a group of people as one of the means of learning the explicit and tacit aspects of their life routines and their culture” (DeWalt & DeWalt, 2011, p. 1). The immersive case study was the primary approach to applying the case study strategy, in which I was immersed in a primary design case study and used the proposed framework to design a given space. For a more effective data collection method, I video recorded the design process and watched these clips to deeper reflect on this experience. More details about this process is explained later in the Immersive Case Study chapter in this dissertation.
3.4. **Delphi Method**

The primary reason for conducting the Delphi method is to achieve consensus among a panel of experts—in this case, in the field of architectural education and practice—regarding the proposed process, the objectives and questions of this research, and the method used to achieve and answer them. However, there is a secondary reason for conducting the Delphi survey as a platform for providing insights and suggestions to enhance this research or the future relevant research’s questions. Members of the panel of experts were purposively selected according to the main selecting criterion of having expertise or professional experience in the fields of architectural design, architectural design education, and architectural design software development. This selection criteria guaranteed to a great extent the ability of the participating members to make informed decisions. To get the most out of using the Delphi method, it was conducted in a way that maintained its key elements. First, to maintain the anonymity of the participants, all participants remained anonymous and their identity was protected both while conducting the survey and even after the completion of the final report. This allowed for the free expression of opinions, encouraging open criticism, and facilitating acceptance of errors when reviewing judgments by preventing some participants from being negatively impacted by other participants (because of differences in reputation, authority and personality, etc.). Second, controlled feedback was carried out by sharing with all experts the qualitative or quantitative analyses of their responses after each round. Accordingly, each participant was asked to comment on other participants’ responses, defend or alter his original viewpoints, or develop new ideas. Third, iteration, considered the most important element, was used to achieve the key objective of conducting the Delphi technique, or developing consensus among the experts.
The general structure for conducting the Delphi method is readily available in the literature; however, there is no universal way of conducting it. Moreover, most conducted studies that use this method emphasize the important factor of reducing the potential bias in responses (Hallowell & Gambatese, 2009). For this research, specific guidelines were carefully considered for rigorous implementation of the Delphi method to produce more reliable results. These guidelines include the expertise requirements, the number of rounds, the number of panel members, the feedback process, and measuring consensus (Hallowell & Gambatese, 2009). Figure 3.2 below shows the general workflow of conducting the Delphi survey in this research.
Figure 3.2. Overview workflow for conducting the Delphi method
4. Chapter Four: Logical Argumentation

4.1. Introduction

As previously stated, the main objective of the logical argumentation (LA) strategy is to build the initial logical framework as a departure point toward developing the design process for exploring, evaluating, and framing the best possible visual connections to the outside environment. In other words, it is a framework to enhance the explorative ability and decision-making process, therefore, the design cognitive ability of designers, which in turn enables them to achieve better visual connections. To do so, I mainly utilized the logical argumentation strategy empowered by one of its main tactics, identifying the first principles, to achieve two main objectives—based on my interpretation of the identified problem and its potential solutions. First, I broke down the whole problem to be investigated (i.e., the inability of design process to effectively explore and frame the best visual connection to the outside environment) into core pieces and then recombined them back together in a more effective way. Second, I added new ideas and concepts from other unrelated or unappreciated fields. This strategy, through the tactic of identifying first principles, works effectively in freeing the researcher from preexisting boundaries and allows them to look at existing things in a more novel way. Also, I used this strategy to achieve or build a road map of interoperability among all the core concepts (logical block) of the developed framework. However, the resulting framework from this strategy is an initial one that requires testing and further enhancement.
4.2. Breaking Down the Problem to be Investigated

The problem that this research aims to investigate can be summarized as the following question: Why has the current approached to exploring and framing the desired visual connection to the outside environment NOT been effectively achieved in the context of the traditional design process? To break this problem down even further, I assume that there are two potential reasons that are limiting/preventing designers from effectively exploring and framing the best visual connections to the outside environment:

1. There is a lack of awareness of the important role of achieving well-designed visual connections to the outside environment in the phenomena of true “dwelling” and “placemaking.”

2. There is an essential flaw in the traditional design process that prevents designers from exploring, evaluating, and framing the best possible visual connection to the outside environment.

Therefore, logical argumentation seeks to investigate whether the above hypotheses to determine if any are contributing to the problem as stated.

For the first potential reason, I hypothesize that this is not contributing to the problem. My evidence to defend this line of thinking is as follows. First, designers are human beings, which means they automatically tend to design spaces with a strong visual connection to the outside environment. This hypothesis is supported by several theories, such as biophilia and naturalistic tendencies of humans, that state that humans are inherently satisfied by direct and indirect contact with nature and their surrounding environment. Second, the available literature about built environments is full of theories and philosophical views that emphasize the importance of connecting with the outside environment as a requirement to achieve true
“dwelling” and “placemaking.” The Table 4.1 below includes several views of famous theorists, architects, and philosophers, who implicitly or explicitly refer to the importance of achieving a well-designed visual connection to the surrounding environments in order to provide true “dwelling” and meaningful spatial experience. This table shows some of the philosophical and theoretical views and statements which can support building logical blocks of the logical system.

In conclusion, I believe that the importance of achieving a well-designed visual connection to the outside environment is undisputed for most designers and even for the clients, so that there must be other reasons that limit or prevent them from achieving it.

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<tr>
<th>Heidegger:</th>
<th>Juhani Pallasmaa</th>
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<tr>
<td>A boundary is not that at which something stops, but as Greek recognized, the boundary is that from which something begins its essential unfolding (Heidegger, 1977).</td>
<td>Architecture domesticate limitless space and enable us to inhabit it, but it should likewise domesticate endless time and enable us to inhabit the continuum of time (Pallasmaa, 2012).</td>
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<td>The building boundary, as the space-defining element, is the main element responsible for giving otherwise similar spatial organizations different characters (Norberg-Schulz, 1980).</td>
<td>There are two psychological functions, “orientation” and “identification,” involved in man’s dwelling … Man dwells when he can orient himself within and identify himself with an environment or, in short, when he experienced the environment as meaningful (Norberg-Schulz, 1980).</td>
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<th>(Norberg-Schulz, 1980):</th>
<th>Tadao Ando:</th>
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<td>It is meaningless to imagine any happening without reference to locality. Place is evidently an integral part of existence (Norberg-Schulz, 1980).</td>
<td>Natural elements become meaningful when they are introduced into the architectural space in “a form cut off from the outside world” (Ando, 1995).</td>
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<th>(Ando, 1995b):</th>
<th>Tadao Ando:</th>
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<tr>
<td>Architectural form needs natural elements to become manifest and provide a meaningful spatial experience that reveals dynamic natural phenomena—such as the passing of time and the seasonal changing throughout the year (Ando 1995).</td>
<td>“Those places where the internal order meets the external order, that is, the area of fenestration in a building, are of extreme importance” (Ando, 1995, p.449).</td>
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Regarding the second potential reason (i.e., there is an essential flaw in the design process that prevents designers from exploring, evaluating, and framing the best possible visual connection to the outside environment), I think that this hypothesis might be the underlying reason causing the identified problem. More specifically, one drawback in the design process that limits the cognitive thinking and decision-making process (i.e., exploratory thinking and evaluative thinking) of designers in the context of the traditional design process is that designers often design with a limited understanding, connection, and awareness of the building context. However, this potential reason (the essential flaw(s)) may actually be due to several intertwined underlying drawbacks that are individually or collectively contributing to the problem. I think that there have been two main underlying drawbacks, related to the design process, that limit the cognitive and explorative abilities of designers the most; moreover, I think that these two drawbacks are holdovers from a traditional design process that predates digital development. However, after the digital development and its influence on the fields of designing the built environment, I think there should be new ways of looking at the architectural design process, represented in the logical argumentation workflow presented below (Figure 4.1). My hypothesis regarding the inherent drawbacks of the traditional design process are summarized as follows, and discussed in more detail in the next section:

<table>
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<th>Table 4.1 cont.</th>
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<td><strong>Kenneth Frampton:</strong></td>
<td>The role of the building boundary and its fenestration’s innate capacity is to “inscribe architecture with the character of a region and hence to express the place in which the work is situated” (Foster, 1983, p. 22).</td>
</tr>
<tr>
<td>Critical Regionalism is to “mediate the impact of universal civilization with elements derived indirectly from the peculiarities of a particular place” (Frampton, 1983).</td>
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First, the traditional design process is mainly an outside-in oriented process that does not allow designers to explore and examine the indoor-outdoor relationship from an inside-out point of view.

Second, there is a spatial and temporal separation or discontinuity between the actual design context and the subsequent building context.
Figure 4.1. The workflow for using the logical argumentation method to build the initial logical framework.
4.2.1. First Drawback: Outside-in-dominated Design Process

As mentioned above, the design process is mainly an outside-in oriented process in which designers tend to take an outside position, meaning from the position of a maker and spectator rather than of an occupant (Franck & Lepori, 2007). To some extent, this kind of design process, dominated by an outside-in approach, limits designers’ ability to explore how spaces are intended to be spatially experienced in relation to the outside environments—where the design located. However, the hallmark of designing from the inside-out is to reveal what is already there, but hidden, in consideration of the non-formal forces that affect the decisions of the design process (Franck & Lepori, 2007). Therefore, this approach better informs designers’ decisions regarding the indoor-outdoor relationship. Considering the above, I believe that developing and integrating an inside-out design method to the design process is the first step to extending designers’ cognitive and explorative ability in order to achieve the best possible visual connection to the outside. By this, I mean that there are other spatial forces that should be considered in addition to the visual connection to make more informed and rational design decisions. Therefore, the proposed design approach should be integrated with the design process in a way that works in a complementary and compatible manner with the design process’s workflow. The following sections address an initial solution to this identified drawback in the design process.

4.2.1.1. Developing and Integrating Explorative Inside-out Design Approach to the Design Process

This goal of phase of building the logical framework is to propose answers to the primary
questions: What are the main generic steps of the proposed inside-out design approach and what are the design decisions that each step should inform? Also, it tries to find answers to the secondary questions: How will this approach be integrated into the design process, how should its steps be distributed along the design process for effective integration with the design process’ workflow and how will it inform the decision-making process most, and what stage(s) of the design process should be modified for better exploration, evaluation, and framing of the visual relation to the outside environment?

4.2.1.2. **Generic Steps of the Proposed Inside-out Approach**

In general, the number of generic steps for the proposed design approach depends on the hierarchy of the decision making in the design process. More specifically, the steps should be distributed along the conceptual and development stage of the design process in a way that augments and informs the key design decisions throughout these two stages (Figure 4.2). The estimated number of steps to inform the design decisions during the conceptual and development stages may be between four and five. Theoretically, each step should enable designers to conduct specific levels of exploration and evaluation of the quality of the visual connection to the outside environment and, therefore, inform their related design decisions. While conducting these steps and other steps, designers should consider other “starting biases” and limitations of their design. Ultimately, these exploration levels do not force the designer to make specific design decisions, rather they should expand their cognitive ability and let them decide according to all involved design factors and relevant scenarios of visual connections. These steps, as in the traditional design process, are compatible with the nature of design thinking and could be conducted in an iterative manner.
Figure 4.2. The distribution of generic steps of the proposed design approach
First Step:

This step aims to facilitate certain levels of exploration and evaluation of the visual connection to the surrounding environment at the beginning of the conceptual design stage—namely the site analysis and programming phases. The exploration in this step aims to identify what are the areas in the surrounding context that might provide the best possible views to be framed from an inside-out viewpoint. This level of exploration will inform the design decisions regarding a form’s origination, transformation, orientation, and the main spatial movement axes within the building site.

Second Step:

As the design process progresses and the 3D model becomes more elaborate and takes shape, the levels of exploration and evaluation should inform more specific design decisions. The design decisions to be informed in the second step are mainly related to the building boundary configuration such as the shape, orientation, and sizes of openings on the exterior and interior walls. Also, these design decisions, to a lesser extent, include the transformation and orientation of the building form.

Third Step:

This step is designed to be the final step of the exploration and evaluation of the visual connection, which is conducted during the conceptual design stage. As with the previous steps, this step is also designed to be conducted by using the design software. However, it aims to augment design decisions slightly differently than in the previous steps, mainly relating to the structure of elements in the internal configuration of the space such as walls, floors, and ceilings.
As the design process progresses, the exploration and framing process becomes a more bidirectional one, meaning that it informs the design of the internal configuration elements and is influenced by these elements simultaneously.

**Fourth Step:**

This step is designed to be the first conducted during the design development stage. This step aims to explore and evaluate the visual connection through a more elaborate design of the openings on the building boundary and interior design elements, therefore, inform the related design decisions. The design elaboration decisions made during this step might include the selected material, the characteristics of the openings’ frames, and their patterns. This step also should be conducted by using the design software.

However, I believe that integrating an inside-out approach to the design process is not enough to yield informed design decisions alone—especially in the context of limited awareness and understanding of the surrounding context that could inform the exploration and evaluation process of the inside-out design approach. This leads us to a discussion of the second drawback, which is the spatial and temporal separation or discontinuity between the actual designing context and the actual building context.

**4.2.2. Second Drawback: The Spatial and Temporal Separation or Discontinuity between the Actual Designing context and the Subsequent Building Context**

We live in a complex three-dimensional world, therefore, when we think of making a physical intervention (such as a building, a bridge or the like), we first need to have a deep understanding and awareness of the physical world and its interactions. Admittedly, the physical
presence of designers within the actual context of a design project could provide them with data, mainly visual data, that would better inform their design decisions. However, this solution is not practical for many reasons—especially in the context of the hallmark non-linear workflow feature of the architectural design process, which requires continuous data flow and feedback throughout the design process. Moreover, the site itself might be situation far away or be too hazardous to visit regularly. Even if the design location is inspectable, designers cannot always explore and examine multiple inside-out views from any specific point in the space—especially from elevated points of view. Accordingly, the physical presence and movement of designers within the real environment or other alternative media (such as scale models with synthesizing photos of the surrounding context) have several limitations in providing the necessary information throughout the design process. In short, these traditional options (e.g., physical presence and scale models) are neither interactive, accessible, accurate, nor explorative. Table 4.2 below shows a comparison among different methods of designing in context based on personal design experience as they relate to the aforementioned characteristics.
Table 4.2. Comparison among different methods of designing in context

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Digital Immersive context</th>
<th>Real Environment</th>
<th>Physical Model with photography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>For any point and level elevation</td>
<td>Only for the ground floor level</td>
<td>Only for 1:1 scale, which is impossible</td>
</tr>
<tr>
<td>Interactivity</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Time and effort saving</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Yes</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>Exploration</td>
<td>Unlimited</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>Informative</td>
<td>Yes (stores information for most objects)</td>
<td>Visual information only</td>
<td>Visual information only</td>
</tr>
<tr>
<td>4D (time dimensions)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

I believe that this spatial and temporal separation in the traditional design process is inherent to all fields concerned with designing built environments. Designers have been trying to resolve this issue by synthesizing a design context that might be similar to the actual building context by visiting the site, taking several pictures of the site, making sketches for some part of the site, etc. In other words, designers have been trying to build context with as much data as possible about the actual building context (see Figure 4.3). For example, traditional methods and spatial data sources used for exploring the visual connection to the outside, such as examining multiple photos of the surrounding context or synthesizing them onto scale physical models of the proposed design, may only reveal limited visual information necessary for the visual spatial exploration. However, even if these approaches help in some cases, there is still too much spatial
data that will be missing, lost, or badly managed, which would still prevent conducting an effective exploration, evaluation, and framing of the best visual connection to the outside environment. I think that using these traditional spatial data sources has been a source of the spatial and temporal separation between the actual context of design and the actual context of building and the reason for the potentially lost or badly managed spatial data necessary to explore and evaluate the best possible visual connection to the outside environment.

Accordingly, I assume that merging the two contexts into one informative and accessible context should resolve this issue in the design process. I think that there are two main things should be considered in order to do that: 1) the approach should provide informative spatial data sources and 2) it should facilitate an effective exploitation medium of the available 3D spatial data model.

Figure 4.3. The spatial and temporal separation or discontinuity between the actual designing context and the actual building context
4.2.2.1. **Provide Informative Spatial Data Sources**

Again, even with the integration of an inside-out design approach into the design process, this approach needs informative spatial data sources to facilitate an effective use of the design process for spatial explorations and to inform its design decisions. Practically, I believe that the proposed inside-out design approach should be connected to accurate and interactive 3D digital representations of the exiting context instead of the traditional spatial data sources. More specifically, this research proposes using available geospatial 3D models, which may be promising solutions to this issue. However, even the availability of 3D digital representations of the existing context is not adequate enough for the proposed inside-out method to be able to fully expand designers’ cognitive and explorative abilities. Therefore, I recommend that these data sources should be used through a more integrative and accessible manner.

4.2.2.2. **Facilitate an Effective Exploitation Medium of the Available 3D Representation Models**

The availability of 3D digital representations of the exiting world alone is not enough to inform design decisions in the context of the traditional design process. This is because the traditional design process is not interactive and not dynamic enough to exploit their capabilities fully. Accordingly, the proposed inside-out design approach and the design process should support access to such 3D representation models in a seamless, interactive, and exploratory manner. More specifically, the digital modeling stage of the design process should be connected and informed directly and interactively from these 3D representations. For a more effective implementation of this modification, there are some basic concepts that should be considered, such as digital immersion, 3D geospatial models, movement and perception, and digital morphogenesis.


4.2.2.3. Inside-out Design Approach & Immersive Virtual Environment

As noted, one of the main reasons for designers’ inability to explore and frame the visual connection is the spatial and temporal separation between the designing context and the building context. Because of this, designers often lack a sense of presence during the design process. In reality, designers cannot be engaged in the design process and visiting the building site at the same time. Even if, theoretically, designers are able to be present at the building site throughout the design process, there are several physical limitations that may prevent them from effectively exploring, evaluating, and/or framing potential visual connections to the surrounding context within the built environment. However, immersive virtual environments (IVEs) could provide a sense of presence found in physical environments and allow for designing to be activity facilitated in this special designing environment at the same time. Accordingly, the concept of digital immersion within a space is considered one of the main logical blocks in building the logical framework to develop and integrate an inside-out design approach to the design process. However, overcoming the concept of immersion as a logical block in the proposed logical framework requires a consideration of the supporting hardware and software and the issue of interoperability.

