DESIGNING BIOPHILIA INTO INTERIOR ENVIRONMENTAL PRACTICE: A BIOPHILIC DESIGN ASSESSMENT TOOL DEVELOPMENT

By

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To my Family: I could not have completed this without you

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TABLE OF CONTENTS

page

LIST OF TABLES

LIST OF FIGURES

Figure page

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

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Evidence is growing for nature inclusion in the interior yet there is little support for helping interior designers integrate it. This study uses the restorative environmental design (RED) framework to explore the systematic development, testing, and expansion of the Biophilic Design Matrix (BDM) tool.

In the three essays included, the first essay focuses on the BDM development, which now contains a total of 54 biophilic design attributes within six element categories. These were developed through cognitive testing from the original version and then pilot tested with 23 practitioners completing pre and post-questionnaires about their perceptions of biophilia and experience doing an assessment of a lobby space with the BDM. After BDM use, practitioners perceived an increase in knowledge of biophilic design. The modified version is now called the Biophilic Interior Design Matrix (BID-M) which seems to be valid and reliable. The second essay contributes by linking research to specific attributes through a literature review and identifying how practitioners are using biophilic design in their practice within color, light and materiality. Differences and commonalities were found between the evidence for specific attributes and the actual attributes being used by designers. Essay three explores the BID-M

being used in an undergraduate studio course for assessing how it can support conceptual design and design development to aid students with biophilic integration. Their perceived importance of biophilic design, confidence in using it and knowledge about it were statistically significant in the group that had the BID-M throughout the project compared to the group that did not. Additional comments showed a perceived value to the BID-M in design education and requests for earlier adoption into the curriculum. This supports the Council for Interior Design Education standard 7-a to help guide theoretical implications of the built environment with biophilic design a listed referenced criterion.

Overall, the findings support both practitioners and students using the BID-M to assist biophilic inclusion throughout the design process. Also, using the checklist as a quick reference and the online repository, with its growing research base, should be useful to help designers include thoughtful biophilic variety.

CHAPTER 1
INTRODUCTION

> People's physical and mental well-being remains highly contingent on contact with the natural environment, which is a necessity rather than a luxury for achieving lives of fitness and satisfaction even in our modern urban society
>
> —Stephen Kellert
> *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life*

How can interior design aid people's connection with the natural world through the built environment? That is a big question for modern interior design research since Americans spend an average of more than 90% of time inside (Klepeis et al., 2001; US Environmental Protection Agency, n.d.; U.S. Environmental Protection Agency & Office of Air and Radiation, 1989) and this time inside can greatly limit the amount of nature contact (Kellert, 1993). Research shows positive benefits associated with nature contact (Berman, Jonides, & Kaplan, 2008; Kahn, 1997; Ulrich, 1984, 1991, 1983), yet questions exist as to how designers of built environments can tackle nature integration in the interior to facilitate optimal wellbeing.

In a design paradigm called restorative environmental design (RED), Kellert (2008b) defines RED as including both sustainable low-impact environmental strategies, as well as positive impact (biophilic design) features, that "fosters beneficial contact between people and nature in modern buildings and landscapes" (p. 5). This paradigm uses the definition of biophilia as the innate need people have to connect with nature and natural systems (Wilson, 1984). Interior design is important to the work of RED because it includes the specifying of features that either provide or do not provide opportunities to reconnect with nature inside of the building shell and through interior/exterior connections (Kellert, 2008b). Offering nature-based features to users in buildings should increase biophilia and ultimately wellbeing. Biophilic design is an

underexplored area of interior design knowledge. The outstanding problem addressed in the three papers in this study is the further development of the Biophilic Design Matrix (BDM) tool to aid interior design identification and application of biophilia. This included the further development of the design attributes, testing in different settings, using it as an assessment tool and pedagogy tool and using it with designers of different experience levels. This was all to see how such a tool could support practice and education in what is termed here as biophilic interior design. Additionally, the three categories of color, light and materials are key to interior design (Bosch, Edelstein, Cama, & Malkin, 2012; Dalke et al., 2006), yet they have not had much alignment to biophilic design approaches for their use. This study begins to address this need as well, specifically for supporting evidence-based design practice.

Evidence-based design (EBD) is seen as a "process of seeking answers to design problems not a product that supplies ready answers or standard solutions pulled out of the practitioner's files" (Hamilton, 2010, p. 126). The evidence base for design has a history starting with research around Taylorism and the Hawthorne Studies back in the early twentieth century, but the landmark study by Roger Ulrich in 1984 connected health with the built environment through a controlled experiment to start what would be called evidence-based design (Center for Health Design, 2010).

While evidence-based design is not a new concept, for interior designers there is still a need for new validated research tools and continued theory development. When such tools are available they can then be used to aid design decisions that further looks at how people are benefiting, or not, from the environment (Center for Health Design, 2010). I created the BDM in 2012 to aid biophilic identification, specifically child life play spaces. It was developed based on the LEED checklist format where a credit is either fulfilled or not. The BDM has been further

validated with additional testing (Weinberger, Butler, McGee, Schumacher, & Brown, 2016). One other tool exists has been proposed that integrates a quadrant overlay on each space for attempting to count feature frequency with a focus on quantity to assess childcare centers (Caballero, 2013). How the further integration of biophilic design can best be supported in a user-friendly version was untested prior to this project.

Biophilia has begun to be supported by evidence from a wide variety of fields. The evidence shows nature connections offering positive influences on human health, productivity and environmental attitudes (Beute & Kort, 2014; Kahn, 1997; Louv, 2008; Van den Born, Lenders, Groot, & Huijsman, 2001). Research shows that active and even passive viewing of nature can influence health and wellbeing (Kahn, 1997; Tennessen & Cimprich, 1995; Ulrich,1984). Active engagement with living nature provides optimal restoration, but even passively viewing nature or natural representations, such as complex fractal patterns and varied visual surroundings, seems to allow the mind to easily range from directed attention to fascination as needed for mental and physical wellbeing (Hagerhall, 2004; Joye, 2007; Kaplan, 1995).

Designers have had increasing reason for including biophilic design in the interior since the beginning of the 1980s with the development of the concept of evidence-based design as an interdisciplinary approach to building and sharing evidence (Cama, 2009; Ulrich, 1984). The design field is attempting to incorporate nature into the interior using evidence-based design (Barnes, 2010; Browning, Ryan, & Clancy, 2014), especially healthcare facilities, however, research on design has not found vast adoption in practice (Huber, 2016). The development of tools by the Center for Health Design offers a patient room design checklist and evaluation tool as well as a safety risk assessment ("chd | The Center for Health Design," n.d.). The Center also

offers case studies that highlight best practices for others to consider. These are very targeted to performance and specific wellness objectives. The adoption rate of these tools is unknown, and they are not designed specifically to guide designers with their attempts at integrating biophilia.

Theory Building

What is unique about restorative environmental design (RED) versus traditional design practice? "Restorative environmental design, aka biophilic design, provides a more holistic approach to the design of buildings and environments. It marries green design principles with an approach that seeks to connect nature and humanity" (2011, para. 3). This can be seen in the construct diagram, Figure 1, where nature influences people (biophilia) and people influence nature (sustainability). Where people connect with nature biophilia results. When people build and act sustainably, then they preserve or even restore nature. When both are present, restorative environmental design can exist in a symbiotic relationship.

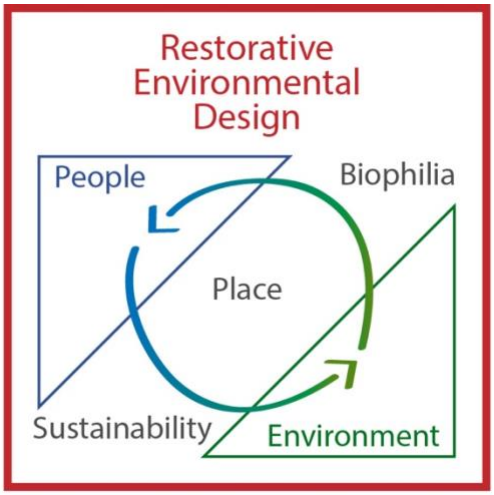


Figure 1-1. Supporting theoretical framework diagram.

Much of the research directed at the restorative part of restorative environmental design currently comes from environmental psychology. This includes attention restoration theory and psychoevolutionary theory focusing on stress reduction and attention restoration (Hartig, Bringslimark, & Patil, 2008; Kaplan, 1995; Ulrich, 1983). This is a view of nature influencing

people's behavior, health and wellbeing. However, these theories fall short of the greater impact that restoration, as proposed by Kellert in RED, offers. This is the nurturing of nature connections to facilitate a healthy relationship with nature for both personal wellness and a global awareness and benefit. Since theory building is an ongoing process "in the discipline of interior design, researchers should not only be analytical but also engage in a creative process that requires adjustments and revisions to theoretical propositions and methods" (Clemons & Eckman, 2011, p. 32). This study does so by seeking evidence for a user-centered design/assessment tool to guide designers while also allowing understanding how interior design plays a role in biophilic design. A struggle with design theory application in building design is well stated by Bardenhagen and Rodiek (2016) specifically regarding health facilities and the challenges are "to be able to identify which, among the myriad elements available, will best combine to optimize the intricate human–environment relationships and desired therapeutic outcomes that exist or are proposed to exist in the space" (p. 149). How designers can include natural connections is prompting further validation of the BDM.

Biophilic Design Matrix

The Biophilic Design Matrix (BDM) is an evidence-based design tool. The BDM is aimed to be contextually relevant and useful for designers, because if it is "not contextually situated, and therefore relevant to the audience that must act on those findings, there will be no action until the audience finds that contextual relevance" (Barnes, 2010, p. 131). Initial testing of the BDM involved eight hospitals and 24 child life play spaces (McGee, 2012). The inter-rater reliability during initial scoring with a test-retest of matrix coding had agreements of 89% by the first rater and 94% by the second rater. The matrix scores for the 24 spaces (n=24 of 26 child life play spaces in the state studied) had a mean total score of 21.5 out of 52 attributes. The score ranged from a low score of 14 and high score of 39. The six elements were: 1) Environmental

features- most obvious and well recognized nature characteristics, 2) Natural shapes and forms- nature representations and simulations, 3) Natural patterns and processes- properties derived from natural features and processes, 4) Light and space- light qualities and space relationships, 5) Place-based relationships- culture together with ecology, rooted in the local geography, and 6) Human-nature relationships- paired biological needs. The BDM had an internal consistency, Cronbach's Alpha of .804, but showed areas where item development may assist with reliability. The revised version of the BDM and its use as a design assessment tool now provides a chance to investigate validation of its contextual relevance for diverse users.

The BDM tool aligns with two worldwide programs that integrate biophilia, WELL ("WELL v2," n.d.) and the Living Building Challenge (International Living Future Institute, 2014). Each of these supports biophilia integration in the design of buildings. WELL is a framework that seeks to advance health and well-being through the built environment ("WELL v2," n.d.). It has an indoor plant feature, with a percentage of the wall or floor space needing coverage, and other options for using nature features, lighting and layout, as well as natural patterns and outdoor connections. These features are based upon the Living Building Challenge which is a green building certification program and sustainable design framework seeking ideal built environments (International Living Future Institute, 2014). There are additional related features like circadian lighting systems as well. The Living Building Challenge references Kellert's original list of biophilic features. However, Kellert's list of features was not developed specifically for interior design, so this research aimed to better develop the BDM for clear and reliable definitions for interior application to relate with frameworks such as WELL and Living Building Challenge.

Besides these few growing sustainable design frameworks, the availability of research developed tools or frameworks has increased but has had limited adaptation by practitioners (Browning et al., 2014; Huber, 2016, 2018; Quan, Joseph, & Nanda, 2017). Interior designers are commonly seeking out research, but they often use fast surfing tendencies when reviewing information, use familiar sources and do so as quickly as possible (Huber, 2018). There is an "opportunity to narrow the research utilization gap by making scholarly sources more approachable" (p. 25). Since interior designers are seeking out more knowledge specifically about biomimicry/biophilic design, this research used participatory methods for a user-friendly biophilic interior design language to improve the utilization gap. This led to three areas of focus in this research. The first, was the BDM being revised through cognitive testing and then further tested with practitioners in a new context. This was in the hope that these revisions would make the Matrix more valid, reliable and user-friendly. The second area of focus was the attribute "color". It was a key shortcoming of the original version with its definition being "any color". This was addressed by adapting the Color Planning Framework (Portillo, 2009) into the Matrix and was a key improvement. Third, the BDM was used in an undergraduate interior design studio as a pedagogical tool for teaching and learning about biophilic design as well as aiding its incorporation.

The research questions of the three essays were:

Essay 1

1. How do designers perceive biophilia?
2. What is the optimal BDM for designers as a design tool for usability?
3. How validly and reliably does the revised BDM appear to measure the variety of biophilic features present when used by interior designers?

Essay 2

1. What evidence for color, light, and materials can support the biophilic design attributes?
2. How through color, light and materials is biophilia being incorporated into design practice?

3. What are the similarities and differences between the research available and designers' use of color, light and materials?

Essay 3

1. How do interior design students perceive biophilia?
2. How is the BDM helpful for interior design students?

The Biophilic Design Matrix development process included cognitive testing with practitioners using a questionnaire with pre- and post-questions surrounding an assessment of a given healthcare lobby space. They were asked to evaluate the given images of the space for the presence of the biophilic attributes. Sixty-four features were finalized and then tested with practitioners using the questionnaire. Furthermore, a literature review linked research to the attributes through a PRISMA-P modified format. Finally, two groups in a studio project for undergraduates were compared to investigate how the BDM can aid biophilic design in a hospitality studio. One half of the class was given the BDM throughout the design process, the other half was not. At the end, everyone completed an assessment of their own design solutions and a pre- and post-questionnaire was included. The use of a mixed method approach was employed for strengthening the BDM to expand the potential for future application.

CHAPTER 2
ESSAY 1

A systematic development of the biophilic design matrix attributes, broadened application and further validation of a biophilic interior design tool: The objective of this research was to develop the Biophilic Design Matrix. It was originally created to support designers in identifying and quantifying biophilic features through a visual inventory. This study continues the process of establishing a formal language for biophilic interior design, as well as validating the Biophilic Design Matrix. Background: The Biophilic Design Matrix offers a variety of choices for designer-driven integration of biophilia. It was developed to assess the variety of biophilic features in the interior. Methods: The original BDM attributes were reassessed and those appropriate to interior design were put through two rounds of cognitive testing with pre- and post- questions. The list of features was then refined, definitions developed, and examples included for each attribute to aid in the ease of biophilic identification. Fifty-four design features were finalized. The attributes were then further tested with 23 practitioners. Results: The systematic development and validity testing of the tool resulted in a matrix relevant to designers. It now offers an expanded application beyond the original setting. Also, its usability and functionality are attested. Practitioners showed increased perceived knowledge of biophilic design after use. The six element categories showed internal reliability, as did the Biophilic Design Matrix as a whole. Conclusions: The revised Biophilic Interior Design Matrix (BID-M) enhances users' knowledge of biophilic design and is useful throughout the design process for guiding creative biophilic design solutions.

Literature Review

Love of life. This is an innate need people have to connect with nature and natural systems, or biophilia (Wilson, 1984). Modern Americans are spending more time inside with

limited direct contact with nature (Klepeis et al., 2001). It has been a growing concern since connecting with nature has positive influences on human health and wellbeing (Heerwagen, Judith & Hase, 2001; Kahn, 1997; S. Kellert, 2008; Louv, 2008; van den Berg, Koole, & van der Wulp, 2003). Research has shown active and even passive viewing of nature can be influential (Hensley, 2015; Kahn, 1997; Ulrich, 1984). Active engagement with nature is optimal, but even viewing features found in nature, such as complex fractal patterns, allows the mind to easily range from directed attention to fascination as needed for mental and physical wellbeing (Hagerhall, 2004; Joye, 2007; Kaplan, 1995). These views of natural features create a "neurological nourishment" as our brains effortlessly process complex information from living or artificial sources (Salingaros & Masden II, 2008). People react negatively to an environment that is neurologically non-nourishing with distress and anxiety. There needs to be organized complexity, not too plain and not presenting disorganized complexity. Biophilic design then needs to mimic this natural complexity. In a recent study, an increase in biophilic variety was found to parallel an increase in the assessment of "best" playroom by specialists (Weinberger, Butler, McGee, Schumacher, & Brown, 2017) which may indicate that as natural environments are varied, so people seek similarly nature-based varied interior spaces. In this way, biophilic design is serving as a modern "rediscovering" of the connection between humans and the sensorial environment around them (Salingaros, 2011).

There are also economic advantages of biophilic design across diverse building sectors that show fiscal disadvantages of ignoring nature, including profit loss (Browning et al., 2012; Heerwagen, 2010). It can be argued that "incorporating nature into the built environment is not just a luxury, but a sound economic investment in health and productivity, based on well-researched neurological and physiological evidence" (Browning et al., 2012, p. 3). A literature

review reveled increases in healing rates, learning rates, productivity, property values, reduced absenteeism, medical costs, stress and even reduced prison costs Browning et al., 2012). These findings support commercial investment interests.

Restorative Environmental Design

In design people are attempting to help preserve the natural world through limiting resource use and it has become the standard approach. A new approach to sustainability goes beyond simple resource reduction and can be seen through a design paradigm called restorative environmental design (RED) which is a unique concept defined as:

> … an approach that aims at both a low-environmental-impact strategy that minimizes and mitigates adverse impacts on the natural environment, and a positive environmental impact or biophilic design approach that fosters beneficial contact between people and nature in modern buildings and landscapes. (Kellert, 2008b, p. 5).

Designers of interior environments are substantially responsible for specifying features that either provide, or do not provide, opportunities to reconnect with nature both through interior/exterior connections and interior features (Kellert, 2008b). Offering nature-based features to users in buildings should ultimately allow people to increase their biophilia and research shows that such connections can increase health (Beute & Kort, 2014; Hartig et al., 2011) and wellbeing (Kahn, 1997; Kaplan, 1995; Matteson, 2013; Ulrich, 1984, 1991). The great amount of time spent in the interior (Klepeis et al., 2001) and the nascent research support (Green & American Society of Landscape Architects, 2012) requires looking specifically at biophilic interior design, also how it might support RED.

In RED, a sustainable approach goes beyond minimizing environmental impact to increasing ecological health. However, it is becoming apparent to many that the next step for the sustainable design movement is mimicking the natural habitats humans innately prefer (Cama,

2013). How interior design can best mimic nature is still a vague and elusive strategy, since currently there is little support for guiding best practices for how to create such natural spaces.

Kellert first operationalized biophilia in 2008 to guide designers and other building stakeholders. Based on this list of features, the BDM was applied to interior child life play rooms in healthcare settings and added a scoring procedure (McGee, 2012). Preliminary reliability was good but the need to further develop the BDM was apparent. The process of instrument development typically has an iterative nature. The formulation of concepts and the measurement process when applied commonly leads to further modification in order to capture a more adequate representation (Adcock & Collier, 2001). The development of a measurement tool for biophilic design asked the following research questions:

1. How do designers perceive biophilia?
2. What is the optimal BDM for designers to enhance usability?
3. How validly and reliably does the revised BDM appear to measure the variety of biophilic features present in a space when used by interior designers?

The Original Biophilic Design Matrix

Opportunities for improvement of the original BDM were noted by the researcher and by the inter-rater testers as they attempted to use the original BDM. The matrix was not particularly user friendly and quite time consuming to complete. Many of the attribute definitions adopted from Kellert's original list were wordy and difficult.

The attribute *color* in the original BDM showed no discrimination because it was simply described as "any color", as such it was not very informative. Color is complex with direct relationships with lighting and materiality (Bosch et al., 2012). It seemed of key importance to develop these three concepts for interior design application. The adaptation of the Color Planning Framework (Portillo, 2009) was introduced to address this weakness. This framework uses five categories for an evidence-based approach to color planning and how they impact people and

space design. These are now adopted and have been adapted to represent color, light, material and space concepts more distinctly in the fourth element group of the BDM which is now called *color and light*. The new attributes in the element of "color and light" are based on Portillo's (2009) five design tactics: compositional (shaping space), communication (creating meaning), preference (reflecting individuality or market trends), response (arousing feelings and responses) and pragmatics (responding to resource parameters). To illustrates further, an example of *communication* is color selection inspired by the site for telling a visual story connecting the inside with the outside. This is based on the human need for communicating through design and interpretive meaning. Regarding color as *composition*, "working with color compositionally requires objective problem-solving to integrate color, lighting, and materiality" (Portillo, 2009, p.7). It needs to be understood individually and with its surrounding composition, such as color palettes based upon nature. *Preference* can include such things as personal preference for certain natural fabrics or colors over synthetic ones. Also, types of art preference varies with more nature representations preferred (Eisen, Ulrich, Shepley, Varni, & Sherman, 2008) . *Response* to the natural environment is an innate reaction and designers can mimic these considerations as people will have responses to stimuli in the interior. Comfortable seating in an area where you want a low-stress feeling, is one example. *Pragmatic* concerns can include sustainability features and maintenance considerations that increase life cycle as well as safety features, like using resilient fabrics and lighting in high traffic areas. These 5 attributes adopted from the Color Planning Framework further develop the BDM as a tool for designers to use in the design process.