4.2.2.4. 3D Geospatial Context Models

Immersion within 3D digital representations of real-world objects could provide accurate, accessible, interactive, and explorative sources of information to understand and analyze the surrounding world and inform decisions regarding human physical interventions. These representations can reference most of the objects in a particular area such as terrain surfaces, sites, buildings, vegetation, infrastructure and landscape elements, and other related objects. In
addition to the reasons mentioned before, there is an added advantage for conducting this research within 3D geospatial projects, namely the potential to integrate the 3D GIS domain and the Architecture, Engineering, and Construction industry (AEC) domain into one holistic environment. This integration will yield numerous benefits for both the GIS industry and design and construction industry. The design process is one of the direct beneficiaries of this integration as well, through designing in a larger and smarter context. This integration could provide more effective ways, in terms of accessibility, interactivity, time and effort saving, accuracy, and exploratory capacity, to achieve this research’s objectives and other related research objectives to be conducted in the future—especially with the introduction of 4D GIS models. In short, 3D geospatial data sources are growing and developing exponentially as a rich source of spatial data for the effective management of built environments, gaining an increasing interest among several stakeholders. Therefore, the architectural design process, as a decision-making process, cannot remain separate from this valuable source of information to enhance its outcomes.

However, integrating a 3D geospatial context into the architectural design process means that there needs to be a data exchange between the geospatial domain and the AEC domain, which means a level of interoperability between them should be achieved. In fact, there is growing research interested in achieving full interoperability between the Geographical Information System (GIS) domain and the Building Information Management (BIM) domain at different levels. For some reason, most of the GIS/BIM integration research has been focused on transferring data in one-way direction, from the AEC domain (BIM) into the geospatial domain (GIS)—which is mainly advantageous for urban planners, urban designers, or stakeholders who are mainly concerned in managing built environments at the macro level. In the context of the
objectives of this research, this operation of data transfer, from the AEC domain into the geospatial domain (GIS) is not very useful; instead, the inverse operation from the geospatial domain into the architectural design domain is what should be achieved or proposed. There are several logical reasons for directing this research to support integration in this way, from the geospatial domain to the architectural design domain, not vice versa. Some of the most important reasons are that (1) it allows for staying inside the architectural design platform to leverage the available modeling and rendering tools so that the 3D model of the building and its boundary can be effectively adjusted and (2) the indoor-outdoor relationship can be examined in an interactive way.

4.2.2.5. Host Designing Framework: Force-based Framework

Another basic concept to be considered in building the logical framework of this research is the type of the generic framework that the proposed inside-out design approach and the design process will operate within. As previously mentioned, there are three main generic designing frameworks: the force-based framework, type-based framework, and concept-based framework. According to the features of each of them discussed in Chapter 2.3.2.2, the proposed design approach will best operate within the force-based framework. This type of generic framework, the force-based framework, looks at the artifact of architectural design as “direct resolution of formal, environmental, and social qualities” (Plowright, 2014 p.186). This approach accounts for how determined forces influence the building form’s origination and it transformations through a series of explorative and evaluative thinking. Accordingly, it allows for various design responses to the explored visual connection to the outside environment. It also helps achieve the best indoor-outdoor relationship quality, free from any formal rulesets, patterns, or preconceived
image, although with the translation of the spatial forces (explored views) into concrete architectural form (Figure 4.4).

Figure 4.4. Generic framework of a force-based design process including thinking styles (Plowright, 2014)

4.2.3. Interoperability among the Identified Logical Blocks

The above-identified logical blocks require achieving a certain level of interoperability among them, especially between the digital design process and the 3D geospatial models. Most literature suggests that most research regarding the interoperability between the architectural design process and 3D geospatial models has been conducted on the integration between Geographical Information System (GIS) and Building Information Modeling (BIM). For example, one study shows how these are considered heterogeneous environments that need interoperable methodologies and tools (Fosu, Suprabhas, Rathore, & Cory, 2015). However, my research does not aim to achieve interoperability between these two different domains at the technical level. Instead, it aims to demonstrate the effectiveness of such integration on the outcomes of the design process, and especially on the quality of the explored and framed visual connection to the outdoors.
To a great extent, the proposed design process and its outcomes depend on achieving a level of integration and interoperability between the architectural design process and the 3D geospatial sources in a way that facilitates georeferencing 3D design models within an informative 3D geospatial context. Accordingly, choosing a software or combination of software should consider allowing data flow between these two domains—especially from GIS to BIM.

4.2.3.1. Workflow for Transferring 3D GIS Data into Architectural Design

It is possible to transfer 3D city models from a CityGML format to a BIM/CAD platform, such as Revit, Sketchup, or ArchiCAD. This scenario would be the best one in terms of saving time, preventing data loss, and using the design tools available in design software. Unfortunately, it is not currently applicable because of the interoperability gap that prevents importing 3D geospatial data into different design platform such as the Revit software (Figure 4.5).

Figure 4.5. Workflow for transferring 3D GIS data into Architectural Design Platform

4.2.3.2. Workflow for Transferring Data from Architectural Design Platform into 3D GIS Domain

It is also possible to transfer 3D building models (such as Revit models) from the format...
of Industry Foundation Class (IFC) to a GIS platform such as ArcGIS software (Figure 4.6). This scenario is applicable, but it seems to have many limitations. First, it is a time-consuming process because it needs third party intermediary data conversion technology, such as Feature Manipulation Engine (FME), to convert an IFC model into a CityGML format (Fosu et al., 2015). Therefore, there is potential for a significant data loss of BIM/CAD information during the conversion and transferring process. Second, GIS platforms do not have modeling or visualization tools. Consequently, designers will no longer have the ability to modify their design in direct and effective way after the transfer.

Figure 4.6. Workflow for transferring data from Architectural Design Platform into 3D GIS domain

4.2.3.3. Workflow for Transferring 3D Building Models and 3D city Models into Spatial Data Aggregation Platform

InfraWorks 360 has data aggregation, modeling, design, simulation, analysis, and visualization features. It supports many 3D model formats such as Revit and SketchUp, and
exchange formats such as CityGML and Collada (Figure 4.7). COLLADA is an XML-based exchange format for 2D and 3D graphics data, maintained by the Khronos Group (Khronos Group, 2020).

Figure 4.7. Workflow for transferring a 3D building model and a 3D city model into another system

Apparently, this workflow might be the best one to conduct this research because it allows for:

1. Creating, building, and updating a real-world context models by using real-world data,
2. Importing 3D city models in CityGML and Collada formats (Figure 4.8),
3. Importing building models in their actual format and georeferencing them accurately (Revit model) within the created real-world context models,
4. Updating any modification that might be done to both of the BIM and GIS models inside their own original platforms,
5. Being effective in terms of interoperability, saving time, and maintaining the original
information of both BIM models and Geo models, and


![Different 3D file formats supported by Infraworks 360](image.jpg)

For the reasons mentioned above, the third workflow is the most suitable for conducting this research and achieving its objectives. Accordingly, the software combination to be used should contain Infraworks 360 software along with another common design software, such as Autodesk Revit, ArchiCAD or SketchUp. The decision for the initial choice of Infraworks 360 is based on its hallmark feature as a geospatial and engineering BIM platform that allows for planning, designing, building and managing infrastructure in the context of the real world. At the same time, the decision to choose an architectural design software is harder because of the great parallels that exist among architectural design software used by designers nowadays. However,
choosing the most suitable one is critical for effectively testing the proposed inside-out design approach. There are many aspects among the many available architectural design software that can be compared. However, it is important that any decision to choose one particular design software over another should consider two main factors:

1. How much is the software adopted by the targeted audience (in this case, designers)?
2. How much does it facilitate testing the proposed design approach and conducting this research?

Admittedly, it is highly recommended to select a design software that supports the Building Information Modeling (BIM) system. Due to the scope of this research, I will not be discussing in detail what the benefits of BIM software are or why it has been adopted by many design and construction schools and firms across the world. Rather, in short, BIM software enhances the design experience and the construction process at different levels of modeling, visualization, analysis, documentation, and managements.

According to The Business Value of BIM in North America (2013), the industry-wide adoption of BIM increased from 28% in 2007 to 71% in 2012. Moreover, according to the G2CROWD (2015) report on architecture design software, the leading design software are AutoCAD, SketchUp, Revit, ARCHICAD, MicroStation, and Vectorworks Architect—based on the customer satisfaction (based on user reviews) and market presence (based on products’ scale, focus, and influence). Of course, designers across the world use these design applications for different reasons; such as the price, compatibility with other software, modeling and rendering capacity, etc. For this study, the selected software should have features that allow for the effective testing of the proposed inside-out design approach. Accordingly, I have built a
comparison table, which might facilitate choosing one or two software among the many available design software (see Table 4.3).

| Table 4.3. Comparison among most common design software according to identified criteria that support achieve the proposed process |
|---|---|---|---|---|---|
| | Revit | AutoCAD | ArchiCAD | Vectorworks Architect | MicroStation | Sketchup |
| **Design and documentation tools** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Integrated visualization and analysis tools** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Conceptual design tools** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Algorithmic design and support** | Yes | No | Yes | Yes | No | Yes (Grasshopper) |
| **Free education license** | Yes | Yes | Yes | No (free trial) | Limited | Yes (not for the full version) |
| **Support BIM** | Yes | No | Yes | Yes | Yes | a quasi-BIM platform |
| **Immersive design review and collaboration in virtual reality** | Yes | No | No | Yes | No | Yes |
| **Support georeferencing 3D models** | Yes | No | Yes | No | Yes | Yes |
| **The experience of the researcher** | Yes | Yes | No | No | No | A modest experience |
Table 4.3 cont.

<table>
<thead>
<tr>
<th></th>
<th>Revit</th>
<th>AutoCAD</th>
<th>ArchiCAD</th>
<th>Vectorworks Architect</th>
<th>MicroStation</th>
<th>Sketchup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Export IFC models</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Supported by Infraworks 360</strong></td>
<td>Yes In the original format</td>
<td>Only for IFC format</td>
<td>Only for IFC format</td>
<td>Only for IFC format</td>
<td>Only for IFC format</td>
<td>Yes In the original format</td>
</tr>
<tr>
<td><strong>Operating system</strong></td>
<td>Win</td>
<td>Mac/Win</td>
<td>Mac/Win</td>
<td>Mac/Win</td>
<td>Win</td>
<td>Mac/Win</td>
</tr>
</tbody>
</table>

According to the comparison presented in the table above, it seems that Revit and SketchUp software are the software that could better facilitate conducting this research. They are both supported by Autodesk Infraworks 360 software, both Revit and Sketchup models can be imported into Infraworks 360 software environment in their original formats, and any change made inside Revit and Sketchup software can be smoothly and quickly updated inside the Infraworks 360 environment. Also, both applications have promising partnerships with great geospatial data and map production companies – Autodesk with Esri and SketchUp with Google Maps.

To choose only one application from the two, I had to make one more comparison between them (see Table 4.4). In this comparison, I added new comparison points along with some of the previous comparison points. It is noteworthy that most of the comparison information is from the G2-CROWD platform. The comparison shows that Revit outperforms SketchUp in some aspects and Sketchup outperforms Revit in others. On average, there are only slight differences between the two software. However, I found that Revit has a more advanced
tool to accurately geolocate the model inside the Infraworks 360 model. Accordingly, either Revit or SketchUp along with the Autodesk Infraworks 360 could be used to test the proposed design approach and the modified design process. Fortunately, both software (Revit and SketchUp) have been commonly adopted by most of the targeted audience of this research; otherwise, the research outcomes would be less important and its objectives and goals may not be achieved as desired. For the sake of conducting this research, I used Revit software. This is because I think that I possess better experience in using Revit than SketchUp. Also, as mentioned, it seems to have a more accurate geolocation tool and more BIM applications compared to Sketchup.

<table>
<thead>
<tr>
<th>Comparison Criteria</th>
<th>Revit</th>
<th>Sketchup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Partnership</strong></td>
<td>Esri</td>
<td>Google</td>
</tr>
<tr>
<td><strong>IFC export/import</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Ease of use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Based on 486 reviews</em></td>
<td>7.3</td>
<td>8.9</td>
</tr>
<tr>
<td><strong>3D/Solid modeling tool</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Based on 455 reviews</em></td>
<td>8.4</td>
<td>8.5</td>
</tr>
<tr>
<td><strong>Drawing tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Based on 458 reviews</em></td>
<td>8.5</td>
<td>8.2</td>
</tr>
<tr>
<td><strong>Rendering tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Based on 431 reviews</em></td>
<td>7.7</td>
<td>6.8</td>
</tr>
</tbody>
</table>
Table 4.4 cont.

<table>
<thead>
<tr>
<th>Comparison Criteria</th>
<th>Revit</th>
<th>Sketchup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Import/Export file</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on 871 reviews</td>
<td>8.1</td>
<td>7.9</td>
</tr>
<tr>
<td><strong>File Interoperability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on 378 reviews</td>
<td>7.5</td>
<td>7.3</td>
</tr>
<tr>
<td><strong>File size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on 444 reviews</td>
<td>6.3</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Task-based interfaces</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on 335 reviews</td>
<td>7.8</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>Product Direction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on 483 reviews</td>
<td>8.9</td>
<td>7.6</td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$228/month for a professional plan. Free educational license</td>
<td>Sketchup free, Sketchup pro $695, Student License $49</td>
<td></td>
</tr>
</tbody>
</table>

4.3. The Target Audience

One of the main drivers of this research is to bridge the gap between the work of architects and interior designers in dealing with the stated problem of architectural design. Specifically, this research seeks to inform architects’ decisions to design spaces in a way that makes it easier and more effective for interior designers to emphasize the explored and framed visual connections to an outside context. Therefore, I believe that the target audiences of this research are architects primarily, followed by interior designers (practicing designers and design students), and finally occupants of the building and customers.
4.3.1. Architects

Architects represent the first tier of achieving the desired indoor-outdoor relationship by making major design decisions regarding a building form’s origination, its transformation, and its orientation. Moreover, architects make major design decisions regarding the configuration of the building boundary. This will minimize any conflict that may occur between architects and interior designers. Therefore, the tasks of interior designers in designing the interior spaces that emphasize the explored and framed views architects will be much easier.

4.3.2. Interior Designers

In light of the proposed process, I believe that interior designers represent the second tier of achieving the desired visual connection to the outside environment. Accordingly, they could further emphasize the framed visual connection for the spaces designed by architects. They could also use the proposed process either to explore and frame potential visual connections—and make the design decisions regarding the configuration of the interior design elements of given spaces—or to emphasize the framed views.

4.3.3. Others (Occupants and Clients)

As the third tier to achieving the desired visual connection, occupants and clients could help in resolving the issue of high subjectivity in making design decisions. Including various viewpoints could yield more coherent and informed decisions regarding the quality of the indoor-outdoor visual relationship within the built environments. According to a phenomenon known as the “wisdom of crowds,” the collective decision could surpass individual decisions. In other words, looking at the problem from different perspectives could improve the decisions
made and reveal more aspects that could further enhance the quality of the indoor-outdoor relationship within the built environment.

4.4. Limitations and Potentials

While conducting this logical argument to develop the framework of integrating and using the proposed inside-out design approach in the design process, several limitations and issues were confronted. These issues and limitation were determined through being metacognitively aware of the ultimate goal of the study. For example, it may be difficult for only one researcher to use the first principle to enumerate all possible basic blocks necessary to build the conceptual logical framework. There may also be difficulty in achieving adequate level of operability among all identified basic blocks and define the logical relationship. Finally, there is uncertainty that the resulted framework may actually be an accurate representation of the reality that it aims to explain. These issues and limitations were identified through a metacognitive approach:

1. What information is known about the problem?
2. What information is needed to be known to solve the problem?
3. What strategies are needed to solve the problem?

First: What information is known?

It has been implicitly and explicitly agreed among most theorists and designers that having a well-designed visual connection to the outside environment is essential for achieving true “dwelling” and a meaningful spatial experience. According to my logical argument (see Section 4.2), I realized that there are two essential drawbacks in the current design process that
makes it ineffective for exploring, evaluating, and framing the best possible views from inside points of view. These drawbacks are: first, the outside-in design approach currently dominates the design process; second, there is a spatial and temporal separation between the design process context and the building context. Accordingly, I thought that enhancing the design process in a way that allows designers to consider exploring and framing views to the outside environment would require reducing or eliminating the existing temporal and physical separation. Theoretically, the best way is to merge these two distinct contexts into one context. However, this leads to the second point of the metacognitive strategy, which requires identifying the information needed to solve the problem. One of the limitations confronted in conducting this part of the research was the lack of information from relevant literature, which made the second point harder to resolve.

Second: What information needs to be known?

This limitation pertains to the information needed to be known to reduce or eliminate the separation between the design process context and the building context. In other words, what information is needed to merge these two contexts into one informative, interactive, and accessible context? During the logical argument, I determined that the 3D geospatial data can be used to develop a 3D digital context of the building context in which the designer could be immersed during the design process.

Third: What strategies are needed?

Answering the second question involves the third limitation, which focuses on what
strategies to use when introducing 3D geospatial data into the design process. In order to overcome this limitation, one must know if using the 3D geospatial data would be applicable and effective in helping a designer explore and frame the best possible visual connection to the outside environment. In trying to answer the third question, I conducted an immersive case to test and develop some strategies to introduce the 3D geospatial data to the design process. To overcome the second hurdle, I conducted 3 rounds of a Delphi-based survey to develop consensus among experts about the need for and effectiveness of integrating the 3D geospatial data into the design process.