Design and Assessment Tools

Designers are adopting tools in the design process more commonly to support green building design standards (Edwards, 2010). LEED is the most common sustainable building

design standard (Nguyen & Altan, 2011) with little biophilic consideration (Kellert, 2004). WELL v.2 is a health and well-being focused building design standard that includes both a quantitative and qualitative biophilia feature ("WELL v2," n.d.). These address nature incorporation qualitatively within environmental lighting, layout, natural patterns and direct interaction. For the quantitative feature, a specific minimum amount of indoor plants is needed. It also has other related features like a water category, but its goal is specific to health-related considerations in general, not concerned with experiential connection to nature that addresses human health, well-being, and spirit. WELL uses the Living Building Challenge as its guidance for these two biophilic features. The Living Building Challenge v3.1 has similar features without a plant mandate and are specifically using Kellert's original definitions for biophilic design that he proposed in 2008. It is a green building certification program and sustainable design standard for ideal built environments including integrating people with nature (International Living Future Institute, 2014). It includes design features that incorporate actual nature, represent nature, natural patterns, color and light, natural relationships and connections to the place. The Living Building Challenge creators, International Living Future Institute, also host a biophilic design initiative aimed to connect people with nature in the built environment and increase access to resources plus connecting research and researchers with design practitioners ("Biophilic Design Initiative," n.d.). This includes access to case studies, a map and links to biophilic examples. This is helpful in supporting biophilic design. These tools were not developed specifically for interior designers and relies upon the original language from Kellert to guide biophilic design. After a review of the top tools available for aiding biophilic design, currently there is a lack of interior design biophilia focus that could offer specific, user-friendly interior design tactics for designers to use.

Sustainability and evidence-based design do offer models for reference in development of the BDM. Examples like LEED and the Living Building Challenge are used as both a design and assessment tool and were used as references to expand the BDM, initially an assessment tool, to a design tool as well. The BDM can best be symbiotically used with these existing tools in aiding biophilic design. Many of the items in WELL and Living Building Challenge correspond to biophilic attributes, so it would be optimal if the BDM were used as inspiration and guidance to achieve the goals of such building standard programs. This research supports this through adding improved wording and examples in the revised BDM to guide design application of biophilic design.

Method

Research Design

This study integrated a mixed-methods approach in an exploratory manner. Social science exploration is a designed process for "maximizing the discovery of generalizations leading to description and understanding of an area of social or psychological life" (Stebbins, 2001, p. 3). This study attempted to further operationalize biophilic design for interior design practice through two phases, Phase one: BDM development and Phase two: BDM Testing (Figure 2-1).

The online survey used in both phase one cognitive testing and phase two BDM testing with practitioners used a photoethnography method for completion of the BDM assessment of the given site. The site images were provided through a link added to the online survey. This photo-based assessment was a consistent approach with the original instrument development that proved preliminary reliability and validity (McGee & Marshall-Baker, 2015). The lobby of a research building waiting areas was used for both phases. This LEED platinum building seemed an appropriate example to use as it was:

> Inspired by the principles of the Biophilia Hypothesis, the project emerges from the inherent human affinity for natural systems and processes. Understanding the environmental forces of the site, as well as the surrounding context which includes wetlands, wooded gardens, a parking structure and a cogeneration plant, informed the programmatic organization, massing and site strategies. The concept…emerged from the desire to provide sustainable healing, working and educational environments ("University of Florida Clinical Translational Research Building," 2014)

This same site was used for the phase two study.

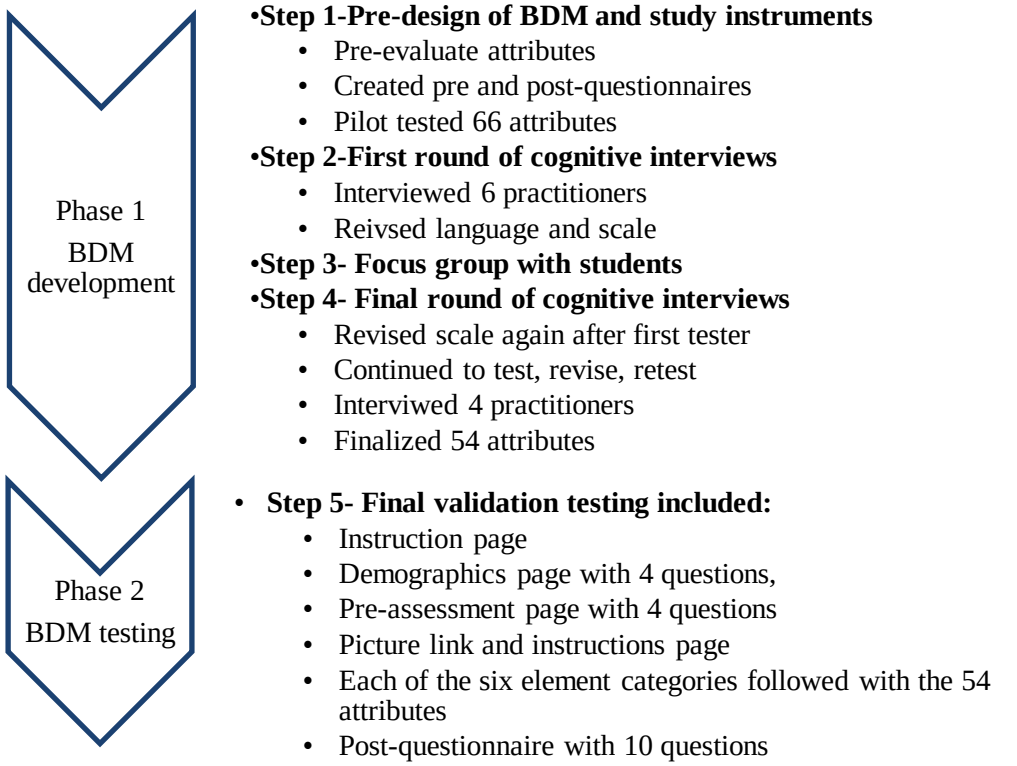


Figure 2-1. Study process diagram.

Phase One: Biophilic Design Matrix Development

Step one

Phase one had four steps of development. The first step was the preparation needed to begin the cognitive testing. It started with reassessing the initial list of attributes from Kellert (2008) to see which ones were appropriate generally to interior environments. Of the 74 features, 66 were included in the first phase of development. The eight not included were exterior focused

and/or duplicated in other features. Additionally, four were merged for similarity in interior design: *sensory variability* with *information richness* were merged and *simulation of natural features* with *biomorphy* were also merged. Moreover, the need to further develop color, as well as its interaction with light and materiality in the interior, were attempted to be resolved by adapting the Color Planning Framework (Portillo, 2009, see Essay 2).

The definitions were only modified if needed for clarity in the application to interior design. These were organized in Kellert's six elements: *actual natural materials, natural representations, natural patterns and processes, light and space, place-based relationships and human-nature relationships.* See Table 2-2 for the element definitions.

The pre- and post-questionnaire and the BDM assessment were created as a single online survey. The initial questions were developed by creating multiple versions of each to see which ones seemed to be clear and concise. It was then pilot tested with an interior designer for readability, use of the site images and general flow of the survey. The feedback helped to revise the clarity of the instructions and images to prepare for the first round of cognitive testing.

Figure 2-2. Site image examples.

Step two

Step two was then testing the BDM in a round of cognitive interviews. Cognitive interviews (CI) are the administration of a draft version of an instrument that includes additional collecting of verbal information about the participant's survey response and their mental

processes (Beatty & Willis, 2007). Cognitive interviewing procedures were used in order to verify that the tool made sense to the target population and was answerable (Krueger & Casey, 2015), also evaluating the quality of responses and if the question was collecting the kind of information intended (Beatty & Willis, 2007). This approach emerged in the 1980's in the cognitive sciences to add insights into questionnaire design decisions (Campanelli, 1997). The use of this testing was to make sure everything made sense to the users for gaining valid information, as such "cognitive testing should be a standard part of the development process of any survey instrument" (Collins, 2003, p. 229). Additionally, "cognitive interviewing can play an important role answering the current demand about empirical and theoretical analyses of the response processes as a source of validity evidence in psychological testing" (Castillo-Díaz & Padilla, 2013, p. 963). This is important to measurement error and whether respondents misunderstand questions or concepts. Additionally, it is important to know if people do not know or cannot recall the necessary information, use incorrect judgment references, hide information or are only providing a perceived socially desirable answer. The use of cognitive interviewing can help to identify such issues (Beatty & Willis, 2007).

The two main paradigms since 1984 for cognitive interviews are think aloud and probing (Beatty & Willis, 2007). The think aloud paradigm asks respondents to report what they are thinking while they are attempting to answer the question with the interviewer, who is also prompting for information from the respondent as needed. Notes were taken in the manual, see Appendix C. These notes were typed up and then guided adjusting the BDM and the questionnaires. This testing used "think aloud", as it is a preferred method for being respondent-driven and a low burden (Collins, 2003). The thinking aloud of answers by the individual was to see if the items in the BDM seemed confusing when people were trying to answer.

The probing paradigm uses interviewer probes regarding comprehension, confidence ratings and paraphrasing, instead of thinking-aloud. Think-aloud interviews alone may suggest a problem but not explain what the problem is, and probes address this gap. The blending of the two original paradigms is a new paradigm (Presser, 2004) and was used in this study where the participants were asked to think aloud with additional prompting via a post-questionnaire including a variety of probing types used. The CI probing process can be distinguished in four key probing types: anticipated, spontaneous, conditional and emergent (Beatty & Willis, 2007). According to Beatty and Willis, anticipated probes are scripted ahead of time based on anticipated issues. Spontaneous probes are not scripted and are a response that interviewers make when looking for potential problems based on their own impetus. Conditional probes are scripted but are based on a response from the participants. Emergent probes are unscripted and are based on responses from the participant. Multiple probing types can be used together to address either expected or encountered problems and useful for identifying the most egregious problems in groups of participants. CI is finished when interviews are yielding diminishing returns. "There is always the possibility that one additional interview could yield a significant new insight, or that an additional interviewer would be more likely to notice additional problems. By the same token, claims that a questionnaire has 'no problems' are impossible—the strongest claim that could be made is that no problems have (yet) been discovered" (Beatty & Willis, 2007, p. 303). This study used mostly spontaneous and emergent probes, with some conditional to allow for flexibility and on-the-spot reactions to the participant.

The cognitive interview selection of participants included establishing a level of expertise in the field of over ten years of interior design practice and used convenience and snowball sampling (see Appendix E). Typically in CI, the sampling is used to "reflect the detailed

thoughts and problems of the few respondents" (as cited in (Beatty & Willis, 2007, p. 295) and not necessarily representative of the population. But, again that is not the purpose of CI, as long as relevant respondents are selected in regard to the topic and have demographic variety (Willis, 2005). The sample size required for CI has been a debated topic with current practice finding that a small sample of participants reveal most critical questionnaire problems (Beatty & Willis, 2007). While one study found it may take more than 50 interviews to reveal an undiscovered issue (Blair, Conrad, Ackermann, & Claxton, 2006), generally CI are conducted in rounds of 5 to 15 interviews with repeated revision of questions tested further to eliminate problems (Beatty & Willis, 2007). Interviews were conducted until relatively few new insights were garnered. While it might be short of the point when all insights might stop emerging, it is based on the principle of diminishing returns and a small number of interviews may suffice. Even one interview has been sufficient (Beatty & Willis, 2007; Charmaz, 2014; Willis, 2005). It has been proposed that:

> one potentially useful variation would be to employ an iterative testing approach, based on rounds of testing with questionnaire revisions between rounds. This approach is arguably accepted as an ideal practice, and it would be useful to see whether revised questionnaires are in fact "better," and how rates of problem identification decline across revisions (Beatty & Willis, 2007, p. 306).

This is the approach used in this study with two major rounds testing ten participants, six in the first round and then four in the second round.

All ten participants were interviewed either in person or via a conference call. The first two participants showed a general appreciation for the BDM and their responses prompted further testing. Two more sets of two participants were tested with minor adjustments made between sessions and had similar results. A major revision was needed to fix clarity issues. The pre- and post-questionnaires also were in need of modification based on feedback from the round one participants.

Step three

The third step of this study included a mid-point assessment of the revised BDM by students. The major revision of the BDM included adding a scale to the response choices and fixing the noted repetition among attributes and difficult language. This revision was then tested in a sophomore undergraduate interior design environment and behavior class to verify if designers of all level of experience could understand and use the BDM. The use of groups of students was a type of focus groups. Focus groups have been combined with cognitive interviews in the same study and complementary (Campanelli, 1997). A focus group is used to better understand the feeling or thoughts people have about a topic; they gather opinions. Similar to a standard focus group, the use of a classroom activity collaboratively builds information socially for increased diversity of perspectives and opinions ("CTI - Collaborative Learning," n.d.). In the past using the differing perspectives of students to reveal missing validity issues has also uncovered issues missed by experts during cognitive interviews (Ding, Reay, Lee, & Bao, 2009). The interior design students' considerations proved very insightful during the middle of the cognitive interview process and aligned with many of the practitioner's comments. Using students as a target audience was purposeful in order to assess usability for designers of all expertise levels.

The process involved the researcher and instructor giving an assignment to the sophomore class. There were 26 students tasked to use the original version of the BDM with 66 attributes for an assessment of an on-campus game room. After they gathered together for an in-class activity, they were divided into small groups of 3-5 students and each group was given one of the six elements (categories), from the original BDM. They were directed to document any issues they had with attributes in their given element. They were then given the new version of the same element and instructed to do the same markup process. Each group afterwards shared

their findings collectively with the class regarding how the BDM should still be improved and the differences they saw between the original and modified versions. The assignment aligned with the environment and behavior course content covering research instrument development. This information showed the need for further elaboration of the scoring procedure and additional fine tuning of the vocabulary.

Step four

After the feedback from the students, additional modifications were made, and a revised BDM version was ready for the second round of cognitive interview testing. The cognitive interview participants gave insightful feedback after using the BDM. Both the first and second round of cognitive interviews highlighted the justification for the BDM and its continued development. For example, CI #7 mentioned "I think this would be a benefit for clients to understand the long-lasting effects of the feeling of a space through biophilia". Another commented regarding how they saw themselves using this list of features (BDM) in the future if available. They said it could be a "key design driver, to create connection to place, natural and cultural references" (CI #10). Another designer noted changes they might make in their next design in how they approach adding color, light and materiality and said they would "Keep it at the forefront of my brain while designing, always keeping in mind I can come back to my 'checklist' to make sure I have covered all categories" (CI #3). The education of the client is an interesting finding. One designer said "Yes - I think this would be a helpful tool to use with clients to identify how, not only do they see the space but also how guests/users see and feel in the space" (CI #7). After the cognitive interview results showed marked improvement with clarity issues and a shorter time length required, the final survey was sent out to practitioners. The BDM was finalized with a score range from 0-3: not present at all (0), weak presence (1), moderate presence (2) and strong presence (3). There was also an option to select "not

applicable" for those features difficult to assess in the given site photos. Not applicable was marked as not present for scoring. See Table 2-1 for the CI participant work experience level, time to completion of the survey and the number of issues they found.

Table 2-1. Cognitive interview overview.

Cognitive interview order	Tester's experience in years	Complete Qualtrics time/ minutes	# BDM comments: clarity issues
1	20-25	65	23
2	20-25	63	15
3	10-14	64	14
4	10-14	50	14
5	14-19	87	18
6	14-19	60	27
7	14-19	68	14
8	21-25	45	10
9	26 +	46	3
10	26 +	25	2
Average	20+	57	14

Phase Two: Biophilic Design Matrix Testing

Phase two used the same data collection already tested in phase one, with an online survey. The practitioners were recruited through direct email, snowball sampling or notification through social media, such as LinkedIn and Twitter.

Instruments

The goal of step five was to test the BDM with practitioners in order to assess the perceptions of practitioners regarding biophilia and the improved usability, reliability and validity of the BDM. The finalized list of attributes is shown in Table 2-2 with the related elements noted and the attributes numbered for easy reference.

Table 2-2. Biophilic design elements and attributes finalized.

Actual natural features- actual (not images) of real nature characteristics in the interior	
1	Air
2	Water
3	Plants
4	Animals
5	Natural materials
6	Views and vistas
7	Habitats
8	Fire
Natural shapes and forms- representations of nature and simulations	
9	Botanical motifs
10	Animal-like
11	Shells and spirals
12	Curves and arches
13	Fluid forms
14	Abstraction of nature
15	Inside-outside
Natural patterns and processes- properties derived from natural features and processes	
16	Sensory richness
17	Age, change and the patina of time
18	Area of emphasis
19	Patterned wholes
20	Bounded spaces
21	Linked series and chains
22	Integration of parts to wholes
23	Complementary contrasts
24	Dynamic balance and tension
25	Natural ratios and scales
Color and light- color, light and material qualities and space relationships to nature	
26	Composition
27	Communication
28	Preference
29	Response
30	Pragmatics
31	Natural light
32	Filtered light
33	Reflected light
34	Light pools
35	Warm light
36	Light as shape and form
37	Spaciousness
38	Spatial variety
39	Space as shape and form
40	Spatial harmony
Place-based relationships- culture together with ecology, rooted in geography	
41	Geographic connection to place
42	Historic connection to place
43	Ecological connection to place
44	Cultural connection to place
45	Integration of culture and ecology
46	Spirit of place
Human-nature relationships- paired biological needs of the human relationship to nature	
47	Prospect/refuge
48	Order/complexity
49	Curiosity/enticement
50	Mastery/control
51	Attraction/attachment
52	Exploration/discovery
53	Fear/awe
54	Reverence/spirituality

Similar to the version tested in phase one, the phase two online survey also included the BDM and a pre- and post-questionnaire. The pre-questionnaire had four five-point ordinal scales. The four questions were on biophilic design and its perceived importance, how much they had attempted it, their confidence in using it, and their knowledge of it. The post-questionnaire included one question that asked when they might use the BDM features and could select all that

applied. A question with a five-point scale asked about the importance of biophilic design in interior design. There was another question with five-star rating options (five being the highest score) and seven categories used to assess the quality of the BDM. Additionally, there were seven open answer questions with unlimited answer length. The open answer formatted questions were not limited in the length of response and the coding process used thematic analysis of the participants' comments. The comments were coded by the researcher and a trained research assistant. They agreed on the coding assignment together. Following the coding, related themes were collapsed, see Table 2-5.

The congruent validity of the answers were tested by looking at item-total correlation and inter-item correlation with relation to Cronbach's Alpha (Gliem & Gliem, 2003), since validity and reliability are key to making sure the findings are truly connected to the construct and are then relevant for others to build upon. Each step of this iterative method in developing the BDM builds validity, reliability and discriminatory power into the BDM.

Participants

The final survey assessment of the BDM with practitioners included interior architects and interior designers. The results included 23 practitioners who completed the BDM assessment, had a Council for Interior Design Accreditation (CIDA) or National Architectural Accrediting Board (NAAB) design degree and had been practicing more than 2 years in interior architecture or design. The demographic breakdown, Table 2-2, showed a variety of experience length. The most common certification was LEED and the most common specialization was corporate design.

Table 2-3. Demographics of participants.

Practice years	Frequency	(%)	Certification	Frequency	(%)	Specialty	Frequency	(%)
< 2	0		AAHID	1	3	Corporate	9	26
2 - 5	6	26	LEED	12	34	Healthcare	6	17
6 -10	4	17	NCARB	1	3	Hospitality	4	11
11 -15	3	13	NCIDQ	9	26	Institution	1	3
16 - 20	2	9	Well	1	3	Residential	7	20
21-25	1	4	State license	7	20	Other	8	23
≥ 26	7	30	Other	4	11			

Results

Research Question One: Perceptions of biophilia.

In general, designers saw biophilia as relatively important (a lot or a great deal of importance) to interior design (M = 3.39, SD = .72) with a moderate amount of attempted application (M = 2.26, SD = .92). They were, however, only moderately confident in using biophilia (M = 2.17, SD = 1.03). See Table 2-4.

Table 2-4. Pre-BDM practitioner's perceptions of biophilia.

	Pre-BDM assessment				
	n	*M*	*SD*	*Skewness*	Kurtosis
Importance	23	3.39	.72	-.77	-.59
Attempted use	23	2.26	.92	.21	-.64
Confidence	23	2.17	1.03	.44	-.85

Note: 5-point scale, 5 being high

Designers' knowledge after using the BDM showed they found the variety of choices available for biophilic design as remarkable as well as the availability of the tool, see Table 2-5, column 1. As one designer described it, "There are many subtle ways to bring in biophilic elements." Another designer responded that having the BDM "is a valuable reference tool as we approach wellness goals of the space; the latter are client mindset dependent."

Table 2-5. Post BDM open answers, four most common comments.

Post BDM Assessment					
Any change in knowledge of biophilia	Relative frequency (%)	Ways the BDM can be improved	Relative frequency (%)	Using the BDM in the future.	Relative frequency (%)
Variety of choices	9	More examples/ case studies	6	Design process/ assessment	10
Tool availability	3	Choices clarified/ common language	2	Reference/checklist	3
Increased knowledge/ desire to learn	2	Qualtrics format	2	Client justification/ teaching	2
Concept defined	2	Shorten/chart	2	Teaching aid	2

Research Question Two: Optimal BDM as a Tool

The general perceptions of the BDM was they would use it in the design process or as an assessment, as shown in Table 2-5 column 2 and 3. One designer said, "*It would be a useful reminder throughout a project and especially in the programming and concept design phases*." It could be improved by adding more examples, including case studies. Their use of it as a reference and checklist for ideation was interesting: "*this could be a great checklist to share with clients as part of the design development process"*. Another person said, "*I could see using the BDM with a client interested in promoting wellness in their space without direct access to the outdoor for their employees (in a commercial setting) to create understanding for the importance of incorporating particular design elements or design decisions*." Another commented "*After using the BDM I feel the need to learn more about it and apply it more into my commercial projects*".

Table 2-6. Post BDM, future design process uses.

When might you use the BDM?		
Design Phase	Frequency	%
Conceptual	7	21
Programming	5	15
Design dev	5	15
Post occupancy	1	3
All	15	45
Other	0	0

One additional question asked more specifically when in the design process they might use the BDM, see Table 2-6. The majority response (n=15) was that they would use it throughout the design process with the second highest (n=7) being use in the conceptual design phase. This was again an interesting finding after their use of it as a post-occupancy evaluation.

Table 2-7. Overall quality of the BDM.

Post-BDM assessments					
How would you rate the quality of the BDM as an interior design tool in the following categories					
	n	*M*	*SD*	*Skewness*	Kurtosis
Instruction	22	3.82	.97	-.77	.36
Definition	22	3.93	.68	-1.43	2.23
Name	22	4.16	.63	-.97	1.19
Choices	22	3.96	.47	-.58	.04
Comprehen-siveness	22	4.39	.75	-.63	-.373
Overall Clarity	22	4.07	.90	-1.21	2.35
Helpfulness	22	3.96	.66	-17.95	3.40
Total BDM score of the given space					
BDM score	22	63.00	21.08	4.51	2.01

Note: 5-point scale, 5 being high, 54 items, one person did not complete this question.

The BDM quality was rated using a 5-point scale; the mean scores ranged from 3.8 to 4.4, see Table 2-7. Also, the BDM as an assessment tool now has a total possible score of 162.

This is based on adding up each attribute's possible score (0-3). The total score for the practitioner's assessment of the given space averaged 63. Several practitioners noted that they saw the space lacking in biophilic variety and feeling very cold, which may have been represented in the BDM scores. This is preliminary testing so there is not a set high vs low score, which may be a future development.

Research Question Three: BDM Validity and Reliability

The element categories were internally reliable as shown in the Cronbach's Alpha results of the elements in Table 2-8 with a range α =.77 to .91 (DeVellis, 2017). The overall BDM as a whole scored α = .94. Additionally, the individual attributes were assessed with the following criteria:

- Cronbach's Alpha, greater than or equal to .70
- Inter-item correlations, greater than .15
- Corrected item-scale correlations, greater than or equal .50
- Cronbach's alpha's if item deleted, decrease in alpha if item deleted

Table 2-8. BDM reliability element and combined results.

BDM reliability testing			
	n	# of attributes	*Cronbach's Alpha*
Actual Natural Feature	23	8	.79
Natural Shapes and Forms	23	7	.77
Natural Patterns and Processes	23	10	.79
Color and Light	23	15	.75
Place-Based Relationships	23	6	.91
Human-Nature Relationships	23	8	.86
All elements combined	23	54	.94

The criteria used excluded 4 attributes: *habitats, composition, pragmatic* and *reflected light*. None of the Cronbach's alpha if item deleted scores for these four items was drastically different from the element category Cronbach's Alpha score: *habitats* (Cronbach's alpha if item

deleted was .82 up from .79 for the element), *composition* (Cronbach's alpha if item deleted was .76 up from .75 for the element), *pragmatics* (Cronbach's alpha if item deleted was .80 up from .75 for the element) and *reflected light* (Cronbach's alpha if item deleted was .77 up from .75 for the element). Additional rounds of test-retesting of the Cronbach's alpha by removing these items and looking at resulting correlation issues increased the Alpha only slightly. These items should be re-assessed before removing them to see if revised definitions with an alternate assessment site may provide more rich information and may contradict these findings. The overall reliability was good, so future testing is needed to expand upon the findings here and address the potentially biased sampling.

Discussion

Designers see biophilic design as important, however they had only moderate confidence and previous experience in using it. Future testing with experienced users of the BDM can see if knowledge increased correspondingly with confidence levels. This would align with other findings of a correlation between confidence and knowledge in evidence-based practice among occupational therapy students as experience increased (DeCleene Huber et al., 2015).

After identifying that biophilic design was important, finding out what kind of tool would support interior designers was even more relevant. The BDM was helpful, had an overall good quality level and was considered a design aid to the entire design process. It was both relevant and useful as a design aid but could also be used to teach clients and explain design decisions. This aligns with Kirk Hamilton's view on an evidence-based designer being one that makes decisions with an informed client (2004). In this regard, it is a tool that designers can use to help clients see the diversity of the needs of building occupants by having conversations with them at the beginning of a project. This is optimal for working within the building information modeling process (Azhar, Khalfan, & Maqsood, 2012).

To insure the future of the work done here, the concept of biophilic interior design is proposed, distinct but under the umbrella of biophilic design. To align with this, the name of the BDM is being changed to the Biophilic Interior Design Matrix with a coordinating toolkit of parts. The biophilic interior design (BID) toolkit has the following four components now available at http://redgatordesign.wixsite.com/biophilicdesign:

- biophilic interior design matrix (previously the BDM), BID-M
- biophilic interior design checklist sheet, BID-C
- biophilic interior design reference document, BID-R
- online biophilic interior design research repository

The BDM was overall seen having a good quality and could be used as an assessment tool so it is now called the BID-M. It was also seen as a design aid so a simplified version without the scoring feature was created (BID-R) for this purpose, as well a single page list of all the attributes created for a quick reference "checklist". Huber found similar to this study that interior designers are seeking information about biomimicry/biophilic design, and there is an "opportunity to narrow the research utilization gap by making scholarly sources more approachable" (Huber, 2018, p. 25). Thus, having used a participatory design process with designers helped to result in an easily adaptable toolkit and is an important advancement toward an established biophilic interior design language being operationalized.

Since nature is a sensorial varied experience, a varied biophilic-based interior should be part of a nature-based design strategy. The original BDM was based upon this idea but was originally only applicable to one setting, had difficult language and required a long time to complete. The new version has improved usability and is easily accessible online with a more robust reliability and validity. The BID-M is poised to aid the identification of a variety of features with validity results indicating the features can be assumed to be biophilic. The impetus is placed on designers to use the list of features for their thoughtful integration of variety to aid

their design process. In this regard as the BID-M develops it can aid designers using WELL and Living Building Challenge. It offers clear language, research support and example strategies to give guidance for designers. This should ultimately encourage more participation in these programs for greater biophilic design, ultimately increasing the knowledge base and encouraging further projects.

Revisiting the four attributes with low internal reliability could be improved, especially with the three that clustered in the color and light category deserving further consideration as a group. *Habitats* (the interior of buildings and their landscapes that possess a close and compatible relationship to local habitats) may have been an issue with people trying to decide whether to include the manmade landscape outside as being considered a local habitat. *Composition* (color, light and materials applied as a composition through unity and/or variety connecting with nature) could have been an issue with the overall design feeling not very natural with the mostly grey interior, while others did see the large window and indoor/outdoor feel very unified. *Pragmatic* (color, light and materials selection based upon maintenance, life cycle cost, existing conditions, external weather and/or environmental choices) could have also varied with some people appreciating the durable materials and others not seeing this an obvious design decision in the photos. *Reflected light* (light reflecting off surfaces) could have been an issue to some not seeing the reflections of overhead light in the floor, while others may have seen the mostly matte surfaces as not offering significant sparkle to count as offering reflected light. These may be examples where the assessment was difficult based on the site used or the definitions and the features need to be improved, or they may be just truly not related close enough to the elements and moved elsewhere or removed. These might however perform better through use as a design tool to justify their inclusion. Overall, the BID-M offers a systematic and

holistic biophilic interior design tool and language for aiding designers in incorporating nature in the interior.

Figure 2-3. Proposed restorative environmental design framework diagram.

In this study interior designers saw relevance in biophilic design attributes and the current list of attributes provides a concrete list to reference, use in the design process and educate others. It also highlights how interior design can uniquely play a part in restorative environmental design. The combination of sustainability and biophilic design can best be obtained when the different design professions work together alongside of the building stakeholders/users from the beginning of the project. A new proposed framework, see Figure 2-2, diagrams how these different parts combine as a bridge between sustainability and restorative environmental design. This ultimately benefits the future of people and the planet when everyone comes to the table and works together to optimize the design solution for sustainability and biophilia.

CHAPTER 3
ESSAY 2

A study of the current status of color, light and materiality in biophilic interior design literature and practice: Although there is growing evidence for biophilic interior design, there is little guidance for designers in attempting to include evidence-based biophilic design features, specifically through the most common interior design tactics color, light and materials. The Biophilic Interior Design Matrix was recently developed to facilitate the identification of a variety of biophilic features among 54 attributes in six elements, with a specific expansion in color, light and materials, however these features lack a current connection to evidence. To address that short fall, a modified systematic literature review was conducted in regard to color, light and materials. In linking research to biophilic attributes it begins to provide evidence and guidance for their adoption. Additionally, a survey of interior design professionals identified the current state of biophilic design practice, specifically regarding the use of color, lighting and materiality. The exploratory literature review found relevance among a variety of the biophilic attributes in 19 studies. Similarities and differences were found with practitioners biophilic design applications compared to the research. Designers focused their biophilic integration on considerations for human response and preference, as well as connecting to the locale. These topics were not as highly identified in the literature. Plants and abstraction of nature were additional tactics used by practitioners that had a greater research focus. An emphasis in research and practice occurred within the newly adopted attributes from the Color Planning Framework and they offer a more robust view of color, light and material integration strategies for biophilic interior design.

Background

Designing with nature has become a growing trend and this includes evidence-based design principles that support the use of nature-based environmental design for optimizing people's wellbeing (Kellert, 1993). This is known as biophilic design, or an approach that attempts to mimic the natural environment to gain possible benefits. The Biophilic Interior Design Matrix (BID-M) assists designers with identification of biophilic features through 54 biophilic attributes that are categorized in six elements. These elements are titled: *actual natural materials, natural representations, natural patterns and processes, color and light, place-based relationships and human-nature relationships*, see Appendix I. There was currently no systematic and holistic way for designers to incorporate nature and so the further development of the BID-M was recently warranted to optimize its usability. Color, light and materiality are three universal concepts used in interior design (Bosch et al., 2012; Dalke et al., 2006), yet they were underrepresented in the BID-M in the original version. Five new attributes were added from the Color Planning Framework (Portillo, 2009) to the fourth element, *color and light*. With this development, there are new opportunities for research. The first is the ability to investigate the current state of biophilic research among color, lighting and materiality with the 54 attributes. Second is investigating biophilic practice in relation to color, light and materiality to see what types of strategies designers are using. This allows for knowing the current state of biophilic design in research and practice to better support practitioners through future research.

The term biophilia was original defined by E.O. Wilson in his studies of biology (1984). Connecting with nature allows people to experience neurological nourishment, with physical, psychological and spiritual outcomes (Kahn & Kellert, 2002; Kaplan & Kaplan, 1989; Louv, 2011; Ulrich et al., 2008). Biophilia is joined with sustainability in the restorative environmental design (RED) framework for creating holistically beneficial buildings. RED views buildings as

being “protective in both direct and indirect ways” (Hartig et al., 2008, p. 139). Within this framework, the Biophilic Interior Design Matrix (BID-M) uses a variety of features to support design decisions for long term beneficial connections between people and nature (McGee, 2012). These features include:

Table 3-1. Biophilic design elements and attributes.

	Actual natural features- actual (not images) of real nature characteristics in the interior
1	Air
2	Water
3	Plants
4	Animals
5	Natural materials
6	Views and vistas
7	Habitats
8	Fire
	Natural shapes and forms- representations of nature and simulations
9	Botanical motifs
10	Animal-like
11	Shells and spirals
12	Curves and arches
13	Fluid forms
14	Abstraction of nature
15	Inside-outside
	Natural patterns and processes- properties derived from natural features and processes
16	Sensory richness
17	Age, change and the patina of time
18	Area of emphasis
19	Patterned wholes
20	Bounded spaces
21	Linked series and chains
22	Integration of parts to wholes
23	Complementary contrasts
24	Dynamic balance and tension
25	Natural ratios and scales
	Color and light- color, light and material qualities and space relationships to nature
26	Composition
27	Communication
28	Preference
29	Response
30	Pragmatics
31	Natural light
32	Filtered light
33	Reflected light
34	Light pools
35	Warm light
36	Light as shape and form
37	Spaciousness
38	Spatial variety
39	Space as shape and form
40	Spatial harmony
	Place-based relationships- culture together with ecology, rooted in geography
41	Geographic connection to place
42	Historic connection to place
43	Ecological connection to place
44	Cultural connection to place
45	Integration of culture and ecology
46	Spirit of place
	Human-nature relationships- paired biological needs of the human relationship to nature
47	Prospect/refuge
48	Order/complexity
49	Curiosity/enticement
50	Mastery/control
51	Attraction/attachment
52	Exploration/discovery
53	Fear/awe
54	Reverence/spirituality

The BID-M was originally based upon Kellert's (2008) proposal of biophilic features. It can be used to assist with creative design generation during the programming and design development or can be used as an evaluation tool (see Chapter 2 and 4). The BID-M supports the evaluation of nature-based features for an overall assessment of biophilic variety. Since nature is a highly varied environment, greater variety should be more likely to support biophilia. This has been initially validated by a recent study where specialists rated spaces and then correlated with the amount of biophilic variety (Weinberger et al., 2017). The recent BID-M redevelopment was through a systematic participatory method with improved reliability and validity (see Chapter 2).

The Biophilic Interior Design Matrix had its foundation in Kellert's proposition of biophilia being a weak biological tendency that is:

> reliant on adequate learning, experience, and sociocultural support for it to become functionally robust. As a weak biological tendency, biophilic values can be highly variable and subject to human choice and free will, but the adaptive value of these choices is ultimately bound by biology. Thus, if our biophilic tendencies are insufficiently stimulated and nurtured, they will remain latent, atrophied, and dysfunctional (Kellert, 2008b, p. 4).

The ability for people to connect with nature, natural systems and processes inside of the built environment ultimately is facilitated or impeded by the design of the building, including its interior design. Evidence is beginning to show that "people's physical and mental well-being remains highly contingent on contact with the natural environment, which is a necessity rather than a luxury for achieving lives of fitness and satisfaction even in our modern urban society" (Kellert, 2008b, p. 4). However, modern Americans spend about 90% of time inside and this limits direct nature contact (Derr & Kellert, Stephen, 2013; Klepeis et al., 2001).

Lighting

In regard to designing with light, the definition of light is "the natural agent that stimulates sight and makes things visible" according to the *New Oxford American*

Dictionary (2018). Designing with light requires thoughtful layers of lighting applied for function and aesthetics and when done well it reveals the beauty of the design and enhances the colors and materials of the space (Livingston, 2014). Light can direct attention, provide functionality for tasks and spark the imagination. Richard Kelly, the "father" of architectural lighting design, used a variety of focal glow, ambient luminescence and the play of brilliants (known today as ambient, task and accent lighting). While light is both a wave and particle and can have objective measurements applied, it is also an important element of composition and reveals form. It is inextricably tied to materiality and the visual assessment people have of an interior with subjective effects on mood (Livingston, 2014). It is also influenced by the room. Livingston notes this:

> One aspect affecting the distribution of light is the way surfaces interact with light. What we perceive as brightness is not just the amount of lighting in a room. Room brightness is a combination of the intensity of the light and the reflecting, diffusing, transmitting, and absorbing properties of the surfaces in the room (2014, p. 67).

The quality of natural light especially influences the interior; direct access to natural light has growing research support (Alimoglu & Donmez, 2005; Beute & Kort, 2014). Some of the specific approaches to the use of light in the BDM include filtered light, reflected light, light pools, warm light and light as shape and form. All of the features are defined in Appendix B.

The quality of natural light especially influences the interior with direct access to natural light having growing research support (Alimoglu & Donmez, 2005; Beute & Kort, 2014). Some of the specific approaches to the use of light in the BID-M include *filtered light, reflected light, light pools, warm light* and *light as shape and form*. *Filtered light* is modulated daylight which reduces glare through the use of blinds, shades or tinted glazing, for example. This is representative of the filtered light found under a tree canopy that offers protection from too much sun exposure. Reflected light is the light that reflects off of surfaces and is what provides the

sparkle, or play of brilliants as Richard Kelly called it. It is the found in sunlight reflecting off of water and the shimmer off morning dew. The use of mirrors and small lights can replicate this. Light pools are pools of connected light in a series on the floor or wall drawing you from one area to another, often surrounded by darker areas, such as in high contrast lighting environments that provide emphasis. Retail stores use this to bring customers toward the highlighted merchandise as in nature; the well-lit path draws us forward. *Warm light* is lighting that has a 2,000 to 3,000 K color temperature and is inviting, like a fire that draws you in to get warm. The use of candle light is a good example that makes a space feel cozy. *Light as shape and form* is present when natural light is manipulated to create stimulating, dynamic and/or sculptural form. The use of light shafts or skylights can represent a beam of light that breaks through a cloudy sky. These lighting considerations are housed in the *color and light* element to align with its close relationship in biophilic design with light, color and materiality.

Materiality

The definition of materiality is the "quality or character of being material or composed of matter, with material being defined as the matter from which a thing is or can be made" (*New Oxford American Dictionary*, 2018). Designing with materiality requires attention to the interconnection of the human experience and how properties engage people (Gesimondo & Postell, 2011). Materials can be highly subjective, such as our preference for a particular material and object materiality is influenced by its properties. Additionally, "environmental context and cultural bias collectively give materials their broader meaning, while interior space offers a spatial framework for daily experience" (Gesimondo & Postell, 2011, p. 3). Portillo adds a poignant thought to the relevance of material selection as it relates to nature:

> Just as the hues of nature have inspired artists through the ages, introducing natural materials into designed spaces creates a coloration that is often nuanced and complex. Some designers and schools of thought embrace a truth-to-materials

> stance that celebrates materiality in design. This perspective elevates natural materials over applied color finishes, such as paint. Regardless of the design stance on authenticity, color planning should be approached with intention and purpose (2009, pg. 5).

Additionally, Portillo (2009) points out that it is not as important to look at if something is authentically "natural", like if a faux painted stone wall is less natural than a real stone wall. It is more important to consider how it is being applied to support the design of the space and ultimately the users as well. The BID-M allows for such an approach as individuals can explore their individual assessments of the degree of strength a particular feature has in the interior while acknowledging variety in effect and affect. Both actual, representational and other types of nature connections are included in the matrix that cover a broad range of nature-features that will interact with color, light and materials.