4.5. Conclusion

By the end of the logical argumentation phase, the main features of the proposed framework to enhance the design process for better exploring of the visual connections to the outside have been identified. In brief, four to five inside-out steps of exploration-evaluation-adjustment to be chronologically integrated to the design process. Each step would be supported and augmented by the digital immersion and virtual movement inside the designed spaces within the 3D digital representation of the surrounding context. Each step would inform the design decisions of each design stage (see Figure 4.9).
Figure 4.9. The generic steps of the proposed framework
5. Chapter Five: Immersive Case Study

5.1. Introduction

As mentioned earlier, the purpose of conducting the immersive case study is to test out the initial design framework that was developed in the logical argumentation phase by using it to design a given space in Blacksburg, Virginia, namely on the campus of Virginia Tech. By doing so, the framework was tested and developed in terms of the level of operability among its core blocks: the 3D digital context model, the immersion level, and the digital modeling process. Also, it was tested in terms of its capability to explore and frame the best possible visual connection. This helped to further develop the proposed inside-out design approach’s generic steps and examine them to achieve the best visual connection to the outside environment. Before testing the framework’s main steps, several steps were needed to be achieved. The main step was to build a digital 3D context model where the design proposal is located. This step is considered essential to conducting the immersive case study and ultimately to achieve the objectives of this research. Of course, this step could be achieved one of several ways and by using a combination of several software. However, for this research and according to the logical argument done previously, Autodesk Infraworks 360 software was used. The reason for choosing this software was discussed earlier and is due its ability for aggregating and adding various sources of 3D spatial data from various sources to build a 3D context model (see Chapter 4.2.3.3). Moreover, it allows for adding various GIS layers to the 3D model through the Autodesk Connector for ArcGIS tool if needed.
5.2. Building a 3D Digital Context Model

This step is important, but not in the long term of using a design tool developed for the proposed framework. As previously mentioned, 3D digital and smart models for many cities have already been developed across the world, such as the 3D Blacksburg model, the Paris model, the Berlin model, and other cities (Figure 5.1). However, the available 3D models have not developed in a way to be accessible by architects through their design tools to support design decisions on the scale of designing an individual building that considers an inside-out designing approach. Hopefully, the outcomes of this research will motivate developers to consider developing specialized tools that allow designers to interactively access these 3D geospatial models from within the design software environments, especially after the recent promising partnership between Autodesk and Esri in 2017 (Autodesk Inc, 2020).

Figure 5.1. Photos of the 3D digital model for Berlin
To overcome this issue in this research and provide an accessible 3D digital context model to be used to develop the proposed framework, I have built a 3D context model by using the Infraworks 360 software. This software is originally designed for planning and designing infrastructure projects in the context of the real world. I took advantage of its ability to aggregate several 3D and geospatial data to build a 3D model of the real world (Autodesk Inc, 2020; Inc, 2020). Infraworks 360 supports several data source types such as 3D models (.3DS, .DAE, .DXF, .OBJ) Autodesk Civil 3D (.DWG, .DXF), AutoCAD files (.DWG, .DXF), Autodesk IMX (.IMX), Autodesk Revit (.RVT, .RFA), CityGML (.GML), Industry Foundation Classes (.IFC), Point Cloud Files (.RCS , .RCP), Raster Files, Spatial Data Format, Shape Definition Files, SketchUp files, SQLite Files, and others.

5.2.1. Steps of Building the 3D Digital Context Model Inside Infraworks 360

There are two main steps for building the 3D digital model of the existing world. First, one must create a base model for the area of interest, which consists of vector and raster data such as the building, terrain, water area, roads. Second, one must add additional 3D geospatial data such as a vegetation layer in the form of point cloud data extracted from Lidar data or 3D GIS data from available sources (see Figure 5.2. The main step of building the 3D digital context model).
5.2.1.1. **First: Creating a Base Model for the Area of Interest**

Infraworks provides two main approaches to start building a 3D context model, either by building the model from scratch or by using the Model Builder tool (Autodesk Inc, 2020; Inc, 2020). For the first approach, building from scratch, the “New” tool available on the software interface could be used, after which several spatial layers, both raster or vector types, could be added, such as elevation, imagery, terrain. For the second approach, the “Model Builder” tool available on the software interface can be used to create a base model from the available spatial
data on the OpenStreetMap dataset.

For this immersive case study, I used the “Model Builder” tool because it provides the ability to search by location and select the area of interest through several available selection tools (see Figure 5.3 and Figure 5.4). Basically, Infraworks 360 assigns random façades onto the buildings created inside the model (Autodesk Inc, 2020; Inc, 2020). However, there is a manual way to map photographic images onto the building models for a more accurate reflection of the existing conditions. All spatial data are retrieved from the OpenStreetMap dataset. However, if more accurate spatial layers become available, such as terrain and elevation layers extracted from Lidar data, Infraworks 360 allows for adjusting the base model accordingly and at any time.

Figure 5.3. The two tools to build 3D context model available on Infraworks 360
After creating the base model for the area of interest (i.e., Blacksburg, Virginia), more layers of spatial data could be imported and configured to the base context model through the “Data Sources” panel. The types of these data sources of the base models include 3D buildings such as existing buildings; vector data such as land use, roads and water areas; and raster data such as ground imagery and terrain. Infraworks 360 supports importing many other sources of data such as Point Cloud, IFC, SQLite, SDF, and others. Also, Infraworks 360, through the recently added tool “Autodesk Connector for ArcGIS,” allows for importing GIS data in a more seamless manner.
5.2.1.2. Second: Adding Additional 3D Geospatial Data

After creating the base model, the next step is to start adding more spatial data types to build a representation of the existing world this is as accurate as possible. The efficiency of this step depends mainly on the availability of spatial data sources. Point Cloud data is one data type that could be used to extract terrain data, vegetation, and cityscape data. In this research, Point Cloud data added to build the context model was used mainly to extract the vegetation layer for the area of interest. The Autodesk Recap software was used to visualize the available multiple Lidar files of the Virginia Tech Campus created by the Center for Geospatial Information Technology (CGIC) at Virginia Tech (see Figure 5.5 and Figure 5.6). The multiple Lidar files were imported and indexed inside the Autodesk Recap software. The Point Cloud data of the area of interest (Virginia Tech campus) were cropped and the remainder was deleted. Then, the Point Cloud data of the area of interest were exported into Infraworks 360 in .RCP format, which is also supported by Infraworks 360. Moreover, Infraworks 360 has tools such as “Point Cloud Modeling” and “Linear Feature Extraction” for extracting vertical from Point Cloud data, such as trees, streetlights, signs, and horizontal features for road design such as lane lines and curb lines.
Figure 5.5. Using Autodesk Recap to visualize the available multiple Lidar files of the Virginia Tech Campus
Then, the exported RCP file was imported and configured into Infraworks 360 through the “Data Sources” panel. Once the RCP file was imported and configured, a data source under the name of “Point Clouds” was added to the “Data Sources” panel. Infraworks 360 supports the ability to configure, refresh, remove, reimport, and rename any data source layer at any time (see Figure 5.7).
5.2.1.3. **Third: Importing 3D GIS Data**

Until the moment of conducting the immersive case study, there was no GIS data source imported into the Infraworks 360 or added onto the 3D contextual model being built. The reason was because of the lack of GIS data or limited access to them. However, the process of connecting to the GIS data and importing GIS data into the model was explored through the Autodesk Connector for ArcGIS tool available in Infraworks 360 and located on the Data Sources panel. The ENTERPRISE LOGIN option and my Virginia Tech username and password were used to login to Virginia Tech ArcGIS Online (Figure 5.8).
Figure 5.8. Using the Autodesk Connector for ArcGIS tool available in Infraworks 360 to import GIS data into the model.
5.2.2. Conclusion

Based on my experience, the more spatial elements added to the built context model, the more design decisions were informed. In this case, I think the resulting model was enough to inform my design decisions while using the framework to conduct the immersive case study. The key thing is to make design decisions based on a determination of the relative spatial positions of each of the design elements, context elements, and the space users within the expected spatial experience. The exploration process is based on two main levels of exploration: first, of what could be seen from specific points, and second, of the quality of the seen framed views through the design elements, mainly the building boundary. Ultimately, the built model allowed for achieving the psychological functions of “orientation” and “identification” as suggested by Norberg-Schulz (1980). As previously explained, these two psychological functions are important for man to gain an existential foothold in a place. “Orientation” is necessary for man to know where he is and “identification” is necessary to know how he is in a certain place (Figure 5.9).

Figure 5.9. Triangulation of the spatial experience of the space user in term of what is seen and the quality of what is seen from a specific point inside the space
5.3. **The Proposed Project: Art Museum on the Virginia Tech Campus**

The type and location of the proposed project to be designed was chosen in a way that aimed to maximize the potentials for testing and developing the proposed process and its integration framework into the design process. For the location, I preferred to choose an area on the campus of Virginia Tech, specifically, at an intersection of aerial lines extending from many landmarks on campus. The initially selected location was adjusted while conducting the 2D and 3D exploration process. By doing so, the proposed design approach could better explore and frame visual connections as part of the indoor spatial experience to multiple recognized landmarks. According to Norberg-Schulz’s (1980) assessment of Kevin Lynch’s ideas, the more connection to recognized areas and landmarks, the more the psychological functions of “orientation” and “identification” are achieved. The landmarks selected for this proposed project include Drillfield, Burruss Hall, the War Memorial, and the Duck Pond (Figure 5.10).

For the type of building, I preferred choosing a building type with a diverse spatial experience. I think it is necessary for developing the capacity of the proposed design process to explore, evaluate, and frame views to outside, complex spatial experiences. This also helped identify any potential limitations or drawbacks in using the proposed design approach. Therefore, I decided to use the proposed design approach to design an art museum with multiple exhibition halls and auxiliary spaces. I think that this type of building allows for the application of multi-levels of 2D and 3D spatial exploration and evaluation of the visual connection. Moreover, for a more diverse spatial experience within the proposed building, the building consists of two levels, which maximizes the examination and development of the proposed design approach for improving visual connections.
Figure 5.10. The potential areas of interest considered during conducting visual exploration; Images downloaded from https://www.pinterest.com/maksud/photos-to-take/ in February 2020
5.4. Applying the Proposed Design Approach

This framework consists of four to five main exploration-evaluation-adjustment steps that are spread along the main stages of the traditional design process, which include the conceptual and design development stages (see Figure 5.33). For this proposed design approach, these steps contributed—through a gradual level of the triad of 2D and 3D exploration, evaluation, and adjustment—to informing the relevant design decisions in order to explore the best possible views, or what I called the “raw views.” Mainly, the 3D exploration-evaluation was conducted inside Infraworks 360 and the 2D exploration-evaluation processes was conducted inside Revit. The main steps of the proposed design approach were then carried out in a sequential and iterative manner along with the corresponding stages of the design process. Moreover, each step was carried out according to a specific procedural strategy and along with several meta-cognitive tasks that helped develop the strategy of conducting each step and, therefore, enhance its outcomes. Also, they facilitated reflecting on and evaluating each step’s outcomes through comprehension monitoring, which therefore made for the best adjustments and understanding the limitations, potentials, and recommendations accordingly.

The following sections shows the main generic steps of the proposed framework as it was developed through the immersive case study stage. In general, the steps are flexible and can be integrated with the iterative nature of the design process. By the end of the immersive case study, a conceptual road map for resolving these issues was set. Several data collection methods and reflections were used, such as observation, taking side notes, sketching, and making a video recording of each step. For example, multiple watchings of the recorded video clips helped greatly to identify and reflect on some emergent issues.
5.4.1. **STEP ONE**

5.4.1.1. **Introduction**

This step, through a series of the 3D and 2D explorations and evaluations of the quality of visual connection, informed the major design decisions regarding the building’s form origination, its transformation, and its orientation to frame and emphasize the best visual connections to the outside. As mentioned earlier, each step of the proposed design approach facilitated conducting two main approaches of visual exploration to the outside environment: the 2D exploration and 3D exploration. For a better immersive experience, two computer screens were used.

First, the 3D exploration was conducted, followed by the 2D exploration (Figure 5.11). The 3D exploration was conducted in two phases: Phase one was the on-site 3D exploration and phase two was the digital 3D exploration inside the Infraworks 360 software. Then, the 2D exploration was conducted inside the Revit software. The logical reason for conducting both on-site and digital 3D exploration was to achieve an exploration of the surrounding environment that was as comprehensive as possible. In other words, each exploration approach should complete the other approach. It is important to note that some environmental elements may be not explorable through on-site exploration; likewise, some other environmental elements may be not explorable through a 3D digital exploration approach. This issue might be resolved in the near future when more accessible and informative geospatial-based 3D contextual models are available. Accordingly, designers could rely mainly on the digital 3D exploration approach to conduct visual exploration. The below shows the main phases and strategy carried out in conducting the first step of the proposed process.
Figure 5.11. The main phases and strategy carried out in conducting the first step of the proposed process.
5.4.1.2. Step One, Phase One: 3D Exploration

First: On-site 3D Exploration

To conduct the on-site 3D exploration approach, I visited the building site several times in order to explore the potential best views that might be seen from several points within the building site. I documented these potential views by taking several photos and making several sketches from several points and notating them on a 2D map of the site plan. By the end of this on-site exploration, four main areas of interest for potential best views were initially determined. While conducting this exploration, I tried to explore as many areas of interest as possible, since the more visual connection to the outside view, the more the psychological functions of “identification” and “orientation” would be achieved (Norberg-Schulz, 1980). These areas of interest were the Duck Pond, Drill Field, Burruss Hall, and the War Memorial (Figure 5.12).
Second: Digital 3D Exploration

As mentioned earlier in the logical argumentation section, there are several reasons for not relying only on the on-site 3D exploration of the views. Some reasons are, in many cases, related to the remoteness of the site, whereas some are related to hazardous conditions at the site. Moreover, some reasons are related to the non-linear nature of the design process workflow, which requires frequent visits to the site for a better exploration and framing of the views. There are also human body related reasons that can prevent a designer from exploring the views from hard to reach points, such as elevated locations. This final point is very important especially in
the context of designing a multi-story building. As a result, sometimes, digital 3D exploration might be sufficient if conducting an on-site view exploration is not feasible.

Carrying out this exploration phase depends essentially on the availability of a 3D digital context model, which was built earlier inside Infraworks 360 (Figure 5.13). First, I started navigating the 3D context model inside the software. This gave me the possibility of freely exploring the surrounding context from any point within the building location, especially views from elevated points. This process emphasized the four aforementioned areas of interest from the on-site exploration phase. Because it would be very difficult sometimes to connect all spaces to these best possible views, I utilized this step to explore several secondary areas of interest that could be explored and framed. To do so, I used the available navigation tool available inside Infraworks 360.

Figure 5.13. Conducting the 3D digital exploration inside Infraworks 360
5.4.1.3. Step one, Phase Two: The 2D Exploration-Evaluation-Adjustment

To utilize the outcomes of the previous phase, the 2D exploration phase was conducted. In fact, this phase of exploration has been very intertwined with the conceptual stage of the design process. It helped, to a great extent, to reflect on the influence of the non-formal forces of the explored views on the building form’s origination, its transformation, and its orientation. Conducting this phase required developing a specific Dynamo script inside the Revit software. The main function of the Dynamo script is to generate 2D radial fields of lines extending from assigned exploration points to the tangent points of the areas of interest. The generated fields of view represent the non-formal forces of the visual connection that may then influence the design decisions at the early stages. The Dynamo script includes three main parameters that need to be set to allow using it to generate the desired fields of view:

1. The geographic coordinates of the areas of interest,
2. The exploration points locations within the building site, and
3. The level of subdividing the generated fields of view.

The Parameters of the 2D Exploration Dynamo Script:

*The geographic coordinates of the area of interest*

This parameter was added to allow designers inside the Revit software to generate shapes that define the areas of interest. For the sake of simplicity, each area of interest was represented by a circular shape with an approximate radius and height. To do so, the geographic coordinates of the approximate center of each area of interest were extracted inside Infraworks 360 and then were exported to an Excel sheet. To be used inside the Revit software, the extracted coordinates
and the latitude and longitude values were converted into the UTM (Universal Transverse Metcator) coordinate system (Figure 5.14). The Dynamo script, through this parameter, allows for the importation of an Excel sheet that contains the coordinates of the areas of interest.

*The exploration points locations and number*

This parameter was added to allow designers inside the Revit software to select the desired exploration point to be explored two-dimensionally. The exploration point is a 2D circular shape imported to the Revit software as a Revit Family file. Designers could start with one point at the center of the building location and more points could be added as the initial 3D layout of the building is developing. To choose a specific exploration point, this parameter facilitates picking any specific point by using the mouse. Also, it is possible to pick multiple points at once with the window selection tool in Revit (see Figure 5.15)
Figure 5.15. Pick multiple exploration points at once with the window selection tool in Revit
The level of subdivision

This parameter was added to allow designers to subdivide the generated fields of view by adding more radial lines between the two radial sightlines that extend from any exploration point to the tangent points of the generated circular shapes, which represent the areas of interest. By doing so, I was able to complete a more accurate exploration of the surrounding objects within the generated field of view and therefore, make a more informed design decision regarding the building form’s origination and orientation. In other words, the denser the field of view, the more accurate the design decision could be. However, this parameter allows for changing the density of the generated field of view at any time while conducting the 2D exploration throughout the design process. This could be carried out manually by changing the number of lines in the Dynamo script (Figure 5.16).

Figure 5.16. Change the density of generated fields of view using the "level of subdivision" parameter in Dynamo script
Conducting the 2D Exploration:

Typically, conducting the 2D exploration at the early stage of the design process was achieved in three main steps:

1. Locating the initial exploration point(s),
2. Generating the field(s) of view, and
3. Creating the initial building spaces and form.

Locate the initial exploration point:

The 2D exploration started by locating one exploration point at the approximate center of the building site inside the Revit software. Then, more exploration points were being added as the design process moves forward. Actually, my preference was to locate the initial exploration point at the center (Figure 5.17). However, designers could locate the initial exploration points at any location within the building site based on their preferences and other design constraints. Also, there is a possibility to start with more than one exploration point at a time. I used the mouse to move and locate the exploration point at the preferred location within the building site.
Generate the field of view and create the initial building from:

Once the exploration point(s) were set at the specific location(s), I opened the Dynamo script and set all parameters: 1) pick the exploration points; 2) link the Excel file, which includes the geographic coordinates of the areas of interest; and 3) set the number of lines for subdividing the fields of view. Once all parameters were been set, fields of view will be generated inside the Revit environment (Figure 5.18 and Figure 5.19). Next, I started sketching 2D lines to define the initial building layout influenced by the non-formal force of the generated fields of view (Figure 5.20).