Color

According to the *New Oxford American Dictionary* (2018) the definition of color is "the property possessed by an object producing different sensations on the eye as a result of the way the object reflects or emits light". Color is a concept that "elevates the human experience and transforms space; yet, the process of designing with color can be quite complex and challenging" (Portillo, 2009, p. 1). Designing with color requires both understanding and accounting for subjective and objective responses. People have individual responses to color and yet there can be commonalities across user groups and cultures (Lee & Park, 2011; Park & Park, 2013). There are objective realities with color that are consistently able to be measured, such as color wavelengths, and these require understanding light because "the properties of lighting and illumination influence color appearance" (Portillo, 2009, p. 45). Plus, the materials in a space brings with them color, as well, being influenced by the conditions of the surrounding materials (Gesimondo & Postell, 2011). To further consider these concepts, the Color Planning Framework

was adopted and adapted within the BID-M to represent color, light and materials. The original BID-M included color defined simply as any color and as such was not helpful in guiding designers in further development of design solutions. It was also clear that there needed to be improvements in the overall user-friendliness of the tool. The revised BID-M addressed these issues and resulted in a list of 54 features with refined definitions and nomenclature that makes it more user-friendly as a tool. The Color Planning Framework (CPF) was used during the BID-M revision as a criteria-based framework with five functions added as attributes.

Color as *preference* is "color, light and materials reflecting the time, place, and circumstances in which we live" (Portillo, 2009, pg. 65). Examples include a designer or firm's signature style and market trends, such as the Pantone color of the year. People have subjective likes and that is a valid design consideration. One example of *preference* would be to reflect local favorite landmarks in the design.

Color definitely influences people's response to a design to various degrees. *Response* is defined as natural inspired color, light and materials integrated for physiological, psychological and/or behavioral responses (e.g., light fixtures that mimic sunrise/sunset patterns). Color response with engagement in interiors can include arousal and emotion, color and temperature, performance and memory, flavor and consumption, and productivity (Portillo, 2009). Color response is influenced by lighting variation and materials used. Currently many design findings from research are hard to generalize but the link to nature and people's general biological response to color, light and materials is a key future research path. Empirical research on "color and emotion, temperature, memory, and the perception of flavors (even food and beverage consumption and preference) shed light on the influence of color. More complex behaviors, like workplace performance, are much more difficult to research and predict" (Portillo, 2009).

Research is needed but nature-based research related to preference is growing (Cho & Lee, 2017; Coad & Coad, 2008; Eisen et al., 2008).

Pragmatics reflects the practical realities of designing with color, light and materials. It is defined as "color, light and materials selection based upon maintenance, life cycle cost, existing conditions, external weather and/or environmental choices". An example is a sustainable flooring choice for high traffic area. This links well with the historical practice and modern rediscovery of the need to use local and regional materials when possible, as well as selections with life cycle and durability in mind.

The two independent research studies included a systematic literature review and a survey of practitioners, see Figure 3-1. The resulting research questions were:

1. What evidence for color, light, and materials can support the biophilic design attributes?
2. How through color, light and materials is biophilia being incorporated into design practice?
3. What are the similarities and differences between the research available and designers' use of color, light and materials.

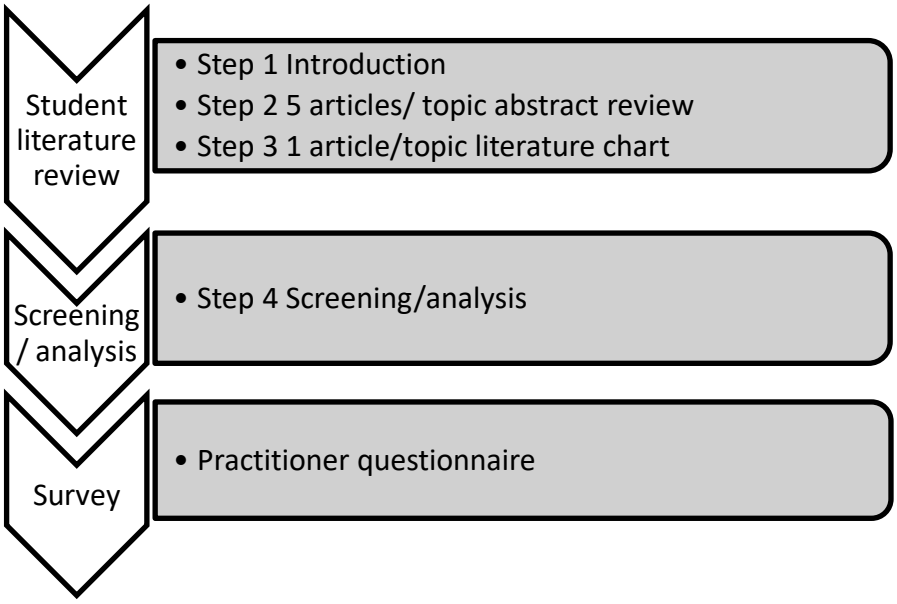


Figure 3-1. Process diagram for both studies.

Study 1

Method

During the process of developing the Biophilic Interior Design Matrix there was found under-representation in the topics of color, light and materiality. It was then desired to develop those topics in relation to linking the available evidence for their inclusion in biophilic interior design.

The protocol for the literature review follows the 2015 PRISMA-P Checklist (Shamseer et al., 2015). This is a protocol that provides a set of items for developing and reporting systematic reviews. The rationale for the review was the growing number of research studies on features that look at biophilia or are related, yet there has not been an attempt to link research to the variety of biophilic design attributes. Since the revision of the Biophilic Interior Design Matrix was aimed at assisting designers with evidence-based design, the list of features could benefit by being linked to research for supporting evidence-based practice. Limitations of the study included not analyzing the entire database of options, as the original number of articles selected was limited from the start to five per topic in order to be feasible for students.

The review focused on intervention and outcomes regarding research for color, light, and materials supporting the biophilic design attributes (see Appendix A for the assignment sheet). Students had already been exposed to how to conduct a literature review. The junior interior design students in a lighting design class had already learned how to conduct a literature review and the learning objectives were to improve upon their ability to access and synthesize research and familiarize themselves with research related to color, light and materiality, as these were the overarching topics covered in regard to lighting design. They were given a set list of criteria to search through the University library OneSearch feature or GoogleScholar. InformeDesign was also highlighted in class.

- Art and Architecture Source
- Building Green
- Compendex
- Dissertations and Theses Global
- Materials Research Database
- Referex Engineering - Materials and Mechanical Collection (Engineering Village)
- Web of Science
- InformeDesign

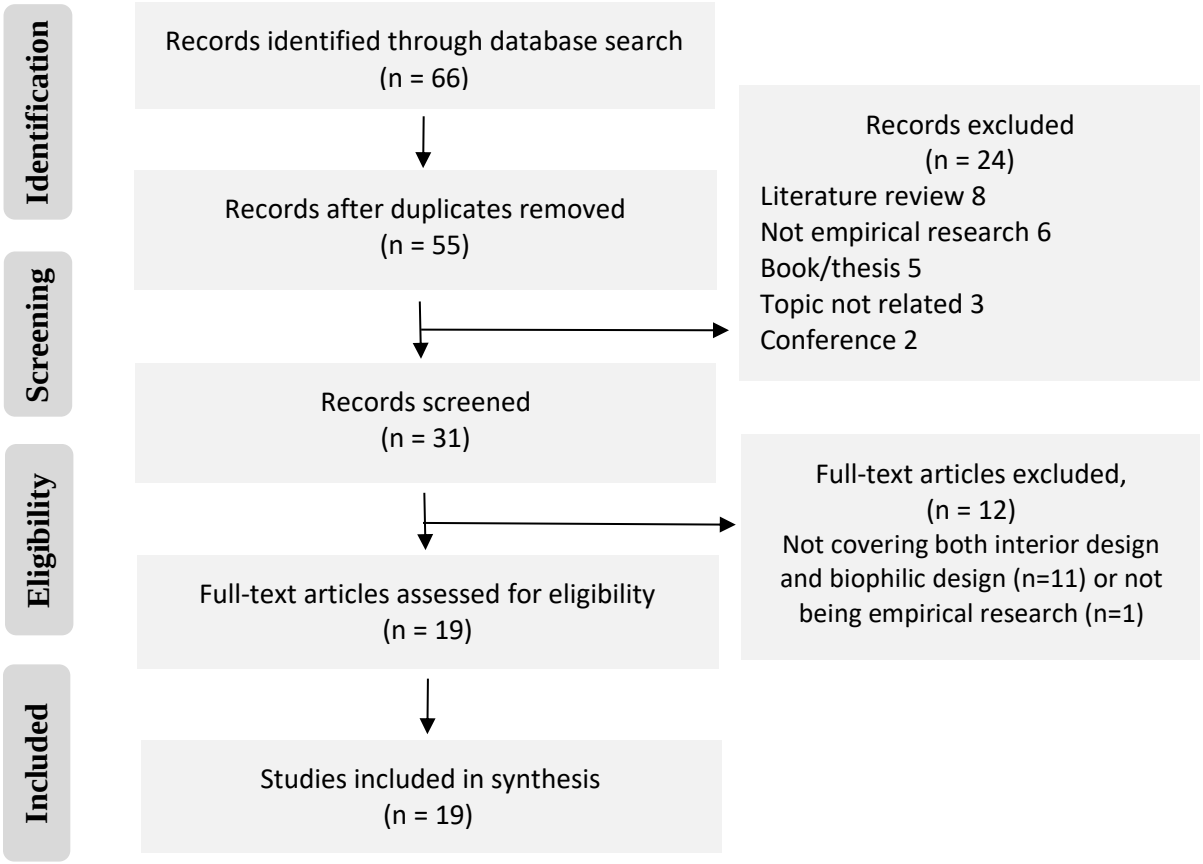
The search criteria were selected for either those closely related to the built environment or as a broad base for related fields. English articles were used with a publication date range from 1984, the date range was allowed to extend if related. The project timetable was just over five weeks for the students' assignment. Then, the assessment and synthesis followed at the end of the semester.

Inclusion/exclusion criteria: Step one began with a conceptual discussion of the project need and the concept of biophilic design. The Biophilic Interior Design Matrix was reviewed, and the updated checklist and definitions were also given. See the flow diagram, Figure 3-2, for an overview of the process. After a review of the objectives of the assignment, in step two each student conducted a review of the research for color, light, and materials that might support biophilic interior design attributes. Five articles were required for each student per topic. Articles were selected by students according to their own interests after an abstract review. In step three after these were turned in, the articles were then narrowed to one per topic in an indiscriminate selection process by the researcher and the final three articles for each student were then used to fill out the given annotated bibliography template.

This process resulted in 22 students having 3 articles, one per topic, for 66 articles total; after duplicates were removed there were 55. The results from step three were then analyzed in step four with the removal of grey literature, obviously not related articles and if an abstract was in another language. This resulted in 33 records screened among three independent reviewers.

Two research assistant each reviewed half of the list, organized alphabetically by title, with the primary researcher reviewing all of the articles. After another screening, two more were removed, for a total of 31 articles relevant for full-text inclusion.

PRISMA 2009 Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097 **For more information, visit www.prisma-statement.org.**

Figure 3-2. Literature review flow diagram.

The studies were scored on a 100-point scale to see if they addressed both interior design and biophilic features, as well as belonging to one of the categories of color, lighting or materiality. For inter-rater reliability testing, the articles were shared with a group folder in Zotero, a research organization application, and GoogleSheet assessment forms. This process and

the form was pilot tested with one article assessed together as a teaching example, then five articles were done independently, and the results compared. If there was agreement of at least 70% that the article was related to both biophilic design and interior design, it was retained.

Table 3-2. Literature review biophilic design results.

	Author	Biophilic Attributes	Color	Light	Material	Biophilic Implication Strength (★-★★★)	Biophilia Benefits
1	Gray & Birrell (2014)	Plants			●	★★	short-term wellbeing and more positive perceptions of working environment after plants added
2	Tavsan & Sonmez (2015)	abstraction of nature			●	★	biomimicry used as design inspiration for design students
3	Rossin (2010)	abstraction of nature			●	★	biomimetic process added to interior design process to solve problems
4	Olguntürk & Demirkan (2011)	abstraction of nature	●			★	color in a pattern is principal component tying it to concept
5	Kim *et al.* (2017)	response	●	●		★★	CQAT used for color quality, luminous environment and circadian action factor varied with finishes
6	Raanaas *et al.* (2010)	Plants			●	★★★	adding plants to a rehab center benefited wellbeing
7	Odabaşioğlu & Olguntürk (2015)	composition, response	●	●		★★	colored lighting affected perceptions
8	Campbell (1979)	composition, plants, preference			●	★★	plants, visual posters and organization influence how people feel and how they see the owner of the space
9	Vouchilas (2017)	preference	●			★★	color preference in designed objects and spaces influences perception of design
10	Theodorson (2018)	natural light, pragmatics		●		★★	natural light and views in classrooms need easy to use daylight control
11	Koranteng & Simons (2012)	natural light, pragmatics		●		★★	natural light reduced from architectural and cultural decisions, education needed about benefits of natural light

Table 3-2 Continued. Literature review biophilic design results.

	Author	Biophilic Attributes	Color	Light	Material	Biophilic Implication Strength (★-★★★)	Biophilia Benefits
12	Park & Farr (2007)	preference, response, warm light		●		★★★	preference for lighting including color temperature, color rendering changes with age & warm lighting use, consideration needed with older populations
13	Dijkstra *et al*. (2008)	Plants			●	★★★	indoor plants add an aesthetic quality that reduced perceived stress
14	Sanati & Utzinger (2013)	filtered light, natural light, preference, response, mastery/ control		●		★★	light shelf helpful for increased daylight access, control of blinds important
15	Park & Farr (2007)	response, preference		●		★★★	perceptions of pleasurable lighting varies by culture
16	Pati *et al*. (2016)	inside-outside, sensory richness		●		★★★	sky representation over patient beds beneficial for acute stress and anxiety levels
17	McCoy & Evans (2002)	order/ complexity, views and vistas, natural materials,			●	★★	views of natural environments and exposure to natural materials may promote creative performance
18	Daneshgarmoghaddam & Bahrainy (2014)	integration of culture and ecology, spirit of place			●	★★	spirit of place can benefit from natural features in the built environment inside and outside
19	Eisen *et al.* (2008)	preference, botanical motifs			●	★★★	nature representation in artwork for children's spaces are most preferred, choices should be available

Note: ★ is low biophilic implications to ★★★ is high

Results and Discussion

The evidence available for color, light, and materials did include a variety of biophilic attributes. This literature review managed to summarize 19 articles in relation to biophilic design: four on color, eight on light and nine on materiality; two had dual topics. The dates ranged from 1979 to 2018 and were found to be appropriate to the review goals, see Table 3-3. The most common biophilic feature was *preference.*

Table 3-3. Biophilic feature frequency in the literature review.

Biophilic features	Biophilic attribute #	Frequency of articles
Preference	28	6
Plants	3	4
Response	29	4
Abstraction of nature	14	3
Natural light	31	3
Composition	26	2
Pragmatics	30	2
Botanical motifs	9	1
Filtered light	32	1
Inside outside	15	1
Integration of culture and ecology	45	1
Mastery/ control	50	1
Natural materials	5	1
Order/ complexity	48	1
Response	29	1
Sensory richness	16	1
Spirit of place	46	1
Views/ vistas	6	1
Warm light	35	1

Note the articles were able to be categorized with more than one biophilic features.

Color

The color literature was not a large contributor to this review, although there has been a great deal of research conducted on the color in design in general (Elliot & Maier, 2014).

Number of articles per BID-M features for Color:

- *Response* (2)
- *Abstraction of nature, Preference,* and *Composition* (1 each)

The addition of the Color Planning Framework into the BID-M provided a key link to the literature reviewed, as 50% of the coding for the color articles was represented in the related attributes from the Color Planning Framework, although this is a small sample. Color had a weak representation in the literature reviewed with only four of 19 articles and a weak to moderate biophilic implication strength. However, growing evidence supports the biophilic features identified here. As they are theoretically tied to human innate needs, these features point to how

people can connect with nature via nature-inspired design features, such as *preference* and *response*.

Response was the most commonly researched biophilic feature related to color and second in the combined list of all three topics. Looking for direct linkages between color and health outcomes is still under-researched and "no sufficient evidence exists in the literature to the causal relationship between settings painted in particular colors and patients' healthcare outcomes" (Tofle, Schwarz, Yoon, Max-Royale, & Des, 2004, p. 4). Also, color can influence behavior and cognition based upon the context, for example aiding wayfinding (Dalke et al., 2006; Wise & Wise, 1988). The color spectrum of light has been directly linked to circadian rhythms and human response with health outcomes (Bosch, Edelstein, Cama, & Malkin, 2012), so there is evidence growing around how color influences people but it also may be influenced by a person's stimulus screening ability. As a study in an office setting found that a person with low stimulus screening reported more dysphoria in red and white offices than their counterparts, high-screeners, who performed better on tasks in the red and poorer in the blue-green offices (Kwallek, Woodson, Lewis, & Sales, 1997). One of the reviewed studies found that colored lighting affected responses in an experiment looking at red, green and white lighting (Odabaşioğlu & Olguntürk, 2015). This is similar to other research that found "demonstrable perceptual impressions of color applications that can affect the experience and performance of people in particular environments" (Tofle et al., 2004, p. 4), such as perceptions of spaciousness and confinement attributed to color value. Additionally, warm colors can promote memory recall which could be helpful for wayfinding (Hidayetoglu, Yildirim, & Akalin, 2012).

Meanwhile, the research on *preference* is additionally growing. One of the studies looked at in this review found that color in designed objects and spaces was a key consideration for preference and being labeled as "good design" by millennials (Vouchilas & Ulasewicz, 2017).

This aligns with other studies about designing for older users having preferences first for blue, then red/green, and then yellow (Bosch et al., 2012; Dittmar, 2001). Importantly, perception of color "is influenced by its context and surrounding variables" (Okken, 2015, p. 12) and as such color is dependent on light and the surrounding contextual materiality. Yet, color was the most influential design element when patterns were studied (Olguntürk & Demirkan, 2011). *Preference* for color also needs to be approached with culture in mind and an awareness of the many variables at play such as noise and ambient temperature physical and psychological states. This makes color research more challenging. As such, there is only a small amount of evidence-based guidance for color in healthcare settings (Park & Park, 2013; Portillo, 2009) and essentially no evidence showing any specific approach to using or defining nature-based color. Perhaps controllability of color, as was found by Coad and Coad, is important since "several participants referred to wanting the ability to control their environment such as changing the color of walls and lighting" (2008, p. 44). As such variety and controllability may be key features exhibited by nature that need to be highly prioritized. Just as a chameleon changes it skin and plants adjust to the amount of light, so the ability to adapt to our perceived preference during a situation is similar to these processes found in nature.

Composition is a core function of interior design and when designers "understand the relationship between color properties, form, light, and materiality, they are able to most effectively utilize color for creating emphasis, contrast, unity, and balance within spaces as well as manipulate how spaces are perceived" (Okken, 2015, pp. 13–14). Consideration for the composition of a design included using local context and natural materials as inspiration. While color is a well-established component of design education, it appears very little in the light of biophilic design research has been attempted. The work by Odabaşioğlu and Olguntürk (2015)

showed colored lighting affecting spaciousness, comfort, quality and aesthetic. This points to how color and light should be studied together as well as apart. It also aligns with the biophilic attribute *response*, as in another study that showed blue interior finishes had greater effect on biorhythm response (Kim et al., 2017). *Abstraction of nature* has had some biophilic design research with patterns (Olguntürk & Demirkan, 2011). Overall, color has much opportunity for expanding the evidence base. Research on color and response offers guidance for considering how variety and controllability can be offered to users of a space. Also, *preference* offers a way to look at the programmatic needs of a space by considering personalized nature inclusion.

Lighting

The research on lighting spanned from weak to strong within nine articles. Lighting with *response, preference, natural light* and *pragmatics* were included in more than one article and focused on here.