While developing the design model and identifying its main spaces, I added more exploration points in several locations and at different elevations for further development and modification of the building form. In other words, the generated visual fields of view augmented
my major design decisions regarding the building form’s origination, its transformation, and its orientation. The outcome of the design process at this point was an initial building form explored and adjusted by the 2D exploration process. By the end of this phase, major design decisions were taken regarding the origination, transformation, and the orientation of its main masses.

Figure 5.18. Set the values of the Dynamic script parameters inside Revit
Figure 5.19. Generate 2D fields using the Dynamo script inside Revit
Figure 5.20. Use the generated 2D fields of view as guidelines for creating initial 2D layouts of the building
5.4.1.4. Limitations

For the on-site 3D exploration phase, the main challenge was that I had to visit the site several times to take photos and make observations. For the digital 2D and 3D exploration, the main constraint that I faced while conducting this step was the slight complexity of the process—due to the number of programs involved and the steps to be followed. In the future, it would be more effective if all view explorations and design decisions of the 3D model were carried out with a single software. Also, there were some minor limitations regarding the abstract representation of the areas of interest, which did not yield well-informed design decisions. However, I assume that these types of constraints will be resolved in future research, when more specialized experts and resources can be involved.
5.4.2. **STEP TWO**

5.4.2.1. **Introduction**

In a similar way to step one, this step, through a series of 3D and 2D exploration, evaluation, and adjustment, informs design decisions regarding the building boundary configuration in order to frame the best possible views to the outside environment. This step’s workflow is similar to the previous one, except it starts with the 2D digital exploration phase as a continuity to the 2D exploration phase in the previous step. Therefore, this step is different from the previous step, which started with the 2D exploration phase, not with the 3D exploration (see Figure 5.21). In this research, this step was conducted within the conceptual stage of the design process, which means that designers could go back to the previous step if there is a need. The building boundary configuration variables that this step helped make more relevant design decisions, including the openings’ dimensions, locations, patterns on the exterior walls, and their generic shapes.
5.4.2.2. Step Two, Phase One: 2D Exploration-Evaluation-Adjustment

This phase was conducted inside the Revit software in a similar way to the 2D
exploration-evaluation-adjustment phase in step one. However, more exploration points were distributed within the emergent spaces to be explored. The distribution pattern of the exploration points was guided by analyzing and mapping the expected spatial experience within the emergent spaces. Mapping the expected spatial experience was done by drawing colored splines that represented the multiple spatial experience scenarios within the created spaces (Figure 5.22).

The same Dynamo script was used to generate fields of view from the distributed points to the tangent points of the determined areas of interest (see Figure 5.23). The intersection areas between the generated fields of view and the external and internal walls informed my design decisions. This included, to a great extent, the building boundary configurations, namely, the positions of the openings on the exterior walls and configuration of the interior walls, and to lesser extent, the building massing and orientation. Accordingly, openings were created on segments of exterior walls where most of the sightlines from the generated fields of view intersect (as long as there are no other design constraints preventing this). As a result, exploring and framing the best view to the outside environment becomes more achievable. It worth mentioning that some design decisions regarding the building form and massing could be reconsidered during this phase (Figure 5.24).
Figure 5.22. Mapping the expected spatial experience by drawing colored splines that represent the multiple spatial experiences scenarios
Figure 5.23. Generate fields of view from the distributed points to the tangent points of the determined areas of interest

Figure 5.24. Make openings on segments of exterior walls where most of the sightlines from the generated fields of view intersect
5.4.2.3. **Step Two Phase Two: 3D Exploration-Evaluation-Adjustment**

This phase is necessary to explore and evaluate the quality of the framed visual connection within a more specific context. Several steps were made to conduct this phase.

1. The 3D Revit model was georeferenced inside the Revit software (see Figure 5.25).
2. The 3D Revit model was imported and located at its specific location within the context model inside the InfraWorks 360 (see Figure 5.26).
3. The viewport of Infraworks 360 located at the center of each assigned point and bookmarks were saved for each point to facilitate moving between the assigned points. I used the available navigation tool (the mouse and keyboard keys). This approach needs to be enhanced by developing a more accurate and interactive tool inside the Infraworks 360 that allows for setting the viewport at the center of each assigned point more accurately.
4. The quality of the framed view from each point was evaluated by me as a designer inside Infraworks 360 (see Figure 5.27)
5. 3D and 2D adjustments, mainly regarding the building boundary configuration, were made on the digital 3D model of the design inside Revit before the model was reimported into Infraworks 360.
6. The last two steps were repeated until obtaining satisfying outcomes to start the third step (see Figure 5.28).
Figure 5.25. Georeferencing the 3D model inside the Revit software
Figure 5.26. Import and locate the 3D model at its specific location within the context model inside the InfraWorks 360

Figure 5.27. The first round of evaluation of the visual connection inside Infraworks 360
Figure 5.28. Make adjustment inside Revit and another round of evaluation of the framed view inside Infraworks 360
5.4.3. **STEP THREE**

5.4.3.1. **Introduction:**

Similar to the previous step, step three starts with 2D exploration and then 3D exploration. It should be noted that this step could be conducted either as a complementary or alternative to the previous step depending on the design constraints to be taken into consideration. This is because some design projects, or parts of them, face constraints that prevent conducting the previous step (see Figure 5.29). For example, exploring and framing the best views may not be a priority for the design. Sometimes, there are site-related constraints, such as the shape or area of the allocated site. Also, there are program-related constraints that should be considered, such as the necessary spatial relationships among the designed spaces. Moreover, there are performance-related constraints, such as having space without direct visual connection or with a high level of privacy.
5.4.3.2. Step Three, Phase One: 2D Exploration

In fact, this step yielded design decisions that were very similar to the ones from the
previous steps, although through a slightly different approach to conducting the exploration-evaluation-adjustment loop. Another Dynamo script was developed to highlight the segments of the exterior walls through which most of the sightlines to the outside pass. To do so, this Dynamo script generates fields of view in various radial ranges—designer can determine a specific range—from the assigned exploration points (see Figure 5.30). This includes all the radial lines that represent the fields of view extending all the way to intersect with the exterior walls unless they are stopped by a solid interior wall.

It is worth mentioning that there are factors that may be considered to make openings on parts of the exterior walls that intersect with the generated fields of view. First, one should consider the functionality of the space, as some spaces function better without openings or at least with specific numbers or locations of the openings. Second, one must consider the density of the intersection. By this, I mean that the parts of the exterior walls that intersect with multiple fields of view that extend from multiple exploration points may be further considered for making openings—unless other factors prevent this. In other words, the framed views through these openings will be seen from multiple locations inside the building. Also, the intersections with the interior walls should inform design decisions regarding the configuration of the interior walls. This step will help in exploring and framing visual connections to the outside without the need to make major design decisions.
Figure 5.30. Using the second Dynamo script to generate different range of fields of view
5.4.3.3. **Step Three, Phase Two: 3D Exploration-Evaluation-Adjustment**

This phase was carried out in a very similar way to the 3D exploration in the previous step. This phase is necessary to explore and evaluate the quality of the framed visual connection in a more specific context. Several steps were made to conduct this phase.

1. The 3D Revit model was imported and located at its specific location within the context model inside InfraWorks 360.

2. The viewport of Infraworks 360 located at the center of each assigned point and bookmarks were saved for each point to facilitate moving between the points. I used the available navigation tool (the mouse and keyboard keys). This approach needs to be enhanced by developing a more accurate and interactive tool inside Infraworks 360 that allows for setting the viewport at the center of each assigned point more accurately.

3. The quality of the framed view from each point was evaluated by me as a designer inside Infraworks 360.

4. 3D and 2D adjustments, mainly regarding the building boundary configuration, were made on the digital model of the design inside Revit before the model was reimported into Infraworks 360.

5. The last two steps were repeated until getting satisfactory outcomes to start the fourth step.
5.4.4. STEP FOUR:

5.4.4.1. Introduction

This step was conducted as an extension of the previous steps to further enhance the quality of the framed visual connection by informing a more elaborate design of the exterior walls and interior design elements. This includes making more detailed adjustments regarding the design components and elements of the external and internal walls (see Figure 5.32). As in the previous step, the exploration-evaluation-adjustment process was conducted inside both the Revit and Infraworks 360 software (). More specifically, the 3D exploration and evaluation were conducted inside Infraworks 360, and 3D adjustment was conducted inside Revit. Several rounds of exploration-evaluation-adjustment were carried out. However, this step relied mainly on conducting 3D exploration. The 2D exploration process does not help much in exploring the specific quality of the framed views through the elaborate design of the exterior and interior walls. Also, 2D exploration is not effective for evaluating framed views between two different levels (a severe limitation).
Figure 5.31. The steps of conducting the 2D and 3D visual exploration

5.4.4.2. 3D Exploration-Evaluation-Adjustment

This phase was carried out in a very similar way to the 3D exploration in the previous step.
1. Each framed view from each exploration point was reevaluated inside Infraworks 360.

2. Any design decision regarding fine details of the configuration of the internal and external walls was made inside the Revit.

3. The new version of the 3D model was reimported into Infraworks 360 for further evaluation of the quality of the framed visual connection.

4. These steps could be repeated multiple times until the designer or the design team are satisfied with the outcomes.

Figure 5.32. Example of making a more detailed adjustment on the exterior wall openings design
5.4.5. Limitations

For the on-site 3D exploration phase, the main challenge was that I had to visit the site several times to take photos and make observations. For the digital 2D and 3D exploration, the main constraint that I faced conducting this step was the slight complexity of the process due to the many numbers of programs involved and the steps to be followed. For example, this process could not yet be achieved inside one single software, and required using both Revit and Infraworks 360. Unfortunately, Infraworks 360 does not allow making modifications to the 3D model. As a result, any adjustment of the design was made inside the Revit software before the adjusted model was reimported back into its original location inside Infraworks 360 for further explorative and evaluative actions. This makes the whole step more complex and time-consuming. Also, regarding the 2D exploration, there were some minor limitations regarding the abstract representation of the areas of interest that did not yield well-informed design decisions. Also, the 2D exploration was not effective for evaluating framed views between two different levels. However, I assume that these types of constraints will be resolved in future research, when more specialized experts and resources can be involved.

5.5. Conclusion:

By the end of the immersive case study phase, more developed framework was achieved. The details of conducting the exploration steps identified throughout the logical argumentation phase became more clear. A specific strategy was developed to conduct each step (see Figure 5.33).
Figure 5.33. The generic steps and the conducting strategies of the proposed framework that were developed by the end of the immersive case study
6. Chapter Six: Delphi Method Survey

6.1. Introduction

The primary reason for conducting the Delphi method is to develop and measure consensus among a panel of experts in the field of architectural education and practice about the importance of the proposed process and its ability to achieve the objective of establishing a well-designed visual connection through an aperture to the outdoors. However, there is a secondary reason for conducting the Delphi survey as a platform for improving ideas and suggestions for this research or future relevant research. To conduct the Delphi method more effectively, it consisted of three rounds, one qualitative (open-ended) round and two quantitative (closed-ended) rounds (Figure 6.1).

The underlying rationale for choosing this method over any other method is due to its ability to aggregate experts’ opinions and feedback within the limited timeframe of conducting this research—especially in regard to the paradigmatic proposed modification of the design process. This method also provides an interaction and communication platform among many experts in the field, which could not be done or would be very difficult to do through other methods. The panel of experts was purposively selected to consist of members with knowledge and experience in the fields of architectural design practice and teaching, which enabled them to give informative feedback and make qualified judgments. To get the most out of using the Delphi method, it was conducted in a way that maintained its key elements. First, the anonymity of the participants remained anonymous and their identity was kept hidden while conducting the technique and even after the completion of the final report. This allowed for the free expression of opinions and encouraged open criticism. Second, controlled feedback was done by sharing
with all experts the qualitative or quantitative analyses of their responses after each round. Third, iteration was used, since it is considered important for achieving the key objective of developing consensus among the participating experts.

Figure 6.1. Overview of the workflow for conducting the Delphi method
6.2. Planning the Delphi Method (Structure of the Delphi Method)

The general structure for conducting the Delphi method is abundantly available in the literature; yet, there is no agreement for the process. However, most conducted studies using this method emphasize the important factor of reducing the potential for biased responses (Hallowell & Gambatese, 2009; Veltri, 1985). For this research, specific guidelines were carefully considered for a rigorous implementation of the Delphi method with more reliable results. These guidelines include the expertise requirements, number of rounds, number of panel members, the feedback process, and measuring consensus.

6.2.1. Expertise Requirements

This step of implementing a Delphi survey is considered one of the most controversial ones because there are no agreed criteria for defining a participant as an expert. Accordingly, recruiting an unbiased representative sample is a primary concern and was addressed by adopting a strategic and unbiased recruiting process. To this end, specific selection guidelines were developed, inspired by the guidelines developed for Delphi studies by Rogers and Lopez (2002) and Veltri (1985). These guidelines were developed as a point-based system that tries to achieve an adequate balance between academic and practical experience in the field of architectural design for the participating experts. The criteria that need to be met under the field of examination were measured in terms of the achievements and experiences in this field. Table 6.1 shows the developed point system used in this study with the main evaluation criteria and allocated points for each criterion. According to this point-based evaluation system, for the potential participant to be considered qualified to participate in this study, they should meet at least five different criteria (experiences or achievements) with a minimum total score of 11.
It should be emphasized that the points allocated for each criterion is determined in a way that helps recruit participants who possess academic experiences and professional experiences.

Table 6.1. The developed point-based member recruiting system

<table>
<thead>
<tr>
<th>Achievement or experience</th>
<th>Points (each)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years minimum professional experience in architectural design</td>
<td>3</td>
</tr>
<tr>
<td>Professional registration (member in AIA, CIDA, NAAB, RIBA or equivalent architectural/interior design professional organizations)</td>
<td>2</td>
</tr>
<tr>
<td>Member of a committee</td>
<td>1</td>
</tr>
<tr>
<td>Chair of a committee</td>
<td>2</td>
</tr>
<tr>
<td>Faculty member at an accredited architecture school</td>
<td>3</td>
</tr>
<tr>
<td>Primary or secondary author of at least two peer-reviewed journal articles</td>
<td>2</td>
</tr>
<tr>
<td>Writer or editor of a book in an architectural design-related field</td>
<td>3</td>
</tr>
<tr>
<td>Writer of a book chapter in an architectural design-related field</td>
<td>2</td>
</tr>
</tbody>
</table>
| Graduate Degree in architecture or interior architecture:  
  Master’s | 2 |
| Ph.D. | 3 |
| **Total** | **23** |

6.2.2. Number of Panel Members

According to relevant literature, there is no perfect number of participating members in any Delphi study and there is no correlation between the number of panel members and the accuracy and effectiveness of the method (Brockhoff (1975); Boje and Murighan (1982). However, the literature suggests that there are many factors that could impact the number of panel members needed for a given case study, which ranges as wide as a minimum of three members up to 80 members. However, a number between 8 and 16 is suggested and recommended in most Delphi studies. In fact, the factors that impacted the number of panel
members in this study are related to the characteristics of the study itself, such as the number of available experts who met the participating qualifying criteria, the desired geographic representation, the capacity of the facilitator, and the timeframe allocated for implementing this study. Moreover, there is another factor that should be considered as it could affect any study, which is the potential withdrawing from the study of any participating member at any time and for any reason, such as disinterest or other commitments. In light of this, I assumed that any number between 8 and 15 panel members would be sufficient for conducting the Delphi survey for this study.

6.2.3. Number of Rounds and Feedback Process:

The number of rounds needed is mainly determined by the ability to achieve the primary objective of reaching the consensus among the responses of the participating experts within the allocated time frame. Therefore, the predetermined maximum number of rounds is three, with a possibility of two rounds only if consensus is achieved after the second round. Moreover, most relevant literature mentions that the best number of rounds to achieve consensus is three, since the change in positions after the third round is minimal or less accurate (Turoff, 1970). In this case, before conducting the first round, a thirty-minute video was prepared to send to all participants. The purpose of this video was to give each participant an opportunity to have a comprehensive understanding of the research problem and the ability of the proposed solution to meet the objectives. The video shared my personal experience of conducting the immersive case study and using the proposed approach to design a building on the campus of Virginia Tech in Blacksburg, Virginia.
6.2.4. Recruiting Experts

The aim of this step is to recruit qualified participants (i.e., the experts) to participate in a three-round Delphi survey. To better accomplish this step, I conducted an extensive search on websites for a number of architecture and design schools and architectural design firms to find qualified participants according to the preset qualification criteria mentioned earlier. I reviewed their education levels, professional and academic experiences, and research interests either on their employers’ websites or on their personal online professional accounts such as LinkedIn and personal websites. The final list contained around 80 potential names, who were all contacted by email. An invitation email to participate in the study was sent to each person from the list. In total, 18 of the 80 contacted individuals responded back that they were interested in participating. In response, the details of conducting the three-round survey were emailed to the 18 participants. Following this, 3 of the 18 participants withdrew right before starting the actual implementation. Fortunately, most of the remaining participants had both professional and academic experiences, which was really needed to better conduct this research. Of the 18, three participants were faculty members, Ph.D. holders, and are founding members for architectural design firms (see Figure 6.2).
6.2.5. The Immersive Case Study Video

Before starting the first round and inviting participants to answer the open-ended questions, I asked all participants to watch the video I made that explained how I conducted the immersive case study. In the video, I also presented the theoretical rationale for conducting this research and the proposed framework for resolving the identified problem. Moreover, the video presented my personal experience of using the proposed process to overcome the identified problems in the design process from the logical argumentation. Finally, in the video, I identified some of the main limitations and potentials of the proposed process. It is worth mentioning that the idea of the video is based on a logical dialogue between two characters, myself and a fictional character, who represents the critical curious side of myself. Most of the dialogue consisted of questions and answers regarding the proposed framework and process along with video clips about the actual steps of using the proposed design process to design an actual building on the campus of Virginia Tech. After sending the video to all participants, I waited for...
one week before starting the qualitative round to ensure that all participants had a chance to see the video.

6.3. **Conducting the Delphi Survey**

6.3.1. **Round Number One:**

To conduct this round in an effective way, I used my blog to share with all participants the four open-ended qualitative questions. By doing so, each participant could post their answers anonymously and see and reply to any other participant’s answers; therefore, the factor of interaction and iterative feedback among participants could be achieved (see Figure 6.3). Accordingly, each expert could have an early opportunity to review, defend, or change their opinion. All responses and answers were used to develop a close-ended questionnaire for the second round.

After one week of sending the video, I posted the open-ended questions on my blog and invited all 15 participants to post their answers and comments (see). Also, the video of the immersive case study was posted on the blog to allow participants to see the video one more time as they answer the questions. I encouraged participants to interact with and reply to other participants’ posts if possible. All participants participated and posted their answers and comments under pseudonyms of their choice. In fact, keeping the identity of participants anonymous helped to promote an increased level of interaction among all participants. The allocated time for this round was three weeks. Friendly reminder emails were sent to all participants every five days to remind them to participate and notified them of new posted comments and replies. Only nine participants out of the 15 participants responded to the questions in round one. The other six participants were removed from the study.
Table 6.2. The four open-ended questions of the first round

<table>
<thead>
<tr>
<th><strong>Q. 1:</strong> Do you think that there is an essential flaw in the traditional design process (not the proposed one) that prevents or limits the ability of designers from an effective involvement of the theories related to the indoor-outdoor visual relationship within the built environments?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q. 2:</strong> Given the goal of promoting healthy built environments through the design of interior spaces that have a strong visual connection to the outdoors by way of a desirable view, do you agree that the proposed process of merging geospatial data into design contributes to meeting this goal? Follow with why or why not.</td>
</tr>
<tr>
<td><strong>Q. 3:</strong> Given the goal of promoting healthy built environments through the design of interior spaces that have a strong visual connection to the outdoors by way of a desirable view, do you agree that you would apply the proposed process to your practice? Follow with why or why not.</td>
</tr>
<tr>
<td><strong>Q. 4:</strong> What suggestions would you have for improving the process?</td>
</tr>
</tbody>
</table>
Figure 6.3. The blog used by participants to post their answers and comments
6.3.1.1. Qualitative Analysis and Result

Approximately 60% (9 out of 15) of the recruited participants responded to the questions in round one. In general, their answers centered around similar points and concerns. A qualitative analysis of all answers was conducted in which specific and distinctive themes were extracted. The method of the whole text analysis that was used is based on a methodology presented in (Corbin & Strauss, 2014). For the sake of simplifying the process, in the beginning, the qualitative analysis was conducted on all participants’ answers to each question individually, then all texts put together, and finally another round of qualitative analysis until extracting themes was complete. In detail, the responses to a question were carefully read several times and a coding technique was used. Then, the text was analyzed line by line to identify segments of text. Each segment of text is referred to as an excerpt, and an excerpt can consist of one or more sentences. The unit of analysis that was used for this study is a sentence. Each excerpt was then coded. A code is a label that captures both the implicit and explicit meaning of the excerpt. A color-based highlighting tool was used to simplify the process (see Figure 6.4). The resulting codes were compared and arranged into categories based on the meaning recorded in the code. The purpose of categories is to conceptualize the meaning captured by a group of codes (Hein, 2017). During the process of refining the categories, each category is internally homogenous and does not overlap with other categories. Then, all the identified themes from all responses were used to form and develop the questions for the second round. More than twenty themes were identified. Most of them were explicitly or implicitly referred to by most participants. The full text of all participants’ answers is available in Appendix A.
6.3.1.2. Categories and Themes

At the end of the qualitative analysis and coding process, 22 themes were identified and four main categories were developed from all the identified themes and ideas (see Table 6.3).

These categories are:

1. Limitations of the traditional design process,
2. Concerns with the proposed design process,
3. Potential advantages of the proposed process, and
4. Developmental suggestions for the proposed process.
Table 6.3. The identified themes and the emergent categories from the coding process of the answers to the first-round questions

<table>
<thead>
<tr>
<th>Categories Name and Number</th>
<th>Themes</th>
</tr>
</thead>
</table>
| **1. Limitations of the traditional design process** | 1. *Time and budget*  
2. *The gap between the design decisions of architects and interior designers*  
3. *The outside-in approach dominancy over the design process*  
4. *Spatial gap or separation between the actual design context and actual building context*  
5. *It emphasizes the importance of the indoor-outdoor relationship but does not provide actual execution solution*  
6. *The physical visit to the building site is not adequate to achieve a thorough realization of all contextual elements for the exploring best visual connections to the outside.* |
| **2. Potential concerns of the proposed design process** | 7. *The availability of geospatial data for all areas*  
8. *The potential need for extra time and cost to use this process*  
9. *Complicated process*  
10. *It is not reliable without the actual site visit*  
11. *Achieve a well-designed visual connection to outside (best views) is not always a design priority.* |
| **3. Potential advantages of the proposed process** | 12. *Promoting Social Sustainability*  
13. *Informing the relevant design decisions at the early stages of the design process*  
14. *New potential professions such as geo-designer or geo-architect*  
15. *Enhance the level of coordination among the design team members and level of communication with clients* |
| **4. Developmental suggestions for the proposed process** | 16. *Teaching tool in design studio would be a good way to facilitate accelerated interface development*  
17. *Develop inside a common architectural design software like the Revit software without extra time and cost*  
18. *Develop a set of guidelines and a step-by-step tutorial for where when and how to use the proposed process.*  
19. *Expand the target use of the proposed process to include indoor-indoor visual relationship*  
20. *Emphasize start exploring the view with an inside-out 2D exploration without any external skin*  
21. *Consider any potential change on the framed visual connection due to any future transformation in the surrounding context and urban expansion*  
22. *More factors to be involved in specifying the best views (shadow, light, night and day, changing of the seasons)* |
6.3.1.3. Findings and Interpretation

This section presents and discusses in detail round one’s findings and interpretations of the four main identified categories and the themes under each category.

Category One: Limitations of the traditional design process

This category represents the identified themes regarding the problems and limitations of the traditional design process that prevent or do not effectively allow designers to achieve the best visual indoor-outdoor relationships. Six themes were identified from the participants’ answers:

1. Limited time, budget, and resources
2. The gap between the design decisions of architects and interior designers
3. The dominancy of an outside-in design approach over the design process
4. Modest involvement of the surrounding context in informing relevant design decisions
5. It emphasizes the importance of the indoor-outdoor relationship but does not provide actual execution solution
6. The physical visit to the building site is not adequate to achieve a thorough realization of all contextual elements for the exploring best visual connections to the outside.

One of the most emphasized themes by most participants is “time, budget, and resources.” Most participants referred to this as a central problem that greatly limits the possibility of exploring, evaluating, and framing the best possible/desired visual connection to the outside environment. For example, participant “Amer” said:

After the approval of the conceptual phase from the client, the design office requested
from the architect to submit detailed and working (construction) drawings to other engineers very quickly in order to finish the project, and then start another new one. Therefore, there is no time to conduct a detailed study for the relationship between indoor and outdoor, unless the contract includes interior design works……. The best scenario for the designer is to sign a contract with the owner to do exterior and interior designs together. Yet, this scenario is not common, as the main issue for the client is cost and budget.

Another statement regarding this theme “time, budget, and resources” was mentioned by the participant “Monet,” who used the story of designing and building the Trump Tower in Chicago as an example:

For example, Donald Trump junior brought a skyscraper crane before he started working on Trump Tower Chicago. He personally checked the view out of every single hotel room and together with the design team (SOM), made the necessary changes to orientation of tower to maximize views. In this case, the resources were available and were supported by the developer. These resources are not usually available which makes your proposal stronger. (emphasis added)

The second theme was emphasized by participants is “the gap between the design decisions of architects and interior designers.” Three participants referred to this as a major obstacle to exploring and framing the best possible/desired visual connection to the outside environment. For example, the participant “Amer” refers to the limited role of the interior designer in exploring and framing the best possible views in the context of the conventional design process:
Even though, if the designer works on the interior, he/she focuses on materials and furniture items only, as the architectural drawings (including elevations and location of windows) are fixed. Another reason for not including such an important relationship is that the interior design starts usually after finishing the skeleton of the building on-site.

So, the interior designer cannot change any window to increase the visual connection.

The participants “CMT” and “Yaman” also emphasized this problem. For example, “Yaman” mentioned: “However, [the design process] usually used to emphasize the architectural part of the design more than the interior space of the building. This emphasis creates a disconnect between the interior and exterior design.” Similarly, “CMT” mentioned: “I think the exterior and the interior spatial designs are rarely designed in parallel. Taking a window for example, an architect asks how does that look from the outside and an interior designer asks how can space plan, whether it be furniture or walls, to acquire the best view.”

The third theme in this category is “the dominance of an outside-in design approach over the design process.” As in the previous themes, this theme was implicitly or explicitly referred to by most of the participants. Overall, they believe that the design process could be more effective in exploring and framing the best view if there was an inside-out designing approach that worked integrally with the outside-in design approach. For example, the participant “Amer” said:

Although architects work also on the three-dimensional form, the link between indoor and the outdoor context is minimal. The focus is mainly on outside aesthetics, materials, and sometimes creating terraces and balconies to do such a connection. When he/she [designer(s)] puts windows on the plan, the focus is to keep the outside look, with limited consideration to the strong relationship between indoor and outdoor.
The fourth theme in this category is the “spatial gap or separation between the actual design context and actual building context.” Some participants believed that the surrounding context should play a bigger role in informing the design decisions in terms of exploring and framing the best possible visual connection to the surrounding environment. For example, the participant “Amer” mentioned that “the actual design process in most offices includes the work on the building as an isolated piece, then the designer adds the context after finishing the exterior image.”

Participant “Monet” assured this issue when they mentioned the Trump Tower design story. Because of the spatial separation or isolation between the context of the design process and the actual building context, the design team had to make a visual exploration to inform the process using a construction crane.

The fifth theme is that “design process emphasizes the importance of the indoor-outdoor relationship but does not provide actual execution solution.” This theme was referred to by two participants. They believed that the traditional design process considers achieving a well-designed visual connection but, for several reasons, it is not effectively achievable. For example, participant “Monet” said: “What I am trying to say is that the structure and process exist but rarely anyone uses them these days.”

The sixth theme in this category is “the physical visit to the building site is not adequate to achieve a thorough realization of all contextual elements for the exploring best visual connections to the outside.” In this regard, the participant “Sean” referred to timing of the site visit, which typically occurs at very early stage of the design process. Accordingly, later design decisions that need more information from the site may not be informed based on just the
information obtained from the first site visit. They mentioned that “the site visit is done at the early stages, and the designer might miss, forget, or be overwhelmed by other design forcing factors. The proposed tool will help designers understand the building site in a deeper manner and provide better information and insight to the whole team.”

Also, participant “Monet” indicated to this issue but in the context of the remoteness between project context and design context, the limited time, and limited resources, saying: “Many factors disrupt the flow such as dedicating enough time for the project, enough resources for the team to travel to the site (these days we outsource projects to non-local firms or to international firms).”

Category Two: Potential concerns of the proposed design process

This category represents the emergent themes regarding the identified concerns of using the proposed design process. In fact, four main themes were identified that represent most participants’ concerns that were explicitly and implicitly expressed about the proposed process:

1. The availability of geospatial data for all areas
2. The potential need for extra time and cost to use this process
3. The proposed process not reliable without the actual site visit
4. Achieving a well-designed visual connection (best views) is not the only design priority.

For the first theme “the availability of geospatial data,” several participants shed light on a potential problem regarding the dependency of the proposed process on the availability of geospatial 3D context models for any potential building site. Many participants explicitly and
implicitly referred to this concern. For example, the participant “Monet” mentioned: “But is geospatial data available for all communities? There is a price tag with constructing point cloud data using LiDAR unless it is integrated with the actual project.” The participant “Ann” referred to this problem as well by mentioning: “Yes. It is especially useful for design in places with geospatial data available. For places that data is limited or nonexistent, such as in rural communities, what would be the work-around for these projects/built environments?”

In fact, I agree that this is a legitimate concern, which is why I touched on this issue earlier in the logical argumentation section in this dissertation. In brief, I mentioned that there is a very promising future for developing the 3D context models soon, and that many 3D city models already been developed across the world. This is at least a partial solution to the concerns expressed by participants.

The second theme in this category is “the potential need for extra time and cost to use this process.” In fact, many participants expressed their concerns regarding the need for extra time and/or additional cost in order to use the proposed process. For example, the participant “Nathaniel” explicitly mentioned that “if it is easily integrated into the existing process without extensive training. It may be valuable to demonstrate to a client but it may be hard to implement as a fee-for-service if the learning curve/ training/ time/money is too steep and hard to justify.” In this context, participant “John” also referred to this issue when they mentioned: “Overall the idea of utilizing and improving technology to aid designers is a great idea….. It would require simplification and integration with other tools and approaches that we already use. A client won’t pay more for just adding another process or tool on so it has to be considered holistically.”

However, there are other participants who believe that learning new skills to use the
The proposed process through a more developed and sophisticated tool is not a big deal and has never been a serious problem before. For example, the participant “Monet” mentioned in their answers: “Learning the software is not a problem in my view – we all shifted our practice and adopted technologies and many different ways. This process does not sound too complicated in my view – if LiDAR data is available and REVIT becomes compatible with it, then your goals might be met.”

The third theme in this category is “the proposed process not reliable without the actual site visit.” However, the proposed process does not suggest skipping the actual site visit. This concern was emphasized by only one participant, “John.” I believe this participant wanted to shed light on the importance of the site visit phase to the design process, mentioning: “Architects need to walk a site, feel the breeze, see the sun. my view always changes when I visit the site even though I had fantastic site data available in the office. I may even have had a 3d virtual or physical model. What happens when the leaves fall from trees or the sun glistens on the early morning frost?”

The last theme in this category is “achieving a well-designed visual connection (best views is not the only design priority.” This theme emphasized by participant “John,” who mentioned: “It must be considered though that increasing access to great views is not the only consideration designers face. It is the complexity and the nuances of the decisions that have to be made between often competing information sets that separates the modest designer from the exceptional.”

**Category Three: Potential advantages of the proposed process**

This category represents the emergent themes regarding the potential benefits or
enhancements of the proposed process to the existing design process:

1. **Promoting Social Sustainability**

2. **Informing the relevant design decisions at the early stages of the design process**

3. **Enhance the level of coordination among the design team members and level of communication with clients**

4. **New potential professions such as geo-designer or geo-architect.**

The first theme in this category is “promoting social sustainability.” This is a significant potential benefit of the proposed process that has been referred to by more than one participant. They believed that exploring and framing the best possible visual connection to the outside while considering other design requirements is one major indicator of enhancing social sustainability. The participant “Amer” explicitly mentioned: “As my PhD study was to enhance social sustainability in high-rise residential buildings, and view to the exterior is one of the major indicators, parallel with maintaining the privacy of the family, I would strongly satisfy to use the proposed tool.”

The second theme in this category is “informing the relevant design decision at the early stages of the design process.” I think that participants believe that this process, through a more developed tool, could inform design decisions by providing a more in-depth realization of the surrounding contextual forces. Participant “Ann” directly referred to this theme when they said: “If there were a way to ‘preview’ the experience of outdoor spaces with accurate geospatial data could help designers avoid developmental blunders and refine designs before they move forward toward being realized.”

The third theme is the suggestion participants made to “enhance the level of coordination
among the design team members and level of communication with clients.” Participants expressed the importance of having a high level of coordination among the members of the design team in order to achieve well-designed visual connections to the outside environment. Participant “Yaman” mentioned: “I think that will help designers understand the building site in a deeper manner which will most likely provide better and much more data to all members of the design team.” Also, participant “Ann” emphasized this point when she mentioned:

It could be helpful for designers across a range of disciplines—interior designers, landscape architects, and architects—so they can have a greater appreciation for how their work relates to others on the team. It would also go a long way to helping avoid blunders and missteps between practitioners on a team for everyone to “see” the vision during the early planning stages.

Finally, participant “CMT” mentioned: “Not only are you now creating jobs, but it’s also would act as a medium between architect and interior designer.”

In this context participants, “Nathaniel” and “CMT” referred to the potential enhancement of communication level with clients, which they mentioned, respectively:

**Nathaniel:** It may be valuable to demonstrate to a client but it may be hard to implement as a fee-for-service if the learning curve/ training/ time/money is too steep and hard to justify.

**CMT:** The biggest reason for me would be for client satisfaction. Clients respond very well to 3-Dimensional design. If you have a client with no architectural design background, they can get lost in construction documents…Sometimes, we even use VR
where the client can walk through the space and look out the window. In screen shots of renderings we photoshop a background into to the window, and in the case of VR we select “city” or “mountains cape” from our pull down list of options in what ever 3D program we are using. Having the ability to show clients the actual view is a huge benefit.

The last theme I would like to discus in this category is the “emergence of new design-related professions such as geo-designer or geo-architect.” One participant, “CMT,” indicated that this proposed process could pave the road for the emergence of new design-related professions such as geo-designer or geo-architect. They argued that designers could be specialized in different design tasks such as 3D modelers or renderers. Therefore, it might be a good idea to have designers on the design team specialize in geospatial design. In this context, participant “CMT” mentioned: “There are architects that become 3D Renderers and Interior Designers and become sales reps, so why not become a geospatial design engineer?! Not only are you now creating jobs, but its also would act as a medium between architect and interior designer.”