Number of articles per BID-M features for Light:

- *Response* (4)
- *Preference, Natural light,* and *Pragmatics* (3 each)
- *Composition, Filtered light, Inside outside, Mastery and control, Sensory richness* and *Warm light* (1 each)

Light has been studied regarding human health and performance and this falls into four mechanisms: enabling performance of visual tasks, controlling the body's circadian system, affecting mood and perception, and facilitating direct absorption for critical chemical reactions within the body (Olguntürk & Demirkan, 2011). In regard to *preference* and *response*, two studies by Park and Farr (2007a, 2007b) looked at lighting in retail environments for how light can affect mood and perception. Pleasure responses to color rendering were found to be varied among cultures. American perceived a higher color rendering index of lighting (95 CRI) as more pleasurable than Koreans and participants perceived the high (5000 K) correlated color

temperature as more approachable. The other study was with older adults. They rated comfort and preference higher for all four given lighting conditions than younger adults. As well, participants in both age groups experienced more visual comfort under the cooler lighting conditions and preferred cool light under all lighting conditions.

The exposure to natural light (or daylight) is well established in regard to controlling circadian rhythm and facilitating direct absorption for critical chemical reactions within the body (Shepley, Gerbi, Watson, Imgrund, & Sagha-Zadeh, 2012; Zadeh, Shepley, Williams, & Sung Eun Chung, 2014). However, natural light and views of nature are often studied in separate fields and without acknowledging the effect one has on the other (Beute & Kort, 2014), as was often found in this review. However, natural light and pragmatics were studied together in studies by Theodorson (2018) and Koranteng and Simons (2012). Natural light was found in both to be preferred for sustainability, but issues were identified with its control. Natural light was reduced due to architectural and culture decisions. Education was needed to increase the use of natural light. Another study (Sanati & Utzinger, 2013) involved a variety of biophilic features: *filtered light, natural light, preference, response, pragmatics* and *mastery/control*. A light shelf was found to help reduce the need for lowering blinds that in turn led to lesser window and view occlusion for enabled task performance. It also showed a significant energy savings which is another good example of p*ragmatics*.

When natural light is not available, however, LED sky representation panels may be used, and this was studied in one experiment where 181 participants were studied with 11 outcomes regarding the benefits of a photographic sky used over patient beds. Significant findings included more positive environmental satisfaction by patients and improved diastolic blood pressure. This aligns with other research (Lankston, Cusack, Fremantle, & Isles, 2010;

McCuskey Shepley, 2006; Nanda, Eisen, Zadeh, & Owen, 2011) regarding nature-inspired art for improving patient outcomes where patients who are ill and stressed prefer the "state of calm created by the blues and greens of landscape and nature scenes instead" (Lankston et al., 2010, p. 490).

Other applications of lighting include *pragmatic* designing with sustainability in mind. "While making decisions regarding lighting, economic factors (first costs, energy consumption, and maintenance) must also be taken into consideration" (Joseph, 2006, p. 10). However, as recently identified (Freihoefer, Guerin, Martin, Kim, & Brigham, 2013), spaces that meet lighting specifications for sustainability may not satisfy the occupants. The response of people to light is a very importatnt design consideration that may take additional education of the users of the space to ensure that the lighting control systems in place are understood and maintained.

Materiality

The most obvious and well-known strategy for including biophilia inside is the incorporation of *plants*. The number of articles per BID-M features for Materiality were:

- *Plants* (4)
- *Abstraction of nature* and *Preference* (2 each)
- *Composition, Order* and *complexity, Views* and *vistas, Natural materials, Integration of culture and ecology, Spirit of place and Botanical motifs* (1 each)

Along with natural light and views, as already discussed, plants are perhaps one of the most impactful biophilic attributes that can improve perceptions of wellbeing (Dijkstra, Pieterse, & Pruyn, 2008a; Gray & Birrell, 2014; Park & Mattson, 2009; Raanaas, Patil, & Hartig, 2010). Gray and Birrell (2014) conducted a study with the integration of plants into a workplace and found short term positive effects but several other adjustments made the space different from previous offices, limiting implications. Another study found subjective wellbeing increased in one of the study groups when plants were added to common areas. A study of hospital patients

exposed to rooms with plants showed reduced feelings of stress through the mediating variable of attractiveness (Dijkstra, Pieterse, & Pruyn, 2008b). A similar integration of plants in a hospital room setting with surgery patients found having plants in the rooms during recovery had positive influence on health outcomes in comparison to the control group (Park & Mattson, 2009). These findings are not unexpected within the RED framework and biophilia theory with plants offering an actual natural connection that is direct and more impactful than representations. Representation of plants, or *botanical motifs*, has also been studied in nature-themed art work and was the preference of children given art choices (Eisen et al., 2008). This is similar to *abstraction of nature*, where the concept biomimicry is included. It is when engineers and designers look to nature to inspire design solutions to human problems (Benyus, 2002). Two studies reviewed used biomimicry to help design students (Rossin, 2010; Tavsan & Sonmez, 2015). One used it as design inspiration and one looked at integrating it in the design process.

Combining direct and indirect connections to nature with plants and visual imagery into an office space was tested with students and the aesthetic quality reduced perceived stress (Campbell, 1979). Even views of natural environments or use of natural materials can be influential (McCoy & Evans, 2002). McCoy and Evan's study specifically looked at creativity and found that "environments perceived low in creativity potential were consistently windowless, finished in manufactured or composite materials, and with overall cool colors" (2002, p. 420). The preference for windows with a view (*views and vistas*), *natural materials* and warm colors seems to also promote creativity. This was then tested in a second study. The researchers next compared two spaces and found that greater creativity was expressed in the more natural environment. Both spaces had *natural light* but the more natural environment included more *natural materials* and warm colors. Teasing these two variables apart did not

occur and could also be useful. The researchers noted that testing with different ages and for different lengths of exposure would also be helpful. The differences within the settings in the study limit the generalizability but "if human responses to physical settings include enhanced levels of creativity performance, the implications are vast" (2002, p. 425).

This snapshot of current research shows that there has been emphasis in research among certain areas with *response, natural light* and *plants* being the most common. This review supports also looking at the current state of biophilic design in practice regarding the use of color, light and materials.

Study 2

The present use of color, light and materials related to biophilic design was unknown. Study 2 sought out practitioners to understand the current strategies being used.

Method

Respondents

The respondents were recruited by direct email, snowball sampling or notification through social media. The participants included 23 interior architects and interior designers. The average length of practice was over 15 years of experience. Additional certifications were most commonly LEED and corporate design was the most common specialization. The National Qualification of Interior Designers was the most common accreditation, $n = 9$.

Table 3-4. Demographics of respondents.

Practice years	Frequency	(%)	Certification	Frequency	(%)	Specialization	Frequency	(%)
< 2	0		AAHID	1	3	Corporate	9	26
2 - 5	6	26	LEED	12	34	Healthcare	6	17
6 -10	4	17	NCARB	1	3	Hospitality	4	11
11 -15	3	13	NCIDQ	9	26	Institution	1	3
16 - 20	2	9	Well	1	3	Residential	7	20
21-25	1	4	State license	7	20	Other	8	23
≥ 26	7	30	Other	4	11			

Data Collection

A questionnaire was sent out to ascertain practitioners' current use of color, light and materials in their design practice in relation to biophilia. This email provided a link to the Qualtrics online survey with an open answer question that had no minimum or maximum requirements. Thematic analysis of the open answer questions categorized responses into themes and the coding was jointly assigned by two researchers. The coding process looked at the concept of color, light and materiality separately and each comment was coded in regard to each of the three concepts, with multiple attributes possible per response. Following the coding, related themes were collapsed. The responses (n=19) ranged in length from 3 words to 86.

Results and Discussion

The findings showed the practitioners used a variety of approaches to integrate color, light and materials into their projects. Twenty-nine different biophilic attributes were represented and 25 not included. Forty-nine comments were assigned to color, 41 for light and 61 for materials. The top three most common features for each category are discussed next.

Most comments per BID-M features for Color, number of comments in parenthesis:

- *Natural materials* (6)
- *Geographic connection to place* (5)
- *Composition* and *Ecological connection to place* (4)

In general, the top themes represent that color was most often tied to the composition of the space and the local context. The use of natural materials and representations brings with it color influence. "*Colors can be drawn from natural imagery*" one practitioner stated. Another comment highlights that designer's approach biophilic design "*by designing an interior that seems appropriate to its location and varying the stated design elements to create a texture like one would find in nature.*" Additional participants talked about using nature-based artwork and tying the concept of the design to the locality for very project specific design solutions.

Highest comments per BID-M features for Light:

- *Natural light* (7)
- *Pragmatics* and *Geographic connection to place* (4 each)
- *Ecological connection to place*, *Response,* and *Views and vistas* (3 each)

For light, *natural light, pragmatics* and *geographic connection to place* were the top three attributes. *Natural light* and *pragmatic* included considerations for efficiency and the conservation of energy. This includes the use of *natural light* when available and allowing as many people as possible to have close access to it. Manipulating color temperature, especially *warm light,* was another variable that designers use in their designs. Also, designers use artificial light to mimic *natural light* through intensity and circadian rhythm systems to more closely align people's *responses* with natural ones. *Pragmatics* was also a common consideration including maintenance and conservation of energy.

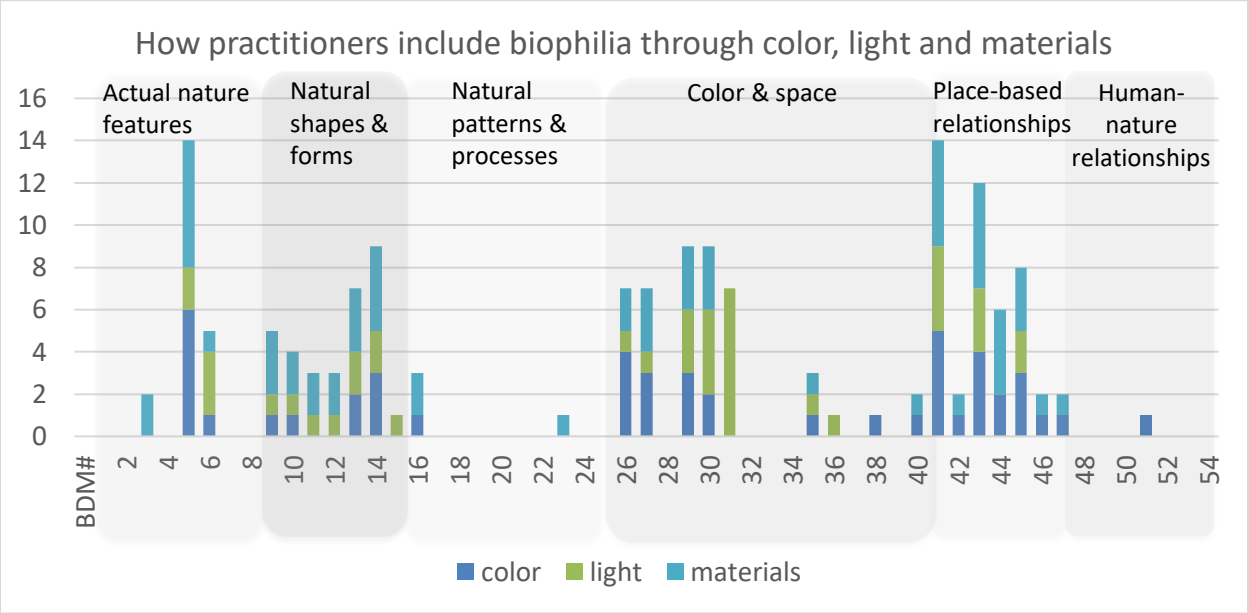
Top comments per BID-M features for Materiality:

- *Natural materials* (6)
- *Geographic connection to place* and *Ecological connection to place* (5)
- *Abstraction of nature* and *Cultural connection to place* (4)

Some of the *natural materials* mentioned (aside from *plants* specifically mentioned twice) includes natural wood, stone, natural fabrics, crafted and rustic materials and natural

artwork. Practitioners also mentioned using organic shapes, patterns and textures. These tactics are represented within the *natural patterns and processes* element. Designers also use "*layering in terms of materials and views*" and *"symbolic use of color and images in wayfinding and branding*". Human considerations were also noted, like creating soft, comfortable and warm spaces while avoiding sterile spaces. Again, local context was mentioned with an example being that the designer would "*search for locally or culturally related materials, etc."*

Table 3-5. Frequency of practitioner comments by BID-M attributes, element categories blocked in color boxes.



As shown in Table 3-5, the six categories of biophilic design, which are named elements, had varied representation in the numbers of comments. Color, light and materials did group into two most common areas, *color and light* and *place-based relationships* with 46 and 44 comments respectively, out of 155, see Table 3-5. This shows a real sensitivity from the practitioners for making design decisions specifically to connect the users with the local environment. Perhaps opportunities for expanding the strategies designers use for biophilic

design should consider additional attributes.

Many of the strategies designers use showed thoughtful joint consideration of color, light and materials. Interestingly, *geographic connection to place* was a biophilic feature that placed in all three categories. Next, *natural materials* and *ecological connection to place* was found in two out of three categories. One example of a participant's comment highlights this:

> Participant A: We favor using a mix of natural texture (sisal rug, grass-weave wallpaper, wooden blinds). We have a preference for using natural fabrics such as linen, cotton, and silks (when appropriate). Many of our projects include designing custom window treatments, we favor drapes with the use of sheers to bring in more light but providing some privacy. We specify color temperatures aiming for 2700-3300K. We select sustainable materials, natural materials, such as real wood furniture (or repurposing existing) as opposed to MDF laminated furniture. Our projects focus designing for life and durability (excluding kids, pets, and wine). For example, by using real wood furniture, which is durable and can be finished rather than a piece (laminated MDF) that cannot be repaired. Finally, we often purchase and pot up plants to complete the finished project.

Another participant noted that these biophilic design approaches can "*be used as basic design tools in any projec*t".

Table 3-6. Frequency of comments by biophilic element.

Biophilic Element Categories	Definition	Frequency of comments
Actual natural features	Actual (not mages) of real nature characteristics in the interior	23
Natural shapes and forms	Representations of nature and simulations	24
Natural patterns and processes	Properties derived from natural features and processes	4
Color and light	Color, light and material qualities and space relationships to nature	46
Place-based relationships	Culture together with ecology, rooted in geography	44
Human-nature relationships	Needs of the human relationship to nature	3

Color, light and materiality are important to interior design and a key focus of the development of the Biophilic Interior Design Matrix. Through the adoption and adaption of the Color Planning Framework (CPF), the ability to capture the essence of how interior design can optimize nature integration allows for a more sensitive capture of color, light and materiality from the original version. The current study shows that there is a diverse range of research being produced to aid designers for an evidence-based design approach and designers commonly use human-centered design attributes. The top attributes shared by both the literature review and practitioners were *abstraction of nature*, *composition*, *natural light*, *natural materials*, *response* and *views and vistas*. Two of the six features were from the Color Planning Framework, so its addition appears to have strengthened the BID-M. This shows how some similarities exist between research and practice. Interestingly, the literature review found 17 of 38 biophilic features in the articles were represented in the Color Planning Framework items, further validating its inclusion.

The similarities with research and practice can be seen in Table 3-7. The use of *composition* was shared by both through color application. This aligns with research that has found that a palette composition with pastel colors can benefit anxiety reduction in some people (Ireland, Warren, & Herringer, n.d.). Additionally, color composition has been shown to influence atmosphere and perceptions of a space (Smith & Demirbilek, 2010). *Pragmatics* was also a shared common strategy for lighting a space including the control of natural light and limiting glare. Strategies such as daylight tubes can help (Almusaed & Almusad, 2014).

Differences exist in the more common reliance of natural materials and natural light by the practitioners. These are two common sense ways of creating a biophilic feeling within a space. Their use could also be due to a lack of familiarity with the other options avaiable in

biophilic interior design. In comparison it is interesting to see that research has had an emphasis on *plants* and *response.* These topics may be easier to research with targeted ways to control variables. A review of the psychological benefits of indoor plants among 21 studies found heterogeneity in the results which limit general beneficial claims (Bringslimark, Hartig, & Patil, 2009) so while plants may be easier to research and to get funding, challenges remain. Infection control is a key consideration for plant inclusion in healthcare settings, for example, but current guidelines have found that with simple control protocols "flowers and potted plants need not be restricted from areas for immunocompetent patients" (Center for Disease Control, 2003, p. 149) . Concerns for infection and maintenance, however, may be why it is not as commonly used.

Table 3-7. Comparison table ranking highest to lowest frequency of attributes identified in the literature and by practitioners, top three most frequent attributes.

Biophilic attributes found in research					
Color	#	Light	#	Material	#
Response	2	Response	4	Plants	4
Abstraction of nature	1	Preference	3	Abstraction of nature	2
Composition	1	Natural light	3	Preference	2
Preference	1	Pragmatics	3	Composition	1
		Composition	1	Order and complexity	1
		Filtered light	1	Views and vistas	1
		Inside outside	1	Natural materials	1
		Mastery/control	1	Integration of culture and ecology	1
		Sensory richness	1	Spirit of place	1
		Warm light	1	Botanical motifs	1
Biophilic attributes used by practitioners					
Color	#	Light	#	Material	#
Natural materials	6	Natural light	7	Natural materials	6
Geographic connection to place	5	Pragmatics	4	Geographic connection to place	5
Composition	4	Geographic connection to place	4	Ecological connection to place	5
Ecological connection to place	4	Ecological connection to place	3	Abstraction of nature	4
		Response	3	Cultural connection to place	4
		Views and vistas	3		

A larger, targeted systematic review of each feature may be helpful to draw additional research together for designers to reference in relation to all three concepts. Color, light and materiality are complex and have been studied in multiple ways across many disciplines. This review, although very targeted and the sample perhaps had a bias towards an interest in biophilia, has been an important starting point for attempting to explore the current state of biophilic design research. Additional research among the biophilic attributes can support designers in their attempts at evidence-based design.

An important finding regarding color in both research and in practice aligns with Elliot and Maier's recent color literature review where color has "important influence on people's affect, cognition and behavior" (2014, p. 112). Natural inspired color can be included through referencing the local context and incorporating natural materials. This was similarly a key focus of current design practice. Designer's selection of color is a key component that can thoughtfully incorporate local environmental colors. This creates an easy connection to nature while being fully controlled by the designer through selection of hue, saturation and value in the overall design concept (Portillo, 2009).

In this paper, light in interior design research focused on biological studies of natural light. This was similarly found by Gillis and Gatersleben (2015) in their review of psychological literature on the health and wellbeing benefits of biophilic design. They also found evidence was greater in supporting attributes of biophilic design like natural elements, while it was lacking for attributes like natural materials and processes. Material incorporation in this paper was dominated by studies that looked at the benefits of plants and the use of abstract nature images. The practitioners focused instead on the use of natural materials and connecting to the local context. Gillis and Gatersleben similarly found that natural materials had limited psychological

research attention (2015). This difference can be due to the difficulty of researching complex interior environments with such broad constructs. However, a study of natural materials found that preference varied for the amount of natural materials and variety is needed (Nyrud, Bringslimark, & Bysheim, 2014). Variety is a key design consideration. This is supported in the theory of biophilia, where varied incorporation of natural features should provide people with nature connections, but it may elicit individual preferences. Considerations for users, their preferences and needs, is a primary concern for biophilic interior design. Additional research to provide best practice support is needed for the use of natural materials and connecting to the locale.

Many studies and strategies were used by the designers that related to more than one color, light and material category. These are somewhat inextricable concepts. In fact, it is probably when all three of these concepts are thoughtfully used together that truly biophilic designs are created. They are tools used by interior designers in their attempt to fulfill project goals. To support this endeavor, the BID-M provides guidance for individualized design decisions for interior designers. It also now allows for access to relevant research to support practitioners in their biophilic designs. It also can support researchers in identifying opportunities to support designers based upon current practice. The many under-explored areas of research and practice that are represented in the biophilic design attributes affords additional opportunity for designers to try new approaches and for additional research to offer guidance. A more varied incorporation of nature may allow designers to apply their creative ability in exciting new ways that can be studied and shared through programs like the Biophilic Design Initiative and case studies. With increased adoption of biophilic design and more buildings being studied, interior

design can be leaders in offering human-centered designs that creatively provide restorative environments.