**Category Four: Developmental suggestions for the proposed process**

This category represents the emergent themes regarding participants’ suggestions and visions for developing the proposed process for a more effective design ability and therefore, for a wider adoption level. Several themes were determined under this category:

1. *Using as a teaching tool in design studio*

2. *Develop into a digital design tool inside a common architectural design software like the*
Revit software without extra time and cost

3. **Develop a set of guidelines or a step-by-step tutorial for where, when and how to use the proposed process**

4. **Expand the target use of the proposed process to include indoor-indoor visual relationship**

5. **Consider the dynamic and changing phenomena, natural or man-made ones, that influence exploring and framing the visual connection.**

The first emergent theme is “using as a teaching tool in a design studio.” This theme was suggested by participant “Nathaniel,” who mentioned: “Using it as a teaching tool with a group of well-directed students would be a good way to facilitate accelerated interface development. (as was done with Revit, etc.)”

The second theme is the idea to “develop into a digital design tool inside a common architectural design software.” This theme was suggested by many participants. They argued that this will make using the process more effective. For example, the participant “Nathaniel” mentioned in their response: “The interface wants to be as direct and accessible as Wikipedia or MSword. A mature design should be able to drop a 3D model into a location within a ubiquitous data source like google maps and see/test probable views without being dragged through a distracting process… if too onerous most designers would revert to old means.”

The third theme in this category is the idea to “develop a set of guidelines or a step-by-step tutorial for where, when, and how to use the proposed process.” This theme represents suggestions by many participants. For example, the participant “Ann” mentioned: “A tutorial or set of self-guided lessons so that users could move through a workshop to help themselves
develop the requisite software skills and understand the workflow would be helpful.”

The fourth theme is to “expand the target use of the proposed process to include indoor-indoor visual relationship.” In this context, participant “HRA” believed that this would be useful, especially in case of designing large scale buildings such as airports, since they mentioned: “I believe this process would be very helpful for large projects where a visual connection between interior spaces is required to achieve design goals.”

The fifth and final theme in this category is to “consider the dynamic and changing phenomena, natural or man-made ones, that influence exploring and framing the visual connection.” More specifically, many participants wanted to expand the exploration and evaluation ability of the proposed process to consider any potential change of the framed visual connection due to any future transformation in the surrounding context (e.g., urban expansion) as well as to consider more dynamic aspects of the surrounding environment (e.g., shadow/light, night/day, and seasonal changes). For example, participant “CTM” mentioned:

However, the knowledge base for this process goes beyond technology and spatial understanding, but also involves having a comprehension of shadow and light, night and day, geographical awareness for the changing of the seasons, etc. These are all important factors when considering what is the best view. You could even go as far as to add sun studies and geographical implications to the process.

In this regard, it is worth mentioning that participant Yaman also mentioned: “Also, what about the future of their connections between the interior and the exterior. That are the possibilities of the selected views to be blocked or changed in the future due to the urban expansion?” Finally, participant “John” touched on this point when they mentioned: “Architects need to walk a site,
feel the breeze, see the sun. my view is always changes when I visit the site even though I had fantastic site data available in the office.”

6.3.1.4. **Conclusion**

The qualitative analysis of the participants’ answers revealed many of the potential for and limitations of the proposed process. In fact, most of the identified potentials and limitations are very similar to those that were identified in the phases of the logical argumentation and immersive case study. Also, I would like to say that the level of similarity among many participants’ answers indicates that participants developed a common understanding of the proposed process and the recorded video that they watched about how the immersive case study achieved its main objective.

6.3.2. **Round Number Two**

The identified themes in the qualitative analysis were used to develop questions for a 10-point Likert scale survey for the second and third rounds. The second round and the potential subsequent third round aim to reach consensus among all participants’ responses regarding the asked questions. These questions would include two generic types of closed-ended questions: 1) evaluation of developments and 2) personal details of the participants. Generally, most of the questions are from the category of evaluation of developments and measuring opinion. They were designed on a 10-point Likert scale to evaluate various dimensions of desirability, feasibility, importance, and validity of the proposed process. Many research studies recommend using a larger scale like this, such as a 10-point scale or an 11-point scale instead of a 3-point or 5-point scale (Gracht, 2008). They posit that the larger scale has interval properties that allow for more valid statistical analysis and could better explain the variance among the experts’
responses, especially for the studies measure opinions and the respondents have a high level of education. The remaining questions were about personal details about the participants such as sex, age, professional experience, position in the company, job description, academic degree, etc. The answers to this type of questions helped to obtain more detailed analyses.

After the responses to all questions from all experts were received, the consensus assessment initiated. To measure consensus for the Likert scale questions, the descriptive statistics, an interquartile range (IQR) was used. The interquartile range is the measure of dispersion from the median (Sekaran, 2003). Since I was using a 10-point Likert scale, I predetermined that the questions with a calculated IQR value less than or equal to two, recommended from many studies, would be considered to have reached consensus. Any question with a calculated IQR value less than or equal to two was dropped from any subsequent round. Conversely, any question (item) that received an IQR value of more than two was included in any subsequent round (Gracht, 2008). Three weeks were dedicated to conducting this round. Friendly reminders were sent to participants to urge them to participate and submit the survey.

6.3.2.1. Round Number Two: Consensus Assessment

During this round, all participants were asked to respond to a 10-point Likert scale questionnaire. There were five questions at the beginning regarding the consent form and the personal information of participants, which were not included in measuring for consensus (see Appendix one.) Once all participants responded, the IQR was calculated for all 23 questions. According to the IQR values, 13 out of 23 questions reached consensus after the second round. The 10 questions that did not reach consensus were sent back to the respondents in the third and final round. Table 6.4 and Table 6.5 below show the questions that did not reach consensus
(highlighted) in yellow. As shown in the tables, these questions have an IQR value of more than two.

Table 6.4. The IQR values for all questions in round two

<table>
<thead>
<tr>
<th>Expert # Question #</th>
<th>1 Monet</th>
<th>2 Amr</th>
<th>3 Ann</th>
<th>4 Yman</th>
<th>5 John</th>
<th>6 CMT</th>
<th>7 Nath</th>
<th>8 HRA</th>
<th>9 Sean</th>
<th>IQR</th>
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<tr>
<td>Question Number</td>
<td>IQR</td>
<td>Avg</td>
<td>Included in the 3\textsuperscript{rd} round</td>
<td>Questions with their maximum and minimum responses</td>
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<tr>
<td>6</td>
<td>2.5</td>
<td>6.7</td>
<td>Yes</td>
<td>In context of the conventional design process, to what extent do you agree/disagree that there is an essential drawback in the design process that might limits designers from exploring and framing the best possible visual connection to the outside connection?</td>
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<tr>
<td>8</td>
<td>2.5</td>
<td>6.6</td>
<td>Yes</td>
<td>In the context of the conventional design process, to what extent do you agree/disagree designers could make informed design decisions that emphasize the best visual connection to the outside environment?</td>
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<td>11</td>
<td>6</td>
<td>4.9</td>
<td>Yes</td>
<td>In the context of the conventional design process, to what extent do you agree/disagree that the real surrounding context is not effectively involved in informing the designer's decisions regarding achieving the best visual connection to the outside?</td>
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<tr>
<td>13</td>
<td>4.5</td>
<td>6.3</td>
<td>Yes</td>
<td>In the context of the conventional design process, to what extent do you agree/disagree that there is some kind of a gap between the work of the architect and that of the interior designer or between designing a building's interior spaces and its facades that limits the ability for exploring and framing the best possible visual connection to the outside environment?</td>
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<td>14</td>
<td>2.5</td>
<td>7.8</td>
<td>Yes</td>
<td>According to the immersive case study video you should have seen in the first round, to what extent do you agree/disagree that integrating 3D geospatial data to the design process could better inform designers’ decisions regarding exploring and framing the best visual connection to the outside environment?</td>
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<td>4.9</td>
<td>Yes</td>
<td>To what extent do you agree/disagree that the physical visit to the building site is not adequate to achieve a thorough realization of all contextual components for achieving the best possible visual connection to the outside?</td>
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<td>28</td>
<td>3</td>
<td>7.4</td>
<td>Yes</td>
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</tbody>
</table>

In the context of the proposed process, to what extent do you agree/disagree that a more developed tool of proposed process could bridge the gap between architect and interior designer to achieve the goal of exploring and framing the best possible visual connection to the outside environment?

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To what extent do you agree/disagree that authority adoption is necessary to accelerate adopting and developing this process?

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To what extent do you agree/disagree to expand the target use of the proposed process to include exploring the indoor-indoor visual relationship?

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To what extent do you agree/disagree that using the proposed process as a teaching tool in a design studio would be an effective way to accelerate developing a specialized tool with a well-designed interface?

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<td>0</td>
<td>1</td>
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<td>3</td>
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</table>

**Total** 10

Again, only questions that achieved IQR values of more than two were sent back to participants in the third round. Figure 6.5 below shows the relative positions of all questions based on their IQR values compared to the value of two as the benchmark for consensus.
6.3.2.2. Questions that have not Reached Consensus

As mentioned earlier, 10 questions did not reach a consensus in the second round.

Figure 6.6 below shows the questions frequency based on their IQR values. As they demonstrate, six questions are far from consensus with IQR values of 3 and above, and four questions are considered near consensus with IQR values of 2.5. For example, IQR values for questions number 11 and 13 are 6 and 4.5, respectively. Moreover, these questions have a wide range in answers from 1 to 8 for question 11 and from 2 to 9 for question 13, respectively. This indicates a significant divergence of opinions among the participating experts. However, this divergence in answers might be attributed to the possibility of a different understanding or interpretation of the question for all participants or to the different design and teaching experiences of the participants. Either way, this needed to be confirmed after the final round. Moreover, this divergence in experts' responses might be due to a possible methodological problem in
developing the questions between rounds. Specifically, questions were not tested before they were sent out and therefore may have had problems with clarity and purposes.

![Figure 6.6. The frequency of questions where consensus was not reached based on their IQR values](image)

### 6.3.2.3. Questions that have Reached Consensus

As mentioned earlier, the questions with IQR values of two or less are considered to have reached consensus and were not included in any subsequent round. According to Figure 6.7, 13 questions reached consensus. Therefore, these questions were excluded from the third round. Overall, four questions reached a high level of consensus with an IQR value of one, whereas five questions reached a medium level of consensus with an IQR value of 1.5 and four questions reached a low level of consensus with an IQR value of two (see Figure 6.7).
Round Number Three

As mentioned earlier, this round was predetermined to be the final round. A new questionnaire, including only the questions that had not yet reached consensus from the previous round, was sent to all participants accompanied by a descriptive statistics sheet for all questions (Table 6.6). This sheet included the participant’s own answer to each question plus the average, standard deviation, and minimum and maximum responses of all participants’ answers to each question of the second round. Therefore, each expert had the chance to revise their response to each question either by confirming or modifying it. Then, as in the second round, the IRQ value calculated for each question to measure if these new questions had reached consensus. Three weeks were dedicated to conduct this round. Friendly reminders were sent to participants to urge them to participate and submit the survey.
Table 6.6. Example of the statistic details sent back to each participant with the 3rd round questionnaire

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Your Response</th>
<th>Group Mean Response</th>
<th>Std Deviation</th>
<th>Maximum and Minimum Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>8</td>
<td>8.3</td>
<td>3</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
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</table>

6.3.3.1. Round Number Three: Consensus Assessment

According to the statistical analysis of the responses to the second-round questionnaire, 10 questions did not reach the predetermined consensus level. Therefore, a third-round questionnaire was conducted including only those 10 questions (6, 8, 11, 13, 14, 15, 17, 25, 27, 28). Along with the questionnaire, each participant was provided with a statistical details sheet for these 10 questions (see Table 6.7). By doing so, each participant had the chance to compare their responses with the other participants’ responses. Each participant was then asked to revise their response to each item either by changing or confirming it.

Table 6.7. The statistical details sheet sent with the 3rd round questionnaire

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Experts’ Responses for the Second Round</th>
<th>Group Mean Response</th>
<th>Std Deviation</th>
<th>Minimum and Maximum Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>7</td>
<td>6.7</td>
<td>1.66</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>6.6</td>
<td>1.42</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>4.9</td>
<td>2.76</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>13</td>
<td>6</td>
<td>6.3</td>
<td>2.69</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>14</td>
<td>6</td>
<td>7.8</td>
<td>1.20</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>15</td>
<td>8</td>
<td>4.9</td>
<td>2.52</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>17</td>
<td>5</td>
<td>6.6</td>
<td>1.88</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>25</td>
<td>8</td>
<td>7.1</td>
<td>2.32</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>27</td>
<td>6</td>
<td>7.4</td>
<td>1.67</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>28</td>
<td>6</td>
<td>7.4</td>
<td>1.51</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
</tbody>
</table>
Once the participants finished the third questionnaire, the IQR values were calculated for all questions. The results showed that three out of ten questions did not reach consensus whereas seven questions did (see Table 6.8 and Figure 6.8).

<table>
<thead>
<tr>
<th>Question Number</th>
<th>IQR in the 2nd Round</th>
<th>IQR in the 3rd Round</th>
<th>Reach Consensus</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2.5</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>2.5</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>2.5</td>
<td>No</td>
</tr>
<tr>
<td>13</td>
<td>4.5</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>2.5</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>3.5</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>25</td>
<td>3</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>27</td>
<td>2.5</td>
<td>1.5</td>
<td>Yes</td>
</tr>
<tr>
<td>28</td>
<td>3</td>
<td>2</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Figure 6.8. Change in the IQR values from the second to third rounds for only the questions that had not reached consensus in the second round

The questions that did not reached consensus after the third round were questions number
11, 15, and 25 with IQR values 2.5, 3, and 3, respectively. After the third round, seven questions had reached a high level of consensus with an IQR value of 1, five questions reached a medium level of consensus with an IQR value of 1.5, and eight questions reached a low level of consensus with an IQR value of 2. Therefore, the total number of questions that reached consensus after the third round is 20 out of 23, or 87% (see Table 6.9 and Figure 6.9).

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Group Average</th>
<th>Category #</th>
<th>IQR</th>
<th>Reach Consensus?</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6.7</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>8.3</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>6.6</td>
<td>1</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>7.7</td>
<td>1</td>
<td>1.5</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>7.1</td>
<td>1</td>
<td>1.5</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>4.9</td>
<td>1</td>
<td>2.5</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>6.3</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>7.8</td>
<td>3</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>4.9</td>
<td>1</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>6.4</td>
<td>1</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>7.2</td>
<td>3</td>
<td>1.5</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>8.3</td>
<td>3</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>7.3</td>
<td>3</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>7.1</td>
<td>3</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>7.6</td>
<td>3</td>
<td>1.5</td>
<td>Yes</td>
</tr>
<tr>
<td>23</td>
<td>7.8</td>
<td>4</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>24</td>
<td>8.1</td>
<td>4</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>25</td>
<td>7.1</td>
<td>4</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>26</td>
<td>7.3</td>
<td>4</td>
<td>1.5</td>
<td>Yes</td>
</tr>
<tr>
<td>27</td>
<td>7.4</td>
<td>4</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>28</td>
<td>7.4</td>
<td>4</td>
<td>2</td>
<td>Yes</td>
</tr>
</tbody>
</table>
6.3.3.2. Second and Third Rounds: Findings and Interpretation

According to the statistical analysis for all responses of the second and third rounds, most questions that did not reach consensus in the second round achieved significant improvement in the third round. Therefore, I think that the decision to conduct the third round achieved its desired goal. Only three questions out of 23 did not reach consensus. Figure 6.10 shows that questions 11, 15 and 25 did not reach consensus even after the third round. Overall, the degree in change in the IQR value between rounds was not an indicator of whether or not consensus was met. On the one hand, the IQR value of question 11 decreased by 3.5 points, but did not reach consensus, whereas the IQR value of question 13 decreased by 3.5 and did reach consensus. On the other hand, the IQR value of question 15 decreased by 0.5, but did not reach consensus status, while the IQR values of questions 8, 14, and 27 decreased by 0.5 and reached consensus.
Figure 6.10. Change in the IQR values for all questions from the second round to the third round

Figure 6.11 shows the rank of questions according to their IQR values. According to this figure, seven questions achieved a high level of consensus with an IQR value of 1. Five questions achieved a medium level of consensus with an IQR value of 1.5. Eight questions achieved a low level of consensus with an IQR value of 2. Three questions did not achieve consensus with IQR values of 2.5 and 3. Interestingly, there is no clear correlation between the categories of the questions and their rank. For example, questions 7, 12, 17, and 20 have the same IQR value of one but they belong to different categories. Also, questions 9, 18, and 26 have the same IQR value of 1.5 but they belong to different categories. The same trend applies to all questions.
Questions with a High Level of Consensus

The questions that achieved a high level of consensus questions (6, 7, 12, 13, 17, 19, and 20) are from two categories, category one: “limitations of the traditional design process” and category three: “potential advantages of the proposed process.” Figure 6.12 shows the difference among experts’ responses according to their levels of education, professional experience, and teaching experience. It seems that the difference among experts in terms of their levels of education, professional experience, and teaching experience is not significant. This correlated with the high level of consensus among the all responses to these questions.
Figure 6.12. Difference among experts’ responses according to their levels of education, professional experience, and teaching experience
Questions that have not Reached Consensus

The questions that have not reached consensus, questions 11, 15, and 25, are from different categories, specifically, categories one and four.

**Question 11:** In the context of the conventional design process, to what extent do you agree/disagree that the real surrounding context is not effectively involved in informing the designer's decisions regarding achieving the best visual connection to the outside?

The IQR value for this question changed from 6 after the second round to 2.5 after the third round, with a mean value of 4.9, the highest response value of 1, and the lowest response value of 8 (Table 6.10). This shows a clear divergence among the experts’ opinions regarding the level of the effective involvement of the surrounding context in informing the designer’s decisions to achieve the best visual connections to the surrounding context. Some experts believe that in the context of the conventional design process, the surrounding context could not effectively inform the relevant design decisions and need to be enhanced. On the contrary, some experts believe that the surrounding context could effectively inform the relevant design decisions.

Table 6.10. Some statistical details for question 11 after the third round

<table>
<thead>
<tr>
<th>IQR value after the second round</th>
<th>IQR value after the second round</th>
<th>Group average</th>
<th>Maximum response</th>
<th>Minimum response</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2.5</td>
<td>4.9</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

There seems to be no correlation between the participants’ responses and their different levels of education. For the four experts with Ph.D. degrees, two responded 8, one responded 2, and one responded 1. For the four experts with Master’s degrees, one responded 8 and three responded 5. For the one expert with a bachelor’s degree, the expert responded 2 (Figure 6.13).
Also, it seems that there is no correlation between the participants’ professional experience and their pattern of responses. For the three experts who have 4-6 years of experience, two responded 5 and the other one responded 1. For the one expert who has 7-10 experience, this one expert responded 5. For the five experts who have more than ten years of experience, three responded with 8 and the other two responded with 2 (see Figure 6.14).
Regarding the responses of experts according to their teaching experience, it also seems that there is no correlation between the participants’ teaching experience and their pattern of responses. For the three experts who have 1-3 years of experience, two responded 5 and one responded 2. For the three experts who have 4-6 years of experience, one responded 5, one responded 2, and one responded 1. For the one expert who has 7-10 years of experience, the expert responded 8. For the two experts who have more than ten years of experience, they both responded 8 (see Figure 6.15).
Question 15: To what extent do you agree/disagree that the physical visit to the building site is not adequate to achieve a thorough realization of all contextual components for achieving the best possible visual connection to the outside?

The IQR value for this question changed from 3 after the second round to 2.5 after the third round, with a mean value of 4.9, the highest response value of 8, and the lowest response value of 3 (Table 6.11). This question, to a great extent, is similar to the wide range of responses to question 11, but in a more specific way. Like in question 11, experts had divergent opinions regarding the adequateness of the physical site visit to achieve a thorough realization of all contextual components necessary for making the best visual connections to the outside environment. It seems that there is no consensus regarding the involvement level of the
surrounding context in the design process in light of the conventional design process. In fact, this lack of consensus appeared early during the qualitative analysis of the first round responses and was also confirmed by the statistical analysis of the second and third rounds responses.

<table>
<thead>
<tr>
<th>IQR value after the second round</th>
<th>IQR value after the second round</th>
<th>Group average</th>
<th>Minimum response</th>
<th>Maximum response</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.5</td>
<td>4.9</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

Much like for question 11, there seems to be no correlation between the participants’ responses to question 15 and their different levels of education. For the four experts with a Ph.D. degree, one responded 6, one responded 4, one responded 2, and one responded 0. For the four experts with a Master’s degrees, one responded 8, one responded 7, and two responded 6. It is worth mentioning that all experts with a Master’s degree responded six or more. For the one expert with a bachelor’s degree, the only expert responded 5 (see Figure 6.16).
Also, it seems that there is no correlation between the participants’ professional experience and their pattern of responses. For the experts who have 4-6 years of experience, all responded 6. For the one expert who has 7-10 experience, the expert responded 7. For the five experts who have more than ten years of experience, one responded with 8, one responded 5, one expert 4, one responded 2, and one responded 0 (see Figure 6.17). However, the figure also shows that six out of nine of the experts’ responses to this question were a 5 or higher.
Figure 6.17. Distribution of experts’ responses to question 15 according to the levels of their professional experience

Regarding the responses of experts according to their teaching experience, it also seems that there is no correlation between the participants’ teaching experience and their pattern of responses. For the three experts who have 1-3 years of experience, one responded 7, one responded 6, and one responded 5. For the three experts who have 4-6 years of experience, two responded 6 and one responded 2. For the one expert who has 7-10 years of experience, the expert responded 0. For the two experts who have more than ten years of experience, one responded with 8 and one responded 4 (Figure 6.18).
Figure 6.18. Distribution of experts’ responses to question 15 according to the levels of their teaching experience

**Question 25:** To what extent do you agree/disagree that authority adoption is necessary to accelerate adopting and developing this process?

The IQR value for this question did not change over the second and third rounds and remained 3, with the mean value of 5.3, the highest response value of 8, and the lowest response value of 3 (Table 6.12). Like with the previous questions, experts had divergent opinions on whether the authority adoption of the proposed process could accelerate its development and adoption by architectural design firms and design schools.

<table>
<thead>
<tr>
<th>Table 6.12. Some statistical details for question 25 after the third round</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IQR 2\textsuperscript{nd} round</strong></td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

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Unlike with questions 11 and 15, there does appear to be correlation between the participants’ responses and their different levels of education. For the four experts with a Ph.D., one responded 9, one responded 8, one responded 7, and one responded 5. It should be noted that all of these experts’ responses were a 5 and higher. For the four experts with a Master’s degree, two responded 9, one responded 8, and one responded 7. All these experts’ responses were a 7 or higher. For the one expert with a bachelor’s degree, the expert responded 2 (Figure 6.19).

![Bar Chart: Levels of Education]

Figure 6.19. Distribution of experts’ responses to question 25 according to the levels of their education

Also, it seems that there is a correlation between the participants’ professional experience and their pattern of responses. For the three experts who have 4-6 years of experience, one responded 9, one responded 8, and one responded 7. For the one expert who has 7-10 experience, the expert responded 9. For the five experts who have more than ten years of experience, one responded 9, one responded 8, one responded 7, one responded 5, and one responded 2 (see Figure 6.20). Moreover, Figure 6.20 shows that most of the experts’ responses to this question
were a 5 or higher.

![Years of Professional Experience Chart](chart.png)

**Figure 6.20.** Distribution of experts’ responses to question 25 according to the levels of their professional experience

Regarding the responses of experts according to their teaching experience, it also seems that there is a correlation between the participants’ teaching experience and their pattern of responses. For the three experts who have 1-3 years of experience, one responded 9, one responded 7, and one responded 2. For the three experts who have 4-6 years of experience, one responded 9 and two responded 8. For the one expert who has 7-10 years of experience, the expert responded 7. For the two experts who have more than ten years of experience, one responded 9 and one responded 8 (see Figure 6.21).
I think that the divergence in views among experts for all three questions may be attributable to different reasons, including their different understanding and interpretation of the asked questions or their different teaching and practicing experiences and interests in the fields of designing built environments. For example, some experts have more experience in the discipline of interior design, while other experts have more experience in the discipline of architecture or urban design. In the same way, some experts have more experience in teaching disciplines of design, while other experts have more experience in disciplines of practicing design. In fact, this kind of relationship would require inferential statistics to confirm if there is a correlation or not. Since there were not enough samples to use an inferential statistic, this research used descriptive statistics.
7. Chapter Seven: Discussion, Conclusion, and Future Considerations

7.1. Introduction

This chapter presents some discussions and conclusions regarding this research’s objective of developing a framework to enhance the ability of the architectural design process to achieve well-designed visual connections to the outside in the most effective manner. The discussions and conclusions are also about the research’s ability to, directly and indirectly, provide answers to the research questions and several other questions developed while conducting this research (see Table 7.1).

<table>
<thead>
<tr>
<th>Category of questions</th>
<th>Answering Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The rationale for developing the proposed framework</td>
<td>Logical Argumentation</td>
</tr>
<tr>
<td>The structure of the proposed design approach and the effectiveness and limitations of the proposed process</td>
<td>Logical Argumentation</td>
</tr>
<tr>
<td>The effectiveness and limitations of the proposed process to meet its objectives</td>
<td>Immersive Case Study</td>
</tr>
<tr>
<td>Consensus and validation</td>
<td>Delphi Technique</td>
</tr>
</tbody>
</table>

Moreover, several recommendations for future research that may enhance the outcomes of this research and its development and application are discussed. These future research recommendations were identified during several stages of conducting this research: the logical argument, immersive case study, and Delphi method.

7.2. Categories of the Answered Questions

Prior to and during the duration of this research, several questions developed that needed
to be answered. These questions can be divided into three main categories. The three research strategies used to conduct this research (logical argumentation, immersive case study, and Delphi) collectively contributed to answering these questions and ultimately the central research questions.

7.2.1. Category One Questions: The Rationale for Developing the Proposed Framework

The logical argumentation strategy, through enacting the first principle, provided a critical viewpoint to fundamentally analyze the investigated phenomenon and develop critical questions. Also, it helped to develop initial answers (synthesized from my point of view of and based on my initial bias toward the related literature) to these critical questions related to the rationale of conducting this research with its identified objectives.

- What is the essence of the indoor-outdoor relationship within built environments?
- Is this relationship important to architecture and its users?
- Is this relationship usually well achieved in designed buildings?
- Is a visual connection to the outside an important aspect to this relationship?
- Is this relationship underestimated or overestimated in related literature?
- Can any designers achieve a well-design visual connection to the outdoors? Why or why not?
- Are there problem(s) in the conventional design process that prevent designers from doing so?
- Can the design process be enhanced to facilitate designers to achieve such a thing?
- What form of intervention could be applied to the design process to improve the exploratory capacity and decision-making process of its visual connection?
By the end of this stage, the answers to these questions contributed to the initial framework for developing and integrating the proposed design approach into the design process. More specifically, achieving a well-designed indoor-outdoor visual relationship is necessary to achieve meaningful spatial experiences inside the designed space. A well-designed visual relationship is highly recommended in most related literature, however it is not easily achievable in the context of the traditional design process for several reasons. To determine why, additional questions were asked to determine how to develop and integrate an inside-out design approach augmented by digital immersion within 3D digital representation of the existing world that could make it more achievable.

7.2.2. Category Two Questions: The Structure of the Proposed Design Approach and the Effectiveness and Limitations of the Proposed Process

Developing answers to the questions of this category were started early in the logical argumentation stage. Then, the immersive case study continued to determine the answers in a more informed manner.

- Did the proposed process produce the desired outcomes?
- Was using the proposed process effective?
- What are the main steps of the proposed design approach?
- What is the operational workflow of the proposed design approach in relation to the design process?
- Are there any potential limitations to applying the proposed process?

By the end of the immersive case study (in which the proposed process was used to design a given building on the campus of Virginia Tech), more informed answers were developed. More
specifically, the proposed process greatly helped to explore and frame the best possible visual connection to the outside through different levels of both 2D and 3D exploration and evaluation of the visual connection and 2D and 3D adjustments to the building design. The digital immersion within 3D geospatial models during the 3D digital modeling played a key role in informing many related design decisions. Several limitations were experienced while applying the proposed process, such as the low level of interoperability among the components of the proposed framework (i.e., between the digital modeling process and the 3D geospatial models). For example, many design software and steps were involved in incorporating the 3D geospatial data into the design process and allowed for an exploration of the visual connection and modification of the building model accordingly. This made the whole experience of using the proposed process more complicated and time-consuming. Also, this methodology and its application mainly rely on the availability of 3D geospatial data, which is not currently available for all potential building sites.

7.2.3. Conclusion

According to the answers developed throughout the application of the proposed process, it was brought to the researcher’s attention that the proposed process may not represent the most effective approach to achieving the best visual connection using geospatial data due to several related reasons. These reasons include:

1. The methodology used to develop the proposed process and
2. The methodology used to validate the proposed process.

However, for several reasons, the researcher determined that the methodologies used may still have been the best because of several other reasons:
1. The time dedicated to conduct this research was limited,

2. The specialization of the researcher was not adequate to combine and synthesize all the identified elements of the proposed process in an effective way, and

3. The accessibility to a studio-based application of the proposed process was not possible throughout the duration of conducting this research.

As previously mentioned, these conclusions and concerns were reached by myself (as a designer who tested the proposed process through conducting the immersive case study) and the experts (who participated in the Delphi survey after watching a video detailing my experience during the immersive case study). Despite the participating experts’ admission that the proposed process was important for informing the decision-making process regarding exploring the best visual connection, they identified conclusions and concerns that were very similar to the researcher’s regarding the methodology used for developing and applying the proposed process; both concluded that the proposed process is complicated and time consuming, depends on the availability of 3D geospatial data, and requires a certain level of knowledge before use.

In conclusion, I could say that at this stage in conducting this research, the vision for further developing this research has become clearer compared to the beginning stages. Given the main goal of this research was to develop a proposed process to explore and frame the best visual connection to outside, this research may serve as a road map to better inform development in the future. In other words, this research is necessary for more advanced development to be conducted by a more interdisciplinary research team, within a more flexible time, and with more accessibility to the needed resources.
7.3. **The Method used to Validate the Important Aspects of the Proposed Design Process**

The main method used in this research to validate whether the proposed process is necessary and providing an added value to the design process or not was by conducting a three-round Delphi survey. Despite most experts providing positive responses regarding the potential positive influence of the proposed process on the design process, this method may in fact be inadequate to provide informed views without the actual testing of the proposed process by several designers. However, it was very hard to achieve this scenario in the context of the limited time allocated to this research and limited accessibility to studio-based teaching environments. Also, the proposed process could not be applied before developing it to a certain level that would allow for its use by designers. Therefore, it would seem that the best possible method for validation or evaluating consensus about the proposed process was the Delphi method. In other words, developing consensus among the participating experts regarding the potential positive influence and contribution of the proposed process was the main priority of this research more so than applying the proposed process in an actual design activity in a studio-based course.

Fortunately, the findings of the Delphi survey revealed a high level of consensus, around 87%, among all participating experts regarding the importance of the proposed process in the context of considering future enhancements. Almost every expert responded positively to the question of using the proposed process in teaching or practicing architectural design and also provided some insights for developing it further. Many of the suggested development insights were shared among all experts.

7.4. **Future Enhancement Considerations**

In fact, several future research considerations were identified and suggested either by the
researcher during the logical argumentation stage and immersive case study or by the participating experts during the multi-round Delphi survey.

### 7.4.1. Develop an Easy-to-Use and Interactive Design Tool that Facilitates Applying the Proposed Process throughout the Design Process

By doing so, designers could apply the proposed process without spending extra time, knowledge, and money. In order to provide a more effective experience of the proposed process, it is highly recommended by all experts to develop the tool inside a common design software such as Autodesk Revit or SketchUp. Accordingly, more designers would have the ability to explore the best visual connections to the outside and use the available modeling tool to achieve the desired visual connections.

### 7.4.2. Developing through Teaching

Many participants suggested that the proposed process and its application tool could be used in teaching a design studio. This could help to further develop the design tool and accelerate developing its interface design. Moreover, general end-users’ feedback could be obtained regarding prolonged use (one or two semesters) of the tool from different users using it for different design projects. This feedback could be collected and analyzed to further develop the tool interface. Also, the teaching method could be used to reassess and measure the effectiveness of the proposed process in achieving the best visual connection to the outside throughout the design process.

### 7.4.3. Develop a Set of Guidelines and a Step-by-Step Tutorial for Where, When, and How to Use the Proposed Process
To make the whole experience of using the proposed process and its relevant tool more applicable and extended, one recommendation was, in the future, to develop an illustrative step-by-step tutorial for where, when, and how to use the proposed process. This idea is similar to how the Autodesk company provides videos tutorials and guidelines for any version of a new design tool or development for an existing tool for any of its design software.

7.4.4. **Expand the Use of the Proposed Process to Explore Indoor Visual Relationships**

For some large-scale buildings, indoor visual relationships are complex and need more attention to achieve well-designed visual connections inside the built environment. Many design elements could be involved to form the interior space, which may need to be carefully put together in a way that creates a meaningful spatial experience. Accordingly, it would be a good idea to develop the proposed process to help designers to explore the visual connection within the building and make the necessary design decisions to frame them. Therefore, any design tool for the proposed process to be developed inside a common design software should consider the indoor visual exploration.

7.4.5. **Consider any Potential Change to the Framed Visual Connection Due to Any Future Transformation in the Surrounding Context**

In order to make the use of the proposed process more effective and the explored and framed visual connections more sustained, one thing to consider in future research is to expand its working domain to cover any potential transformations to the surrounding context over time. These potential transformations to the surrounding context can be a result of human or natural processes, such as modifications to the physical landscape due to urban expansion, deforestation,
overexploitation, and improper agricultural and industrial practices.

7.4.6. More Natural Dynamic Phenomena Should be Involved in Exploring the Best Visual Connections

There are many complex factors that could be involved in exploring and framing visual connections to outside in more meaningful and informed ways. These factors are mainly the time-related and dynamic natural phenomena, such as the day-night alteration and seasonal change (e.g., changing foliage color and density over the year, changing shade and shadow throughout the day, etc.). Such dynamic changes in the surrounding context could affect the quality of the explored views. Having more information available about these phenomena would better inform designers’ decisions regarding what best visual connection(s) could be achieved. Accordingly, another thing to consider in future research is developing the proposed process and its design tool to consider these phenomena. However, the complex nature of these phenomena and their many factors may require multidisciplinary-based research and high computational ability.

7.4.7. New Potential Professions such as Geo-Designer or Geo-Architect

In the event that the proposed process is further developed according to the previous considerations, new professions related to the architectural design process may emerge, such as geo-designer or geo-architect. These potential professions could enhance the effectiveness of the design process—namely, the cognitive ability of designers and the level of the decision-making process. This is not limited to exploring the best visual connection to the outside, but the 3D geospatial data itself could also provide a wide range of contextual information (e.g., historical,
social, geographic, demographic, climatic, regulative, etc.). Providing interactive access to the wide-range geospatial database from inside a design software may greatly enhance the decision-making process at various levels.
Reference:


Autodesk Inc. (2020). *Plan and design infrastructure projects in the context of the real world*. Retrieved from


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Appendix A: Script of the First Round

**Question One: Do you think that there is an essential flaw in the traditional design process (not the proposed one) that prevents or limits the ability of designers from an effective involvement of the theories related to the indoor-outdoor visual relationship within the built environments?**

**HRA:**
I do believe there’s an essential flaw of design process prevents incorporating design theories related to indoor/outdoor visual connection. It also depends on the use of space and how important incorporating the inside/outside visual experience. I think the overlap between all design phases limits the ability to study and make changes to enhance the inside/outside visual experience.