CHAPTER 4
ESSAY 3

Biophilic interior design matrix as a pedagogical tool in an interior design studio:

This exploration involved using the Biophilic Interior Design Matrix (BID-M) as a pedagogical tool in an interior design undergraduate studio class. The emergence of biophilia as a relevant concept for interior design has created the need for guidance on how to identify and consider applying biophilic design features in the interior. The BID-M was created for this purpose. After a recent development of the tool, practitioners thought it useful throughout the design process as a design tool. This study aimed to explore using the BID-M during the conceptual design phase and design development, as well as using it in an analysis of the finalized design. The senior interior design students in a 10-week hospitality studio class were divided between two classrooms. One classroom received the BID-M throughout the project, while the other only did the post-assessment. The results showed that interior design students had varied perceptions from before using the BID-M to after. Their perceptions of importance, confidence and knowledge of biophilia were higher with the group who used the BID-M throughout the project. The BID-M offered benefits to the student's design process and integration of biophilic attributes. Overall, it was seen as a helpful tool for biophilic integration by the students. It facilitated ideation and concept development. The students suggested earlier integration of the BID-M in the curriculum and saw themselves using the BID-M in practice as a conceptual and design development aid.

Literature Review

Interior design is in an interesting position when it comes to biophilic design. The first research that pointed to biophilia was Ulrich's (1984) now famous study of gallbladder patients with reduction in pain medication, faster healing, and less negative behavior during a hospital stay for those with a view of nature from inside their patient room compared with similar patients

who had a view of a brick wall. For even passive connections with nature, such as a view of nature, to have an impact on health was a serious change in perception for many people. Evidence-based design developed to look at how buildings can be better designed by using research for design decisions ("History of EBD," n.d.).

Evidence has grown around how nature can be helpful through direct and indirect contact, such as spending time in a park and viewing natural images (Hartig et al., 2011; Kjellgren & Buhrkall, 2010; Ulrich, 1981). One study did a comparison of an actual natural experience with a simulation of the same environment and found "both environments facilitated stress reduction, with the natural environment additionally bringing increased energy and ASC [altered states of consciousness], thus possibly enhancing and promoting restoration" (Kjellgren & Buhrkall, 2010, p. 464). The interior, while not as optimal as nature for providing restoration, also provides shelter and refuge that is needed to conduct modern life (Hartig et al., 2008; Kilmer & Kilmer, 1992). Buildings are "protective in both direct and indirect ways; direct in that it provides protection from what is potentially dangerous in the natural environment, and indirect, in that it reduces impacts on the natural environment that would otherwise subsequently increase the risk of harm to people" (Hartig et al., 2008, p. 139). However, it also is limiting direct contact with nature which can lead to nature-deficit disorder, since people now spend so much of their time inside (Jones, 1999; US Environmental Protection Agency, n.d.; U.S. Environmental Protection Agency & Office of Air and Radiation, 1989). This is not a medical condition but rather "nature-deficit disorder describes the human costs of alienation from nature, among them: diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses" (Louv, 2008, p. 36). How interior design can help to reconnect people with nature while being safely inside is a unique challenge for interior designers, as interior designers specify

products worth $77.95 Billion annually (The American Society of Interior Designers, 2018). This clearly demonstrates how significant the impact interior designers have but just how they should approach integrating nature for best practice is relatively unknown.

The restorative environmental design (RED) framework connects sustainability and biophilic design for optimal beneficial buildings for the users, the location and the global impact that can result (Kellert, 2008b). Additionally, sustainability needs to be taught throughout the curriculum by knowledgeable educators to facilitate student learning to internalize the ethical responsibility involved with their design decisions in order to create designers knowledgeable in sustainability (Demarotta, 2015; Gürel, 2010). This means that "design education has an ethical responsibility to turn out environmentally conscious individuals who are sensible to social, cultural, economic, political, scientific and technological concerns and developments" (Gürel, 2010, p. 185). It is also integrated into the Council for Interior Design Accreditation standard 16: Students must understand standards and guidelines related to sustainability and wellness (Council for Interior Design Education, 2018). In studio design pedagogy it has been found that placing a central emphasis on sustainability in the course makes a difference in the understanding and approach students make in their design. This should be a similar approach taken in teaching biophilic design and this study looks at how biophilic design can be supported in interior design education, specifically through the central use of the Biophilic Interior Design Matrix (BID-M) in a studio course. The BID-M was created to support biophilic design by developing 54 attributes from Kellert's 2008 list of features. It was developed initially by adapting Kellert's features to interior play rooms and added a scoring procedure (McGee, 2012). It was then redeveloped through a systematic process with practitioners to be more user-friendly, valid and reliable (see Essay 1). The testing also found it valid in assessing different types of space. The

finalized list of attributes in their coordinating elements (categories) are found in Figure 4-1. These elements are titled: *actual natural materials, natural representations, natural patterns and processes, color and light, place-based relationships and human-nature relationships*.

Table 4-1. Biophilic design elements and attributes.

Actual natural features- actual (not images) of real nature characteristics in the interior	
1	Air
2	Water
3	Plants
4	Animals
5	Natural materials
6	Views and vistas
7	Habitats
8	Fire
Natural shapes and forms- representations of nature and simulations	
9	Botanical motifs
10	Animal-like
11	Shells and spirals
12	Curves and arches
13	Fluid forms
14	Abstraction of nature
15	Inside-outside
Natural patterns and processes- properties derived from natural features and processes	
16	Sensory richness
17	Age, change and the patina of time
18	Area of emphasis
19	Patterned wholes
20	Bounded spaces
21	Linked series and chains
22	Integration of parts to wholes
23	Complementary contrasts
24	Dynamic balance and tension
25	Natural ratios and scales

Color and light- color, light and material qualities and space relationships to nature	
261	Composition
272	Communication
283	Preference
294	Response
305	Pragmatics
316	Natural light
327	Filtered light
338	Reflected light
34	Light pools
35	Warm light
369	Light as shape and form
3710	Spaciousness
3811	Spatial variety
3912	Space as shape and form
4013	Spatial harmony
14	
Place-based relationships- culture together with ecology, rooted in geography	
15	
41	Geographic connection to place
42	Historic connection to place
43 16	Ecological connection to place
44 17	Cultural connection to place
45 18	Integration of culture and ecology
46 19	Spirit of place
20	
Human-nature relationships- paired biological needs of the human relationship to nature	
21	
47 22	Prospect/refuge
48 23	Order/complexity
49 24	Curiosity/enticement
50 25	Mastery/control
51	Attraction/attachment
52	Exploration/discovery
53	Fear/awe
54	Reverence/spirituality

The desire to test the BID-M in an educational setting resulted in the following research questions:

1. How do interior design students perceive biophilia?
2. How is the BID-M helpful for interior design students?

Restorative Environmental Design

> Reintegrating humans with nature requires not just the integration of human technology into ecological processes, but the cognitive, emotional and spiritual reconnection of humans to nature as a vital step to restoring both planetary health and the health of our societies (Du Plessis & Brandon, 2015, p. 9).

This quote encompasses Restorative Environmental Design (RED). It is a holistic embrace of nature that incorporates the whole being: cognitive, emotional and spiritual. It also seeks to optimize current sustainability practice. It seeks both a "low-environmental-impact strategy that minimizes and mitigates adverse impacts on the natural environment, and a positive environmental impact, or biophilic design approach, that fosters beneficial contact between people and nature in modern buildings and landscapes" (Kellert, 2008, p. 5). This is a vital step to restoring both planetary health and human health. The inclusion of nature in design should be taught then in addition to sustainability.

Biophilic design sees the natural environment as a necessary component for optimal human health and wellbeing (Kellert, 2008). As Kellert stated, "people's physical and mental wellbeing remains highly contingent on contact with the natural environment, which is a necessity rather than a luxury for achieving lives of fitness and satisfaction even in our modern urban society" (2008, p.4). Humans, having great creative capacities, are able to either integrate or separate themselves from nature through the built environment. When people have connections with nature it has been shown to have positive benefits (Ulrich, 2008) and yet there is an incomplete integration of biophilia focus in the dominant sustainability tools available.

Biophilic design emerged at a time when the current sustainability approaches, or "green" design, were focused on minimizing negative environmental impacts through specific buildings and their sites, mostly through conserving resources and site selection (Cole et al., 2012; Kellert, 2008; Robinson & Cole, 2015). Interior designers/architects are in demand who understand sustainable rating systems like LEED (Demarotta, 2015; Kang & Guerin, 2009). LEED is also seen as prescriptive and deterministic with little biophilic design focus (Du Plessis & Brandon, 2015). WELL and the Living Building Challenge are unique in their emphasis on biophilic design and include general guidelines based upon Kellert's (2008) list of biophilic attributes. That list comes from a social ecology background and the language was recently improved for interior designers in the Biophilic Interior Design Matrix (BID-M) (see Essay 1). The existing tools also fall short in supporting cognitive, emotional and spiritual reconnection of humans to nature. Cognitive, emotional and spiritual considerations in the BID-M provide a unique addition to the existing tools that is designer driven and used as a resource for designers seeking a holistic biophilic inventory of feature options to reference. The spiritual connection is especially missing in most tools and this is expressed and experienced by many in nature, but it is an underexplored component for facilitating sustainable action by people (Louv, 2008). The BID-M also addresses the social and cultural context while being nonprescriptive. It is an evidence-based design tool.

Referencing research for guiding design decisions is a hallmark of evidence-based design (EBD) ("About EDAC," n.d.; "History of EBD," n.d.; Hamilton, 2010). In general, research on design and its related benefits has traditionally been poorly communicated to designers and little guidance for designers regarding implementation strategies exists (Browning et al., 2014; Huber, 2016). The BID-M was created to serve as both a helpful design and assessment too, like the Living Building Challenge, where both design development and post assessments are used.

Testing the BID-M with students was aimed to see if the tool was helpful for new designers in an educational setting.

Studio Education and Biophilic Design

The traditional studio model is based upon the master-apprentice model that uses an iterative design process (Forsyth, Lu, & McGirr, 1999). This is used to develop problem solving through active learning, which is a method that engages students in the learning process through learning activities (Prince, 2004). The iterative design process is a hallmark of design education and a major component of the studio learning experience (Forsyth et al., 1999). Within interior design education, the studio experience is where students learn by doing, based on the tradition started in Ecole des Beaux-Arts in Paris (c. 1850) (Hill, 2007). The studio project is where students collect relevant information to create design solutions in a cooperative and competitive social environment. Such assignments involve "wicked" problems with many possible outcomes (Elsheshtawy, 2007). Supporting students in this process is a unique challenge. How to support biophilic interior design in the design studio was not known.

Introducing nature into the studio teaching model is not new, as design has always been inspired by nature. Yet, there have not been many tools available to help students and teachers to communicate clearly about the concept of nature integration. If you are not speaking the same language it is hard to communicate and the BID-M aims to fill this gap (McGee & Marshall-Baker, 2015). Testing the BID-M in a studio course offered a unique opportunity to identify student's perceptions regarding biophilic interior design and their experiences with it, as well as the helpfulness of the BID-M. The studio environment is uniquely poised as a place of learning and a place for scholarship which offers research a valuable platform (Varnelis, 2007). Studio courses allow for research regarding teaching pedagogy, learning modalities, creativity and other

topics while new learning and application of design theory are investigated (Carmel-Gilfilen & Portillo, 2010; D'souza, 2010; Portillo, 2002)

In design education, the use of the BID-M is a way to bring relevant knowledge about biophilic design into consideration within the design process to the task of a complex design problem (Boyer, 1990; Carmel-Gilfilen & Portillo, 2010). This can also be beneficial for addressing cultural and global concerns (Sohoni, 2009). Real inquiry is interdisciplinary and there is rarely one answer (Brooks & Brooks, 2001). This describes an interior design project, that similarly requires assessment and refinement of diverse options and opinions (Kilmer & Kilmer, 1992). It starts during programming and conceptual development but continues into the design development and then finishes in the post occupancy evaluation where additional lessons can be learned.

How the BID-M could be used in studio pedagogy was investigated in light of the zone of proximal development (ZPD) (Newman, Griffin, & Cole, 1989). This theory approach measures and observes what kind of help people needed to complete a task. This also aligns with connectivism, where the learner makes connections to various resources in a unique and individual learning itinerary to solve problems (Baker, 2012; Ioannou, 2017).

The biophilic design matrix is not a typical assessment where there is a right and wrong answer or a right or wrong score, but a tool that might help tame the "wicked" problems designers face. It is a resource for a designer driven response to the unique needs of the project and the design program requirements. The students' given studio task was not measured as a right or wrong answer, but they were asked how much and what kind of help they needed to help incorporate biophilia. The BID-M was recently redeveloped through a participatory deign with improved validity and reliability. Its use should benefit evidence-based design and also assist

with meeting the recently updated Council of Interior Design Educators (CIDA) standards. Since research shows the need for nature integration and the importance to interior design, it is now reflected in the recently updated accreditation standards (2018). It is specifically in Standard 7 Human-Centered Design regarding how interior designers apply knowledge of human experience and behavior to designing the built environment. Students must demonstrate for Standard 7-a an understanding of theories related to the impact of the built environment on human experience, behavior, and performance. The guidance provided for 7-a now includes biophilia as one of the supported theories. So, the availability and application of a tool like the Biophilic Interior Design Matrix was seen to have relevance in interior design education worthy of further testing.

Method

The BID-M as a resource was provided in the studio, along with an introduction and desk critiques, aimed to support the students' individual design processes. At the end, the use of the BID-M and the pre- and post-questionnaires provided opportunity for feedback and reflection regarding the help they desired and received.

Participants

The participants were 20 senior interior design students in their final semester, a hospitality design studio course. Nineteen females and a male started their degree having combined foundation courses for a year and a half with architecture and landscape design students. By the last semester of their final year, they had completed a variety of commercial projects. They had dedicated work space in their studio and were housed in two rooms on separate floors. They self-selected being in either of the classrooms before becoming aware of the project specifics or the research project. One half of the class was given the BDM throughout the design process, the other half was not. Everyone completed an assessment of their own design solutions and a pre- and post-questionnaire at the end. Group 2 was a stronger cohort

academically and was not as excited about the use of biophilic design in their project as Group 1, based upon conversations held in class after the project began. Group 1 was the group that had access to the BID-M, while Group 2 did not. Which classroom had the BDM was randomly assigned before the project began.

Instruments

The instruments used included three surveys. Survey 1 was a pre-project questionnaire. Survey 2 was a jury review of the final projects, and then afterwards Survey 3 was a student self-assessment of their own finalized design with the BID-M that also included a pre- and then a post-questionnaire. These were developed based upon the purpose of the study, see Figure 4-1.

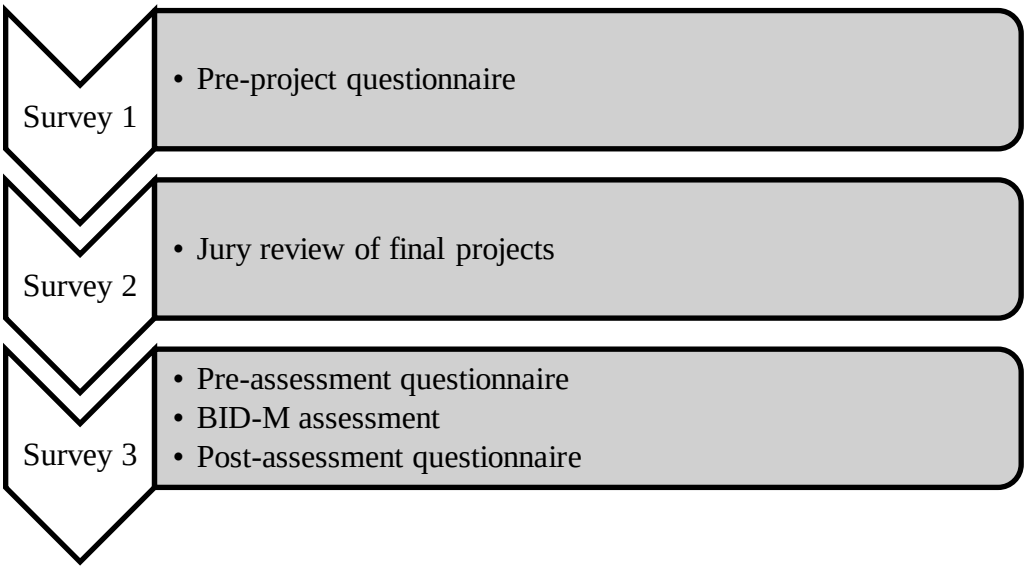


Figure 4-1. Study process diagram.

Survey 1, the pre-project questionnaire was taken before the project started and it included five questions with three open answer and two Likert-type questions. It was a paper form completed during class time. For Survey 2, a jury assessed the work with a given paper form during and following each presentation. Survey 3, the post-project questionnaire, included three parts in the online survey and completed in class. In Part 1 there were four questions, posed before the BID-M; three Likert-type questions and one open-ended question. Then students

assessed their space in Part 2 with the BID-M. Part 3 was after the BID-M assessment where 15 questions were asked of Group 2 and 20 questions asked of Group 1. Group 2's questionnaire had 6 Likert-type, one select-all-that-apply, one rating list, and 7 open answer. Group 1 had an additional 3 more Likert-type questions and 2 more open answers. The process of their completing Survey 3 was a heads down solo activity, but help was available throughout. The students did not appear to struggle with the concepts or the assessment process.

Studio Project and Data Collection

The studio project used a building shell from a recently constructed hotel in Charleston, SC. Students needed to reimagine the entire hotel along with developing their own brand, guest experience, and original design (see Appendix G for the project description). They were all required to integrate biophilic design, specifically, biophilic design variety and thoughtful biophilic integration. There were two instructors. The role of the researcher was to support and guide the Phase 1 work for both studios and then was focused on Group 1 assistance with the BID-M.

The project included three phases. Phase 1: Pre-Design Research (2 week), Phase 2: Design Development Completed (4 weeks) including a project review with juries, and Phase 3: Final Design Presentation (4 weeks) with deliverables due for presentation to a jury. These were individual projects after Phase 1. In Phase 1 groups were given topics to research and share with the class regarding context, client, precedents, hotel branding and trends, programmatic elements and sustainability and hotel design. During Phase 1, the group responsible for sustainability and hotel design shared the supporting general research on the topic which included an introduction to biophilia and sustainability developed with help from the primary investigator. This shared activity allowed for a fast programming phase to quickly move into concept development and

design development. The students were guided by the instructors and the primary researcher to help them complete their project.

Phase 2 began concept generation with the finalization of their individual programs, which were adapted to support the student's choice of a target clientele and concept. During the beginning of Phase 2, a presentation was made to Group 1 regarding the availability of the BID-M with a general review of the content. Also, an introduction was made to the biophilic design checklist, the availability of a website with the BID-M and (following Phase 2) a desk critique was conducted with the researcher. Desk critiques are also typical to the design studio pedagogy (Elsheshtawy, 2007), so after the midpoint critiques (at the beginning of Phase 3) the researcher met with each student and reviewed each feature on the checklist for understanding how they were or might incorporate the biophilic attributes listed. In this process, students talked about their concepts and how biophilic features might be integrated. Group 2 had help from the instructors during this time.

The final presentations occurred over two days. The students presented to a panel of three jurors, two outside professionals and the researcher. The first day included two PhD student/practitioners and day two had two practitioners. Each day included three hours of presentations with each student getting 15 mins for both their seven-minute presentation and feedback. After a brief overview of the form given and biophilic design in general, they were given three items to assess: inclusion of variety of biophilia, thoughtful application of biophilia, and the overall success of biophilic design.

The final presentations were followed by each student conducting a post assessment of their own design using the BID-M with a pre and post questionnaire. Each individual from both classrooms went through the BID-M at the same time and they assessed their own design and

completed the questionnaires. For all the surveys, the analysis of the open answer questions included thematic analysis and inter-rater agreement through joint coding. To compare the differences between groups, independent t-tests were performed. In the end, the student's voices were heard throughout the project and documented their experience, perceptions and considerations of biophilic design.

Results

Biophilia Perception

The pre-phase 1 questionnaire documented 17 out of 20 students learned about biophilia from classes either in their major, Interior Design (n=10), a College sustainability class (n=5), or on their own (n=4). One student both had "*heard it mentioned in studio and researched it further*" and this is representative of their general overall exposure.

Their perception of how to approach using nature inspired features at the beginning of the project was most commonly through human considerations, natural elements or natural representations, see Table 4-2. Plants were common in their selection of natural elements or their representations. A student noted they would use biophilic features in "*organic features that imply plants or with the use of color, also using plants on the inside*". Group 2 generally commented more about wanting help with practical application and creative ways beyond using plants, while Group 1 was more evenly divided in their desires, including wanting more knowledge in general about the topic. One example of a human consideration noted was their using "*elements that help people feel more connected to nature*". An admiral goal but very undescriptive as to what that exactly entails and an example of their understanding of the concept perhaps not being clear regarding tactics for its approach.

Table 4-2. Frequency of open answer themes survey 1, pre-project questionnaire.

	BID-M Group 1	Non-BID-M Group 2
How did you first learn about biophilia?		
Major	6	4
College Sustainability Class	3	2
This Class	1	3
Own	2	2
Other Classes	1	1
Discuss Your Approach to Using Nature Inspired Features (Biophilic Features).		
Human Consideration	4	3
Natural Elements	1	3
Natural Representations	1	1
Local Context	1	1
Support Concept	1	0
Natural Forms	1	0
Integrated Arch.	0	1
Opportunistic	0	1
Cautiously	0	1
How would you like more help with biophilic integration?		
Creative Ways Beyond Plants	2	4
Integrated	1	1
Practical Application	3	5
Human Consideration	2	0
More Knowledge	3	0

Note: Students were able to answer more than one choice.

In survey one, regarding their perception of biophilia before the project and if they saw it as an approach that could aid in making design decisions, there was a difference between Group 1 and 2 (t = 2.83, p= .01). While Group 1 saw biophilia as more of a design aid for decisions, both group's confidence levels were similar and strong going into the project, see Table 4-3.

Table 4-3. Perceptions about biophilia throughout project.

	BID-M Group 1			Non-BID-M Group 2			Independent *t*- test		
5-point scale	*n*	*M*	*SD*	*n*	*M*	*SD*	*t*-test	*p* value	Cohen's *d*
Perceptions BEFORE project, survey 1									
Decisions *	9	4.67	.50	9	4.00	.50	2.83	.01	1.12
Confidence	9	3.89	1.05	9	3.78	.44	.29	.77	.14
Perceptions after project and BEFORE taking BID-M, survey 2 part 1									
Now Decisions	10	4.70	.48	9	4.33	.50	1.63	.12	.72
Important**	10	4.80	.42	9	4.22	.44	2.92	.01	1.13
Confident**	10	4.00	.82	9	3.11	.33	3.04	.01	1.16
Knowledge*	10	3.40	.84	9	2.67	.50	2.27	.04	.94
Perceptions after project and AFTER taking BID-M, survey 2, part 3									
Now Important	10	4.70	.48	9	4.44	.53	.29	1.10	.50
Instruction	10	4.30	.86	9	3.89	.55	.24	1.23	.56
Definition	10	4.20	.68	9	3.89	.78	.37	.93	.43
Name	10	4.35	.63	9	4.22	.62	.65	.45	.21
Choices	10	4.35	.47	9	4.50	.79	.62	.51	-.24
Comprehensive	10	4.20	.75	9	4.39	.65	.57	.58	-.27
Uniqueness	10	4.05	.90	9	3.94	.77	.79	.27	.13
Overall Clarity	10	4.10	.67	9	3.94	.68	.62	.51	.24
Helpfulness	10	4.85	.24	9	4.39	.42	.01	2.99	1.14
BID-M self-score	10	105.50	25.50	9	93.22	21.05	1.14	.27	.52

N=number of students; M=mean; SD=standard deviation.

Note: the BID-M is on a 3 point scale per item for a 162-max value. The perceptions before were taken on a 7-point scale and converted to a 5-point. The other items were one a 5-point scale.

*p<.05, **p<.01

At the beginning of the project students already had a view that biophilia could aid in making design decisions. This remained high after the project, increasing slightly. Group 2 after the project (before the use of the BID-M) scored it M = 4.33, SD = .59, compared to M=4.00, SD=.50 before the project. Group 1 (post BID-M) scored M = 4.7, SD = .4, compared to M=4.6, SD =.50. A Paired Samples test showed no statistical difference between the groups from before

to after the project (M = 4.33, SD =.59) (M = 4.5, SD = .51), $t(17) = -1$, $p <$ n.s. They all retained seeing biophilia as a design aid throughout their project.

Group 2 did show statistical difference compared to Group 1in their lower perceived importance of biophilia after the project (and before taking the BID-M), group 1 (M =4.80, SD .42) versus group 2 (M = 4.22, SD =.44) $t = 2.92$, $p = .01$. Also, how knowledgeable they thought they were in biophilic design was statistically higher in Group 1 (M = 3.40, SD = .84) $t = 2.27$, $p =<.05$ than Group 2 (M = 2.67, SD = .50). Group 1 also had a significantly higher confidence rating regarding their designing with biophilia (M = 4.00, SD = .82) $t = 3.04$, $p=.01$ compared to Group 2 (M = 3.11, SD =.33).

In the post-assessment questions an open answer question asked about any change in knowledge of biophilic design and comments from both groups showed they did perceive a change in knowledge. An example from Group 1 highlights this:

> Before, I had no idea how broad biophilic design was. I thought it was just adding plants to a space, but the BID-M showed that biophilia is achieved through so many different ways. Now I know that biophilia isn't just putting a plant or tons of plants within a space.

Another comment was that "*I have learned so much. I had no clue what it was and I will now use this method within my future designs.*" A comment from Group 2 showed similar knowledge change: "*there are a lot more strategies and ways to incorporate biophilia than I thought.*" Another Group 2 example was "*I now understand that biophilia is very broad in the various ways you can incorporate it though light, material, space, etc*." Overall the change in perceptions from before the project to after using the BID-M included a positive influence on confidence and knowledge, agreement on the importance of biophilic design and its ability to be used as a design aid.

Additionally, Group 1 scored the quality of the BID-M in all but two items higher compared to Group 2. This was after all the students had just used the BID-M to assess their own design solutions. The higher scores by Group 1 were expected. The two items of difference for Group 2 were *clarity of the choices available in the BID-M* and the *comprehensiveness of the choices*. This may be due to Group 2 having just being exposed to the variety of attributes and more excited about their benefits. All the ratings for the BID-M scored relatively high. Group 1 scored all items above 4 out of 5 after having more time and experience working with it in design development. Group 2 scored all items at or above 3.89 out of 5, even with their smaller amount of interaction with the BID-M.

The BID-M assessment of their own design were widely varied but included the same building shell and general programmatic elements. This was used to help all the students have an exposure to the variety of features available within a dedicated time of reflection. Group 1 did have a higher mean total BID-M score but not statistically significant compared with Group 2.

BID-M Helpfulness for Students

To look at the helpfulness of the BID-M, each of the final designs were assessed by two jurors to see if the BID-M had impacted the student's ability to include biophilic inclusion variety, thoughtful inclusion and overall success of the biophilic inclusion. These showed no statistical difference between Group 1 and 2 regarding inclusion, thoughtfulness and success (see Table 4-4). However, the combined scores for Group 1 were slightly higher. Inter-judge reliabilities were calculated for each of the two days judges and the reliability of the rankings on inclusion and thoughtful application were cohesive, but overall success varied. An interrater reliability analysis using the Kappa statistic was performed to determine consistency among each day's reviewers. It was a very cohesive agreement for Day 1 (Landis & Koch, 1977), for example, inclusion Kappa = .93 ($p < .0.001$), 95% CI (0.74, 0.98). See Table 4-5. Comparison of

the two second day jurors ranged from moderate to high, with overall success having only fair agreement. The reviewers on the second day were unique in not being fully trained with the list of biophilia attributes in the BID-M and it may not have been as easy to evaluate everything thoroughly during the quick, 7-minute presentations, when not familiar with the BID-M.

Table 4-4. Jury assessment of student work.

	BID-M Group 1			Non- BID-M Group 2				
	n	M	SD	n	M	SD	*t*-test	*p* value
Inclusion of variety	4	3.56	1.38	5	3.27	1.06	.36	.73
Thoughtful application	4	3.38	1.21	5	3.37	.78	.01	.99
Overall success	4	3.42	1.04	5	3.63	.74	-.36	.73
Inclusion of variety	4	3.71	.63	4	3.42	1.04	.48	.65
Thoughtful application	4	3.58	.77	4	3.29	.97	.47	.65
Overall success	4	3.75	.50	4	3.98	.49	-.66	.53

Table 4-5. Inter-rater reliability for the unique jury panels of each day.

	Day 1 trained judges					Day 2 not-trained judges				
	n	*k*	CI lower	CI upper	*p-value.*	n	*k*	CI lower	CI upper	*p value*
Inclusion of variety	2	.93	.74	.98	.00	2	.81	.04	.96	.03
Thoughtful application	2	.92	.72	.98	.00	2	.60	-.55	.91	.11
Overall success	2	.91	.68	.98	.00	2	.22	-.65	.78	.31

When looking at how they had included biophilia into their projects, both groups relied on their concepts to decide what biophilic features to include, then sought out actual or representations of nature, followed by using the local context for inspiration. Group 1 found the variety of choices in the BID-M to be the most helpful. A student explained this as: "*I found that the matrix given was most helpful in including biophilia design because it gave examples of alternative ways to include plant life without including live plants. The most challenging was trying to not use the same design element throughout and trying to think of more complex ways to use the matrix*" (Group 1). The students answered when they might use the BID-M in the

design process and they unanimously said in the conceptual design phase and design development (19 of 19), then programming (13 of 19) and then post occupancy (10 of 19).

The helpfulness of the BID-M in the open answer questions varied slightly in the frequency of themes identified between the two groups. The concept was the key driver for both groups, see Table 4-6. This was seen in many local inspired and natural feature design concepts. The BID-M was the most helpful for the Group 1 vs the site being used for Group 2. The design development was the most challenging for Group 2. Both groups saw the BID-M as able to help them push their concept and design solutions to more developed states with Group 1 seeing the BID-M as a source of inspiration and a reference. The BID-M Group 1 also found creativity and the BID-M being used as a design tool much more than the non-BID-M Group 2. This is probably connected with Group 1 seeing it as a way to push their concept and design solutions since they experienced this during the project. One student noted "*I have learned so much. I had no clue what it was and I will now use this method within my future designs*." (Group 1). A student from Group 2 said "*Now that I know exactly what the features entail, I could see myself thinking about my options to integrate biophilia earlier in the process*" (Group 2). Additionally, "*It can be another way to reinforce and justify the design decisions that I am making*" (Group 2).

Table 4-6. Open answer process number of open comments per theme.

	BID-M Group 1	Non- BID-M Group 2
Helpfulness after project and BEFORE use of BID-M		
How did you decide what features to include?		
Concept	7	8
Actual or representations of nature	5	4
Local context	3	5
What did you find the most helpful for including biophilia?		
BDM/variety of choices	4	0
Human consideration	4	0
Inspirational photos	2	2
Given site	2	5
What was the most challenging?		
Design development	3	6
Feasibility of appropriate interior biophilia features	4	3
Knowledge of appropriate interior biophilia features	3	2
Helpfulness after project and after use of BID-M		
Please explain how you see yourself using this list of features in the future if available?		
Inspiration/brainstorming	5	3
Push concept/design	5	8
Reference and resource	5	2
Assessment tool	1	2
How do you see the BID-M aiding your future design		
For all projects	3	0
Creativity	5	3
As design tool	5	0
As design reference	0	3
Aid thoughtfulness	0	4
Suggestions you may have regarding the BID-M for its future use in other studio projects.		
BID-M		
User friendly	2	0
Examples	2	1
Pedagogy		
Stronger intro	3	3
BIM/technology	1	0
Intro earlier in curriculum	1	2
Stronger throughout project	0	1
Please describe your experience using the BID-M to assist you with including biophilic design into your project. (Group 1 only)		
Aiding inspiration/creativity	3	n/a
Enhancing project	5	n/a
Challenging thought	2	n/a
Providing design assistance	6	n/a

When asked afterwards about the challenges in using biophilic design, thinking beyond plants was an issue: "*The most challenging was finding ways to incorporate plants since they didn't really relate to my concept*" (Group 2). They also struggled if they didn't see their concept relating, especially to plant inclusion, or they excelled if the concept did easily relate: "*I did not realize how biophilia could be incorporated other than putting plants into my design. This has expanded my horizons.*" "*At first not realizing biophilia could be incorporated through ways other than adding plants to the space made it somewhat difficult*." (Group 2).

Table 4-7. Challenges and helpfulness of biophilic design.

	BID-M Group 1			Non- BID-M Group 2			Independent *t*- test		
	N	M	SD	N	M	SD	*t*-test	*p* value	Cohen's *d*
Biophilic feature inclusion (after project and all have used BDM)									
Challenging Conceptual Development	10	2.1	1.29	9	3.22	1.20	-1.96	.07	-.84
Challenging Design Development	10	2.4	1.35	9	2.78	.83	-.72	.48	-.34
BDM use (after project for Group 1)									
Helpful Conceptual Development	10	4.4	2.83	n/a	n/a	n/a	n/a	n/a	n/a
Helpful Design Development	10	4.2	2.00	n/a	n/a	n/a	n/a	n/a	n/a

When asked about challenges in using biophilic design for concept development and design development, Group 1 was less challenged to use biophilic features to fulfill their design concept/strategy (d = -.84), probably due to having the BID-M list. To illustrate, student quotations of perceptions regarding the BID-M and its use in the design concept phase highlights differences and similarities between Group 1 and Group 2:

Group 1 It was not challenging using biophilic features to fulfill my design concept strategy because part of my concept played off the architects love for nature. This

> matrix further pushed my concept and enabled me to include abstract forms of nature to further show the architects love for nature.

Group 2 I did not have a good grasp on all the different ways that I could incorporate it.

Generally, what was most challenging for Group 2 was design development, compared to Group 1, who had a more even distribution of comments. Remember Group 1 had individual desk critiques working with the BID-M during design development.

Group 1 experiences showed the need for a more rigorous introduction to the concept and the Matrix. Also, perceived benefits for the BID-M were found. They noted not being as engaged with it as they could have been at the beginning until after the desk critiques (at the beginning of Phase 3) as illustrated by one student quote: "*The checklist really became more helpful to me halfway through the project, so I was able to add additional elements after considering it. I do wish I had consulted it a little earlier*." Another student said:

> The first introduction was slightly confusing, however, after moving past the learning curve, the BID-M was a great asset. It gave me ideas that I wasn't able to think of myself and allowed me to explore new concepts that really brought life to my project. For example, understanding what the possibilities of a 'nature motif' could be! Or exploring how 'separate parts become a whole.' Without the initial introduction to these concepts, I would have been going in circles trying to figure out how to accomplish my vision. But with the BDM as an aid, I was able to reflect in new ways!

The BID-M proved helpful for incorporating biophilic design into their design concept/strategy. Additionally, the given list of biophilic features was seen as helpful during design development. It was used for ideation and as a helpful addition to their design process. One student said *"I thoroughly enjoyed it because it allowed me to think of new strategies and motifs. My design probably wouldn't have gone as naturally inclined without it*." Their experience with the BID-M in it assisting them with including biophilic design ranged from wishing they had referenced it more to seeing it as a key to their success, for example "*It was a successful experience and it guided me through not only my concept but also my project.*"

Additional examples of their reflective comments that highlight the overall findings of their experience with the BID-M follow. These describe it being helpful in concept and design development, as well as a reference for expanding their thinking about how to approach biophilic integration. Several examples from Group 1 include:

Student A I decided what features to include in my project after evaluating my concept and figuring out ways to include things such as repetition and scale found in nature.

Student B …I appreciated the examples given in the initial presentation, showed creative ways to integrate biophilia

Student C Before, biophilic design was really difficult for me. However, the Matrix made it so much easier and was extremely helpful.

Interesting results for future educational use of the BID-M were found in the final questions regarding their thoughts about future studio use and additional comments. The students want the BID-M at the beginning of the project, noted by both classrooms, and wished to have had access to the BID-M earlier in the curriculum to grow with the concept as they developed their design skills. A student said they would "*Continue to use this as a tool, it is extremely useful. Introduce it earlier in the design process though. Don't wait until senior year. Introduce it to the sophomores and let them grow with the checklist*." Early integration of the BID-M and biophilic design into studio and support classes should make it more integral to the design thinking process and better help students to internalize the variety of features.

Discussion

Importantly, the use of the BID-M in a studio course resulted in helping students with easier biophilic design integration. It was a benefit that the BID-M offers direction for design decisions through the 54 attribute choices. Use throughout the curriculum should thus be further investigated. The types of educational formats that could be used to train designers/students could include web training, workshops, and in person or web conference presentations.

Examples of possible pedagogy expansion includes a dedicated biophilic design course, different studio levels, environment and behavior theory course, introductory survey course, as well as a sustainability course. It can be used in an introduction to interior design or survey course in order to start a conversation about the concept and type of design considerations students should be making using the BID-R to introduce the attributes and definitions. The inclusion of the links to the website with related evidence can provide for additional discussions about evidence-based design. Courses, like an environment and behavior course and sustainability course, could use a project assessment as a classroom activity with a discussion following about the successful biophilic design decisions made and where students see improvements possible. Or, it could be used in studio with additional project market sectors explored and both lower and upper studio classes used for earlier active engagement with the topic for optimal learning (Prince, 2004). Additional ways that the BID-M can be studied in education include comparing different types of user groups (e.g. cultures) and longitudinal studies.

This study informed the expansion of the BID-M in a few different ways. The first way was through the newly expanded toolkit of parts developed based on student and practitioner feedback to increase the usability. The biophilic interior design (BID) toolkit has the following four components now available at http://redgatordesign.wixsite.com/biophilicdesign:

- biophilic interior design matrix (previously the BDM), BID-M
- biophilic interior design checklist sheet, BID-C
- biophilic interior design reference document, BID-R
- online biophilic interior design research repository

The matrix and checklist were used in the studio project, but a middle-sized version with the definitions was needed, so the reference document was created to have the complete list of features and examples included along with hyperlinks to the online visual examples and research.

The studio process used here could be expanded to include a four-stage process with a pre-design charrette, conceptual design and design development use of the toolkit, and then a post assessment. This is based on a student suggestion that using the BID-M in the studio process could be strengthened by including an initial assessment for earlier hands-on experience with the list of features. A type of pre-design charrette using the BID-M or group design assessment could provide a valuable introduction to the attributes and tools. Students could then use the reference sheet (BID-R) while designing. The BID-R is an interactive tool that could be used to provide the list of features and connect to the additional resources online by the student. The checklist could then be used as a deliverable in the mid and final review process to discuss the strategies used as a visual expression of the features included.

The use of the checklist format could be handy when presenting the biophilic features in design presentations and could also provide guidance for meeting CIDA Standard 7-a: theories related to the impact of the built environment on human experience, behavior, and performance. Biophilia is specifically included as a guiding theory. The toolkit can also help with 7-c to aid students gathering and applying human-centered evidence. Future development of the CIDA standards could include having 7-c expanded to reference design tools as supporting criteria. This would allow for both theoretical understanding of biophilia, as included in 7-a, but also the application of it in 7-c to be included as quality standards of interior design. Since guidance was previously unavailable, this research offers an important expansion for interior biophilic design education being able to develop current pedagogy practice. It also can indirectly support 16-b with the students understanding standards and guidelines related to sustainability and wellness by aiding the biophilic design component of WELL and the Living Building Challenge. This standard could be expanded in the future to mention biophilia, sustainability and wellness.

The use of biophilic design in studio courses using the BID-M could benefit from having the work examples evaluated by professionals for independent assessment of student work. The jurors offered critical feedback regarding practical and beneficial design strategies for students and reciprocally their visit also benefited the jurors in exposing them to a wide range of creative ideas and they felt a sense of reinvigoration after seeing the student work. Studio projects require flexible thinking to produce novel and appropriate design solutions (Meneely, 2010). However, it is not clear how different thinking abilities and personality traits of individuals can be developed in design education as expertise and experience increase. The BID-M tool increases perceptions of biophilic design expertise so additional testing is warranted for how this could benefit creative flexible thinking and how it may be applied differently based on personality or thinking ability. This could be a target for future pedagogy development.

The leading experts in the biophilic design field hold that "we should bring as much of nature as we can into our everyday environments so as to experience it first-hand; second, we need to shape our built environment to incorporate those same geometrical qualities found in nature" (Molthrop, 2011, p. 37). This study, while using a small sample, found that students perceived biophilia as an important concept that broadened their horizons and considerations within the design process. They brought as much of nature inside as they could by considering social-ecological, historical, and place-making, beyond the elementary introduction of plants and natural light. With students who had access to the BID-M throughout the project it helped them to brainstorm and working with both an instructor and the BID-M helped to further develop their designs. It also helped them to better understand the attributes available. Interestingly, using the BID-M supported their desire to find unique ways to integrate biophilia and develop creative designs. It now offers a successful platform for biophilic interior design education to build upon.