**Amer:**
According to my 11-year experience in consultant offices, and also 8 years in academia, and based on the different requirements of projects (time-frame and cost), the actual design process starts usually with two-dimensional drawings and schematic three-dimensional exterior shots. After the approval of the conceptual phase from the client, the design office requested from the architect to submit detailed and working (construction) drawings to other engineers very quickly in order to finish the project, and then start another new one. Therefore, there is no time to conduct a detailed study for the relationship between indoor and outdoor, unless the contract includes interior design works. Even though, if the designer works on the interior, he/she focuses on materials and furniture items only, as the architectural drawings (including elevations and location of windows) are fixed. Another reason for not including such an important relationship is that the interior design starts usually after finishing the skeleton of the building on-site. So, the interior designer cannot change any window to increase the visual connection. The actual design process in most offices includes the work on the building as an isolated piece, then the designer adds the context after finishing the exterior image. When he/she puts windows on the plan, the focus is to keep the outside look, with limited consideration to the strong relationship between indoor and outdoor. The best scenario for the designer is to sign a contract with the owner to do exterior and interior designs together. Yet, this scenario is not common, as the main issue for the client is cost and budget.

**Yaman:**
From my experience as an interior designer and educator, the traditional design process could work for interior design. However, it’s usually used to emphasize the architectural part of the design more than the interior space of the building. This emphasis create a disconnect between the interior and exterior design. That’s why we usually expect an interior design of a building based on it exterior and many times we would be surprised by the difference of the actual design and “image” of the interior we had in mind. Therefore, I believe that creating, updating, and integrating the traditional design process into a more fluid process would create more opportunities to create a stronger connection between the interior, exterior, and
the building site.

**Nathaniel:**
I think that the traditional design processes for most design professionals have a clear intention and understanding of the value of indoor-outdoor visual relationships, however, there really isn't an accessible/robust way to facilitate this understanding to the resolution suggested by this tool. It is my experience that most designers consider indoor-outdoor relationships critical but execute them as general gestures/relationships.

**Monet:**
Yes there is a flaw these days. But let's think about architectural work centuries ago without the use of technologies or even basic AutoCAD and the connection used to be much stronger than today. Many factors disrupt the flow such as dedicating enough time for the project, enough resources for the team to travel to the site (these days we outsource projects to non-local firms or to international firms). What I am trying to say is that the structure and process exist but rarely anyone use them these days. For example, Donald Trump Jr. brought a skyscraper crane before he started working on Trump Tower Chicago. He personally checked the view out of every single hotel room and together with the design team (SOM), made the necessary changes to orientation of tower to maximize views. In this case, the resources were available and were supported by the developer. These resources are not usually available which makes your proposal stronger. But is geospatial data available for all communities? There is a price tag with constructing point cloud data using LiDAR unless it is integrated with the actual project.

**CMT:**
I have ad both experience working in an Interior Design, where we focused primarily on the interiors and worked with architects as external partners and an Architecture firm with a team of interior designers where the design evolved as a collaborative effort. I think the exterior and the interior spatial designs are rarely designed in parallel. Taking a window for example, an architect asks how does that look from the outside and an interior designer asks how can space plan, whether it be furniture or walls, to acquire the best view. That being said, yes, I think there is an essential flaw in the design process that prevents designers/architects from implementing well executed indoor/outdoor designs.

**Sean:**
Yes, I believe there is an essential flaw in the design process that prevents architects from implementing well-executed indoor-outdoor visual relationship designs.

As a designer, I might care about the general overall orientation of the building rather than what to see specifically. A very limited project with a very unique situation the indoor-outdoor visual relationship was the major design force.

**John:** Overall the idea of utilizing and improving technology to aid designers is a great idea. The process proposed appears complicated. Architects need to walk a site, feel the breeze, see the sun. my view is
always changes when I visit the site even though I had fantastic site data available in the office. I may even have had a 3d virtual or physical model. What happens when the leaves fall from trees or the sun glistens on the early morning frost?

**Question Two:** Given the goal of promoting healthy built environments through the design of interior spaces that have a strong visual connection to the outdoors by way of a desirable view, do you agree that the proposed process of merging geospatial data into design contributes to meeting this goal? Follow why and why not

**HRA:**
I strongly agree! Importing geospatial data will help designers to understand the site potentials (pros & cons) and it will help them to achieve their design goals.

**Amer:**
The proposed design process in your study could solve this problem, as architects can do the synergy between the spatial design of interior spaces and the visual connection with the surrounding. As my PhD study was to enhance social sustainability in high-rise residential buildings, and view to the exterior is one of the major indicators, parallel with maintaining the privacy of the family, I would strongly satisfy to use the proposed tool.

**Ann:**
Yes. It is especially useful for design in places with geospatial data available. For places that data is limited or nonexistent, such as in rural communities, what would be the work-around for these projects/built environments? Would it be helpful if part of the tool to be developed included space to develop the environment in the model if the geospatial data didn’t exist? (At least on a conceptual level for early design work.)

**Yaman:**
Using the assistance of geospatial data is one of the important factors in making informed design decisions. I think that will help designers understand the building site in a deeper manner which will most likely provide better and much more data to all members of the design team

**Nathaniel:**
Yes this seems like a smart move especially if it is developed as a simple plug-in to easily available geospatial data bases and architectural softwares.

**CMT:**
There have been many buildings in my life where I stared at a window and thought, if that window was only two feet to the left, it would be perfect. I think the merging of geospatial data into the design process would serve as a wonderful tool in exploring the best view in order to promote a healthy environment. We are taught in school that every decision we make should be an informed decision. Geospatial data integration would truly realize that concept. The integration of geospatial data sounds like it could also be a whole different profession (geospatial design engineer?). The skills that are required to use the programs must be taught and that knowledge must maintained over the years; and as we know technology keeps improving at a rate that is hard to keep up with. That being said, I actually think it’s a positive thing. There are architects that become 3D Renders and Interior Designers and become sales rep, so why not become a geospatial design engineer?! Not only are you now creating jobs, but its also would act as a medium between architect and interior designer.

Monet:
Yes there is a flaw these days. But lets think about architectural work centuries ago without the use of technologies or even basic AutoCAD and the connection used to be much stronger than today. Many factors disrupt the flow such as dedicating enough time for the project, enough resources for the team to travel to the site (these days we outsource projects to non-local firms or to international firms). What I am trying to say is that the structure and process exist but rarely anyone use them these days. For example, Donald Trump junior brought a skyscraper crane before he started working on Trump Tower Chicago. He personally checked the view out of every single hotel room and together with the design team (SOM), made the necessary changes to orientation of tower to maximize views. In this case, the resources were available and were supported by the developer. These resources are not usually available which makes your proposal stronger. But is geospatial data available for all communities? There is a price tag with constructing point cloud data using LiDAR unless it is integrated with the actual project.

Sean:
The proposed process for using the assistance of geospatial data is important and helpful. During the design process, the site visit is done at the early stages, and the designer might miss, forget, or overwhelmed by other design forcing factors. The proposed tool will help designers understand the building site in a deeper manner and provide better information and insight to the whole team. The proposed tool would recall missed information or bought new ideas to the table.

John:
A further evolution of the tool you propose could enhance the toolkit available to designers. It must be considered though that increasing access to great views is not the only consideration designers face. It is the complexity and the nuances of the decisions that have to be made between often competing information sets that separates the modest designer from the exceptional.

Question Three: Given the goal of promoting healthy built environments through the design of interior spaces that have a strong visual connection to the outdoors by way of a desirable
view, do you agree that you would apply the proposed process to your practice? Follow with why or why not.

HRA:
I would apply the process to my projects if I got the right tool. I believe that most if not all designers strive for studying all potentials of surrounding views and make the most of views to enhance the interior space. Many studies found that indoor/outdoor visual connection have a direct impact on users.

Amer:
So, the proposed process is needed to integrate the outdoor context with interior spaces. This process is also very useful for architecture students in their design studios. However, and in my experience, most designers/students focus on plans, and keep the design of elevations to later stages of the design process. Moreover, the time-frame of (real or university) projects is very limited.

Ann:
If I had the software skills, I would try to apply this process, yes. I think this work ties in to very important challenges in design of the built environment. If there were a way to “preview” the experience of outdoor spaces with accurate geospatial data could help designers avoid developmental blunders and refine designs before they move forward toward being realized. It could be helpful for designers across a range of disciplines—interior designers, landscape architects, and architects—so they can have a greater appreciation for how their work relates to others on the team. It would also go a long way to helping avoid blunders and missteps between practitioners on a team for everyone to “see” the vision during the early planning stages.

Yaman:
Since having research evidence that having natural and beautiful views in the building will improve the quality of life in the space. I would most likely use the proposed design process. However, I hope there would be a more developed tool that integrates the traditional design process along with the proposed one.

Nathaniel:
If it is easily integrated into existing process without extensive training. It may be valuable to demonstrate to a client but it may be hard to implement as a fee-for-service if the learning curve/ training/ time/money is too steep and hard to justify. It may be more effective as a teaching tool either to illustrate relevant views /conditions in the architectural cannon (history) or as a diagrammatic tool for pre-design/ schematic iteration (design studio). Using it as a teaching tool with a group of well-directed students would be a good way to facilitate accelerated interface development. (as was done with Revit, etc.)

CMT:
If I had the skills, yes. If I could hire someone that had the skills, yes. The biggest reason for me would be for client satisfaction. Clients respond very well to 3-Dimensional design. If you have a client with no architectural design background, they can get lost in construction documents. Specially in my firm, a 3D model is created, and certain viewpoints are selected to show the client. Sometimes, we even use VR where the client can walk through the space and look out the window. In screen shots of renderings we photoshop a background into the window, and in the case of VR we select “city” or “mountains cape” from our pull down list of options in whatever 3D program we are using. Having the ability to show clients the actual view is a huge benefit.

**Monet:**
I accept to adopt the process in practice. When Revit first came up, it might have taken 5 years for AutoCAD to offer firms of different scale the necessary training. Some countries have now mandated the use of REVIT in submissions for authorities approvals. I can imagine adopting your process will take time if developed well and perhaps having it endorsed by authorities might help make the process adopted officially.

**Sean:**
I agree to adopt the proposed tool if:
1. it is developed more to be much easier than it was explained, someway easy and straightforward like Google Sketchup.
2. For clients who care about seeing 3D models and views selection

**John:**
It would require simplification and integration with other tools and approaches that we already use. A client won’t pay more for just adding another process or tool on so it has to be considered holistically.

**Question Four: What suggestions would you have for improving the process?**

**HRA:**
Establish a set of guidelines and tips for designers to where and when to use this process. Also clarify if the same process can be used for interior/interior visual experience. I believe this process would be very helpful for large projects where a visual connection between interior spaces is required to achieve design goals.

**Amer:**
My suggestion to enhance the design process is to allow the user to work on the two-dimensional plan and indoor partitions without the exterior skin. In this way, designers could have an overall understanding of the context, and then they work on location of windows and glazed facades to achieve both privacy and
views. To improve the proposed process, I suggest to do the process firstly without the skin of the building. So, you need to put all floors and internal partitions without any external facades. So, the designer can feel the importance of outdoor views, then he/she starts with studying location of windows. After that, you can add a detailed visual study to test the relationship between indoor and outdoor from different locations inside the building. Such a suggestion will also give the designer a chance to look from the opposite side (i.e. from the surrounding context towards indoor spaces), and starts with designing elevations.

Ann:
A tutorial or set of self-guided lessons so that users could move through a workshop to help themselves develop the requisite software skills and understand the workflow would be helpful. Maybe it could be as simple as a step-by-step guide or something similar

Yaman:
I think about the post-occupancy evaluation step to be added to the process. Also, what about the future of there connections between the interior and the exterior. that are the possibilities of the selected views to be blocked or changed in the future due to the urban expansion?

Nathaniel:
The interface wants to as direct and accessible as Wikipedia or MSword. A mature design should be able to drop a 3d model into a location within a ubiquitous data source like google maps and see/ test probable views without being dragged through a distracting process… if too onerous most designers would revert to old means.

CMT:
Like I mentioned earlier, this could be its own profession. I am all for simplifying processes, but in this case if it gets over simplified, then we might as well use trace paper, a map, and a straight edge to locate the best views. The role of this geospatial process is to collect, analyze, and create options for best views all while being immersed in the very technical world of GIS and BIM programs. However, the knowledge base for this process goes beyond technology and spatial understanding, but also involves having comprehension of shadow and light, night and day, geographical awareness for the changing of the seasons, etc. These are all important factors when considering what is the best view. You could even go as far as to add sun studies and geographical implications to the process.

Monet:
The project needs to be endorsed at various levels. For example, if three companies are competing against one project, I doubt that one will adopt the process and not the other two as it will impact the timeline. If it comes from the client or the authorities, it might be adopted if the technology becomes available. Learning the software is not a problem in my view – we all shifted our practice and adopted technologies
and many different ways. This process does not sound too complicated in my view – if LiDAR data is available and REVIT becomes compatible with it, then your goals might be met.

Sean:
The process is very unique and breakthrough. Making the visual connection a driving design force is something unique and helpful. However, simplifying the integration would be much helpful and would promote using it as a design tool.

John: Consider making a 30 second promo video where you have to make a pitch that would convince someone to buy this tool? Why would they use it? How does it make their life easier? better? help them succeed? If you can be more succinct and focused that would be very helpful. The background, research and passion you have for the topic are great. But to be successful I think you need to appreciate the consumer mentality. What is it going to do for me?
Appendix B: Survey Questionnaire

Q.1:
Welcome to the research study!
The following questions are developed from all participants' responses in the previous round. This survey should take you around 12 minutes to complete. You have the right to withdraw at any point during the study, for any reason, and without any prejudice. If you would like to contact the Principal Investigator in the study to discuss this research, please email jajone10@vt.edu. By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age.

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

- I consent, begin the study (1)
- I do not consent, I do not wish to participate (2)

Q.2:
How many years of experience do you have in the field of practicing architecture, interior design, landscape architecture, or urban design?

1 (1-3 years) 2 (1-3 years) 3 (7-10 years) 4 (More than 10 years)

Q.3:
How many years of experience do you have in the field of teaching architecture, interior design, landscape architecture, or urban design?

1 (1-3 years) 2 (1-3 years) 3 (7-10 years) 4 (More than 10 years)

Q.4:
What is the highest academic degree do you have in the fields of architecture, interior design, landscape
architecture, or urban design?

1 (Bachelor’s Degree)  2 (Master’s Degree)  3 (Ph.D. Degree)

Q.5:
Have you ever considered exploring and framing the best possible visual connection to the outside environments during your practicing or teaching architectural design?

0 (Never)  1 (Sometimes)  2 (About half the time)  3 (Most of the time)  4 (Always)

Q.6:
In context of the conventional design process, to what extent do you agree/disagree that there is an essential drawback in the design process that might limits designers from exploring and framing the best possible visual connection to the outside connection?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.7:
To what extent do you think that achieving a well-designed and strong visual connection to the outside environment necessary to achieve the true "dwelling" and meaningful spatial experience and enhance the social sustainability within the built environments?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.8:
In the context of the conventional design process, to what extent do you agree/disagree designers could make informed design decisions that emphasize the best visual connection to the outside environment?
Q.9: In the context of the conventional design process, to what extent do you think the factor of time might limit designers' cognitive ability from exploring, evaluating, and framing the best visual connection to the outside environment?

Q.10: In the context of the conventional design process, to what extent do you agree the factor of cost and budget might limit designers' cognitive ability from exploring, evaluating, and framing the best visual connection to the outside environment?

Q.11: In the context of the conventional design process, to what extent do you agree/disagree that the real surrounding context is not effectively involved in informing the designer's decisions regarding achieving the best visual connection to the outside?

Q.12: In the context of the conventional design process, to what extent do you agree that there is a temporal and spatial separation between the actual designing context and the actual building context that limits the cognitive ability of designers to achieve well-designed visual connection?
Q.13: 
In the context of the conventional design process, to what extent do you agree/disagree that there is some kind of a gap between the work of the architect and that of the interior designer or between designing a building's interior spaces and its facades that limits the ability for exploring and framing the best possible visual connection to the outside environment?

Q.14: 
According to the immersive case study video you should have seen in the first round, to what extent do you agree/disagree that integrating 3D geospatial data to the design process could better inform designers' decisions regarding exploring and framing the best visual connection to the outside environment?

Q.15: 
To what extent do you agree/disagree that the physical visit to the building site is not adequate to achieve a thorough realization of all contextual components for achieving the best possible visual connection to the outside?

Q. 16: 
In the context of the conventional design process, do you agree that the design process is mainly an outside-in design process?
Q.17: In the context of the proposed process, to what extent do you agree/disagree that a more developed tool of proposed process could bridge the gap between architect and interior designer to achieve the goal of exploring and framing the best possible visual connection to the outside environment?

Q.18: To what extent do you agree that the factors of time and resources necessary to execute an in-depth indoor-outdoor visual relationship could be overcome by developing a 3D geospatial-based Inside-Out design tool?

Q.19: Do you agree that design decisions needed to achieve strong and successful indoor-outdoor visual relationships should be taken at the early stages of the design process?
Q.20:
To what extent do you agree that the integration of 3D geospatial data into the design process allows achieving a thorough realization of the contextual components for achieving the best possible visual connection to the outside?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.21:
Extent to which you agree that the proposed process could achieve a better coordination level among the design team members: the interior architect, architect, landscape architect, and urban designer?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.22:
To what extent do you agree that the proposed process could achieve a better communication level between the design team on one hand and the clients on the other hand?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.23:
To what extent do you agree that developing an easy-to-use tool without requiring extra time and money is necessary to accelerate adopting this process?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)
Q.24: To what extent do you agree that the wide availability of geospatial data is necessary to accelerate adopting this process?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.25: To what extent do you agree/disagree that authority adoption is necessary to accelerate adopting and developing this process?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.26: To what extent do you agree to expand the target use of the proposed process to consider any potential change on the framed visual connection due to any future transformation in the surrounding context and urban expansion?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)

Q.27: To what extent do you agree/disagree to expand the target use of the proposed process to include exploring the indoor-indoor visual relationship?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)
Q.28:
To what extent do you agree/disagree that using the proposed process as a teaching tool in a design studio would be an effective way to accelerate developing a specialized tool with a well-designed interface?

0 1 2 3 4 5 6 7 8 9
(Strongly-Disagree) (Strongly-Agree)