Two examples of biophilic design that highlight examples of how students approached including a diversity of features are highlighted in Figure 4-1 and 4-2. The spaces shown offer a range of biophilic features, such as plants, natural materials, botanical motifs, curves and arches, fluid forms, abstraction of nature, area of emphasis, patterned wholes, bounded spaces, linked series and chains, and the list goes on.

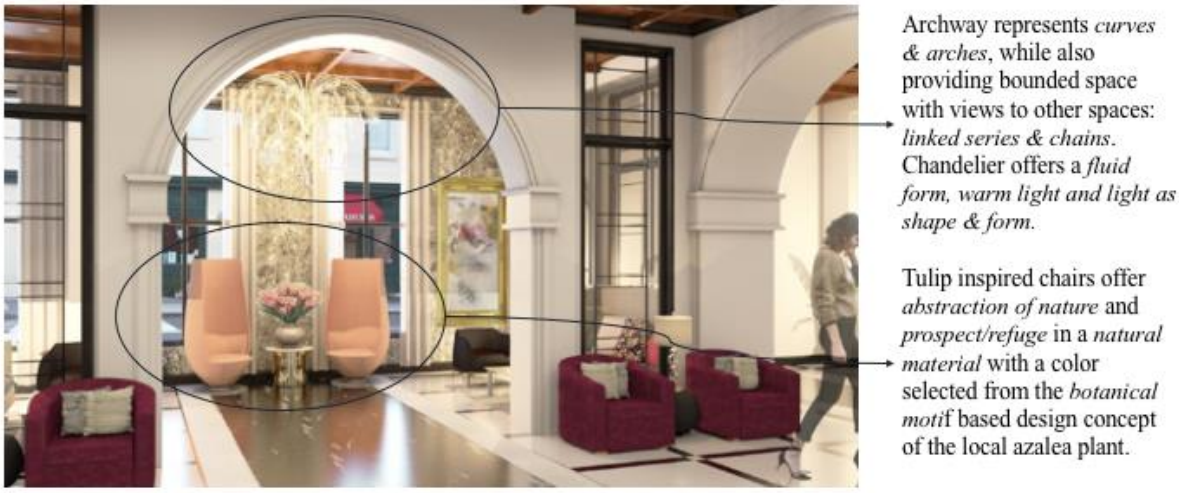


Figure 4-2. Student work example of hotel waiting area.

Figure 4-3. Student work example of restaurant seating area.

The overall quality of the BID-M was satisfactory. Students could see how biophilia could be used to guide their design decisions and it aided their learning process and application.

This included opening them up to the wide variety of ways that they could integrate nature. Although both classes were able to create nature-inspired projects, the results highlight the success of using the BID-M in the studio process by supporting students in making it an easier process. Students benefitted in the concept development and design development phases. They found that it was helpful to tackle the complex concept of biophilic design making them feel more confident and knowledgeable. The benefit of the BID-M as a pedagogical tool was established but there is much more room for additional exploration of teaching and research around the use of biophilic interior design.

CHAPTER 5
CONCLUSIONS

Overall, interior designers do perceive biophilic design as important and as such a tool like the BID-M finds relevance and timeliness in aiding the incorporation of biophilic design. The development of the BID-M now better supports research, practice and teaching/learning. For both practice and pedagogy, the BID-M was seen as useful throughout the design process, beyond post occupancy assessments. Designers may also find online access to an entire tool kit useful. The BID-M offers a new perspective to interior design and adds to the existing body of knowledge in regard to how designers are using biophilic design, how they perceive it and how the BID-M is helpful in trying to use it. Interior designers, from students to experienced practitioners, now have a tool for biophilic design identification that they should find helpful. This was seen in essays 1 and 3. The use of the entire toolkit by students is now relevant to be adopted into multiple types of courses and levels. The ability to tailor the use of the different tools to a variety of course work is an exciting new opportunity for advancement and expansion of biophilic design.

Confidence was higher for students in their biophilic interior design abilities compared to the practitioners. This may be because the students had been taught about the concept and were more familiar with it. Knowledge and confidence is correlated and knowledge levels may influence adoption of evidence-based biophilic design (DeCleene Huber et al., 2015). Future education approaches with the BID tools may find the concrete list of features an approach that supports both confidence and knowledge through initial connection to the concepts and resources and then scaffolded experiential learning through use of the assessment tool.

Designers may find the reference document in the design process the most helpful tool until they are able to internalize the definitions and then use the checklist sheet for its one-page simplicity. This aligns with one of the comments made by a participant about being able to internalize the list after a few uses, whereby a one-page reference sheet would be all that was needed. Designers can be initially trained through a workshop or webinar or be self-taught by simply reviewing the website. Once familiarized with the attributes and tools available, designers can pick the right tool for their needs. Teachers can similarly be trained and assess what tool would fit best with the learning objectives of the class. The importance of being familiar with the list of features is an important consideration found in the differences among judging scores found here. Teachers and those assessing work for biophilic design should consider training beforehand. This is similar to what Amabile (1982) found where topics like creativity needed appropriate judges selected for their level of familiarity with the topic. This appears to be the same for assessing biophilic design output. It is optimal to have reliable and subjective judgements of student work from professionals (Gurel & Basa, n.d.), but biophilic design needs to have specific training not standardly available. The cohesive jury had either used the assessment tool once or completed an exercise with the attributes. Simple training experience or exposure to the attributes should provide adequate knowledge to use and assess biophilic design.

The current lack of biophilic inclusion guiding interior designers in how they can creatively use biophilia as a design tool can now be solved through use of the BID-M and the toolkit. As stated in the introduction, the BID-M can best be seen as symbiotic with other existing reference tools in aiding designers in biophilic design. The ability of tools like LEED provide encouragement for consideration of resource use and consumption patterns. Promotion for platforms of sustainability, wellness and evidence-based design, like the tools offered by the

Center for Health Design and the Living Building Challenge, range in strategies. Developing visual examples and case studies is an excellent approach that designers noted in desiring for biophilic design that the BID-M could offer to support the Living Building Challenge and the Biophilic Design Initiative. A point of difference in programs like LEED, WELL and Living Building Challenge are that they offer accreditation programs for professionals that include education and testing standards. The Living Building Challenge, for example, requires more than 70 hours of experience and a fee to pass the accreditation process, similar to other assessment programs. These types of tools also then certify buildings to reach a certain level of performance. The relatively large time and costs required of these tools is not required for becoming experienced with the BID-M. Completing even one assessment provides knowledge that should be able to guide future design considerations, which is the goal. Access to the toolkit will provide the tools needed for the specific designer's knowledge and needs, while a specific "level" of achievement is not required. The BID-M instead limits the demands imposed on designers rather than increases it once a general awareness is established. It does however offer guidance for obtaining biophilic design in WELL and the Living Building Challenge as they use the same foundational attributes minus the new features from the Color Planning Framework that were added. All the BID-M features now have user-tested language and some have the beginning of an evidence base to guide their application.

Supporting designers through their use of color, light and materials for biophilic design can now be through research support in a variety of attributes. This is important because "colour and lighting can have an impact on peoples' perceptions and responses to the environment" (Dalke et al., 2006, p. 343) and this is a very critical concern of interior design. But it is important to represent nature in these tactics. It would be optimal to be aware and design with the

following mindset: “We are surrounded by an ever-changing palette of color in nature that inspires the principles used in the creation and selection of materials for interior design” (Bosch et al., 2012, p. 13). Regarding light, access to natural light is very important for circadian rhythm and visual connections to actual nature. Window treatments and space planning can help facilitate views and direct access to natural light and are important biophilic considerations. Natural materials are another highly used tactic by designers that allows a direct connection with nature on the interior distinct from most of the other representative attributes in the BID-M and directly applicable through the specification of interior finishes (Dalke et al., 2006). Many of the attributes will involve architects and landscape designers so early programming with the BID-M and the entire design team is important.

Plants are the most common way that interior designers have been supporting biophilia. *Plants* have research that supports its inclusion for sense of wellbeing and stress reduction and is the initial approach that students considered when tasked with biophilic design.

Overall these common approaches shared by students, practitioners and researchers show an innate inclusion of nature-based features in the interior that can and are supported with evidence. They also point to how the RED theory can be further developed through more testing and expanded evidence.

Framework development: Working under the restorative environmental design framework with this research highlights that RED perhaps has areas of specialization needed to work together to fulfill optimal restorative project goals. This further work with RED prompted the diagram Figure 2-2. Prior research has involved a great deal of exterior nature experience from a landscape design perspective where it was found that being in natural environments has positive benefits for wellness (Berman et al., 2008; Beute & Kort, 2014). There is also growing

support for looking at how architecture relates to the people and the community and how community planning benefits individual biophilia (Beatley, 2008; Bender, 2008; Rose, 2008). Ulrich's 1984 examination of interior passive interaction with natural views began to show that interior access to exterior views is a blending of the importance of architecture and landscape/urban design. Sustainability also has a long history with nature with the desire to minimize planetary harm (Edwards, 2005). These are distinct approaches to biophilia that have been growing in research support. Biophilic interior design has also been the focus of research with support for representative and actual interior natural features affecting health (Eisen et al., 2008; Tennessen & Cimprich, 1995; Ulrich, 1984). Together these areas can optimize restorative design decisions for establishing best practices.

Limitations

The limited availability of evidence for attributes is a great need for evidence-based incorporation of biophilic design. However, additional literature reviews and the ability for researchers to use the list of features as inspiration for future studies may help to alleviate this issue.

The need to further train jurors for studio assessments (until wider spread adaption of BID occurs) creates additional demand on both the instructor and the volunteer practitioner. Judgment is always bound by cultural and historic context and it is not expected that universal agreement on the assessed biophilic design of a space remains the same between people, cultures and throughout time periods (Amabile, 1982). This is similar to Amabile's experience with creativity and should be an expectation of additional time requirement.

Differences in personal preference may be a limitation. This is acceptable, however, as individuals will have diversity in their personal experiences with nature since biophilia is a weak biological tendency, as discussed earlier (Kellert, 2008b), and as such it can be fostered or

atrophy. This may influence preference for inclusion of certain features. The BID-M, however, provides a concrete list of features that does not rely on a developed personal biophilia and can offer a way to analytically assess a space and offer choices. Individual assessments will inevitably vary, as was seen here, and the designer will need to select what features are appropriate, but the overall reliability tested here was within acceptable norms (Gliem & Gliem, 2003) even with a small samples size.

As discussed in the introduction, the aim of this research was to better understand how to aid interior designers in biophilic design with multiple aims. Following is a further elaboration of these specific aims.

Aim 1: understanding how to support designer's attempts at biophilic design integration. This was accomplished with the cognitive interviews and the open answer questions in the post-questionnaire of the BID-M that the practitioners completed. The results showed that the designers saw a benefit to the BID-M and could see themselves using it in the future as a conceptual design tool, referencing it throughout the project, using it as an assessment tool and being useful for diverse project types. Additional development of the BID-M and resources can help respond to their suggestions for improvement. The development of the website, checklist and reference sheet are key improvements.

Aim 2: increasing the applicability of the Biophilic Interior Design Matrix. The use of the lobby space for an assessment to test the BID-M was useful. It provided for engaged responses from the participants with several comments that the space in general relied on the landscape design and large windows to provide the most biophilia. This space may have been challenging to some in choosing when to include a feature from the outside or not, since the view outdoors is such a big part of the design and this may have influenced the item reliability.

Overall, the reliability of the BID-M scores shows the ability of the BID-M to be portable across space types, while additional testing and factor analysis may help to further asses this.

Aim 3: understanding how the BID-M can support design education and biophilic design. An interesting insight was that students enjoyed having a concrete list to reference when tackling the complexity of the topic, biophilic design. Before being introduced to the BID-M, students weren't sure what biophilia included, and they considered plants, natural light and environmental considerations as the most common approaches but were excited to find additional options that helped expand their choices. Yet, it was important that the BID-M gave them full freedom as to how to incorporate those choices. Overall, students saw biophilic design as fairly important to interior design. They also could see themselves using it in the future: "I see it aiding any future project that I have". One student noted that "I would like to explore light manipulation even further now that I have gone through this list and have a lot of new ideas now." A student noted that "I now know that biophilic design plays a large part in the overall space planning of a project and the small details such as color and light application." It is an exciting outcome for the BID-M to be useful in a studio course. Students who use the Matrix for evidence-based design decisions in the future can move into practice and use the tool for design ideation as well as use it to explain their design decisions.

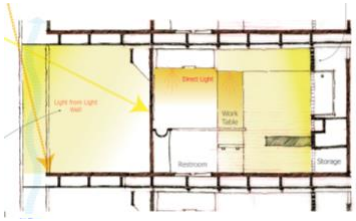
Aim 4: supporting the BID-M features with evidence. A literature review of available research related to color, light and materiality was conducted to identify evidence support for the biophilic attributes and a variety of design features were aligned with research findings. Overall *natural materials* and using the local context were the top color considerations. *Composition* was also a consideration with how color is coordinated and tied into the local context and natural materials selection process. Little research was identified for color in comparison to the other

two topics so many of these strategies that designers use could be aided with a targeted literature review and future research toward color consideration in biophilic design. Light had three common attributes *preference, response* and *natural light* in research. *Natural light* was also the most common practitioner tactic identified. Probably the most impactful features, natural light is also one of the most obvious biophilic light features. Interestingly *plants* were the most common research tool, but *natural materials* were the most common tactic for practitioners. A targeted review of that feature might be justified as a higher priority for future research. Overall, a continued development of identifying and conducting more research of color, light and materiality should prove beneficial to practitioners as they are attempting to use biophilic design.

The continued development of the BID-M and the related tools are the next steps in the evolution of the BID-M. This includes additional testing with students and practitioners to validate use and quality among diverse project types. Also, different cultures and different parts of the curriculum can be explored. A literature review for adding research to the 54 attributes is needed and can benefit both students and practitioners.

In conclusion the BID-M is a useful tool for designers, educators and students to use. It allows for complete control by the designer regarding the application of features but provides a tangible way to approach the concept of biophilia. Additional work on providing these tools online and testing out the best dissemination for the tool is also needed. The justification of this work and future development aligns with the aim of the International Living Future Institute and their Biophilic Design Initiative to ultimately "achieve the goal of broad adoption of Biophilic Design among the design community, building owners and cities" ("Biophilic Design Initiative," n.d., para. 1).

APPENDIX A
ASSIGNMENT SHEET



IND 3431 INTERIOR LIGHTING
COLLEGE OF DESIGN, CONSTRUCTION AND PLANNING
DEPARTMENT OF INTERIOR DESIGN

Project 1
Light the Way: Nature-based Design Research

Background- Light interplays with both color and the materials within a space. This makes it a primary interior design consideration. The biophilic hypothesis poses that people have an innate need to connect with nature. This design topic began with a study that found even viewing nature can have healing implications and affect our wellbeing. Since then, many studies have grown the evidence base for interior designers to draw from when making design decisions. Among these, those that help designers with light, color and materiality choices are especially important for designers to be aware of and this project aims to help you become familiar with this growing evidence base and light the way for other designers to see these connections that you have made between these articles and the concept of biophilic design.

CIDA Standard 12. Light and Color
a) Students are aware of the environmental impact of illumination strategies and decisions.
c) strategies for using and modulating natural light.
e) Students have awareness of a range of sources for information and research about color.
f) Students understand how light and color in the interior environment impact health, safety, and wellbeing.
g) color terminology.
h) color principles, theories, and systems.
i) color in relation to materials, textures, light, and form.

Objective- The project goal is to provide you with a wide range of design research knowledge that can help you with future studio projects and in your knowledge and use of lighting and its interplay with color and materiality.

Requirement- You will individually identify, summarize and share with the class 5 design research articles to add to the Biophilic Design Matrix list of references for any of the attributes.
(see http://redgatordesign.wixsite.com/biophilicdesign/)

Procedure- Article Identification Part 1 Due: 1/31 @ 1pm
Identify 5 relevant articles for each topic (color, light and materiality) in interior design that are related to the features on the Biophilic Interior Design Matrix (BID-M). The BID-M can be found at
http://redgatordesign.wixsite.com/biophilicdesign/biophilic-interior-design-matrix

Process- Using the UF Library search database

- Art and Architecture Source

- Building Green
- Compendex
- Dissertations and Theses Global
- Materials Research Database
- Referex Engineering - Materials and Mechanical Collection (Engineering Village)
- Web of Science
- Informedesign
- Googlescholar
-

Use the following search criteria:
Language: English
Published Date: 1985- present
Publication type: peer reviewed article or dissertation/thesis

Deliverable: Upload to Canvas an Excel file using the following template with citations in APA format. These will be reviewed and 1 citation for each topic will be highlighted for you to focus upon for Part 2.

CONTENTS	Color	Light	Materiality
Citation #1 APA citation followed by (key biophilic features)		Example: Weinberger, N., Butler, A. G., McGee, B., Schumacher, P. A., & Brown, R. L. (2017). Child life specialists' evaluation of hospital playroom design: A mixed method inquiry. Journal of Interior Design, 42(2), 71-91. (biophilic features: spaciousness, color, daylight)	
Citation #2			
Citation #3			
Citation #4			
Citation #5			

Annotated Bibliography Draft Part 2 Due 2/19 @ 1pm

Use the following Guidelines and Template for the Annotated Bibliography.

Process- Complete a summary of each relevant article you read by filling out the given template below. Articles to be used will be provided/highlighted for you by 2/12.

Guidelines for the Annotated Bibliography- Keep the following points in mind when filling out the form and address them as they relate to the article.

- Author/title (Citation). Complete reference for the article formatted using the style delineated in the APA Manual.
- Keywords. Identify the important keywords designers may use to search for this article and its contents.

- Abstract. Copy the abstract.
- Purpose of the Study. Identify the purpose of the study including the questions and/or hypotheses that frame the research.
- Biophilic Feature(s). List all of the biophilic features that are important to the study.
- Key Findings. What are the major findings from the study for interior designers to know?
- Strengths and Limitations of the Study. In what areas was the research strongest? What are the limitations of the study from the perspective of research and/or practice? What do you wish they would have included or focused on?
- Implications. What are the important take-a-ways for practice, education or research? Does the article support or contradict previous theories/research/norms of practice? Does the conclusion explain how the research has moved the body of scientific knowledge forward?

CONTENTS	Color	Light	Materiality
Citation			
Biophilic features			
Abstract			
Purpose			
Key findings in relation to biophilia			
Strengths and Limitations of the Study			
Implications for practice, research and/or theory			
Any other lessons			
2-5 Interesting quotations from article	“	“	“

Deliverables- Fill out the given template using the guidelines provided for the selected 3 articles on color, light and materiality related to biophilia in interior design. Upload Excel file to Canvas.

Annotated Bibliography Final Part 3 Due 2/28 @11:59 pm

Process- Finalize based upon review comments given back by 2/26.
Deliverables- Finalize template of 3 articles on color, light and materiality related to biophilia in interior design. Upload Excel file to Canvas before midnight.

*Judging based on a scale of 1 to 9 for each criterion, with 3 points max per article, 1 being lowest and 9 highest in total, except for Part 1 with 15 being highest score earned, 1 point for each article.

1	Sufficient references in Pt 1 (1 pt each)	1	2	4	6	8	10	12	14	15

2	Use APA format in template Pt 1 (1 pt each)	1	2	4	6	8	10	12	14	15
3	Biophilic connections correctly identified in Pt 1 (1 pt each)	1	2	4	6	8	10	12	14	15
4	Appropriate and relevant articles selected Pt 1 (1 pt each)	1	2	4	6	8	10	12	14	15
5	Sufficient references in the review; Use APA format in Pt 2/3	1	2	3	4	5	6	7	8	9
6	Biophilic features identified Pt 2/3	1	2	3	4	5	6	7	8	9
7	Abstract included Pt 2/3	1	2	3	4	5	6	7	8	9
8	Clarity of the purpose guiding the inquiry in Pt 2/3	1	2	3	4	5	6	7	8	9
9	Well-developed key findings from the body of the literature that also connect with specific biophilic features Pt 2/3	1	2	3	4	5	6	7	8	9
10	Understanding of the strengths and weaknesses/ notable gaps of the research in Pt 2/3	1	2	3	4	5	6	7	8	9
11	Level of synthesis that describes the major implications in Pt 2/3	1	2	3	4	5	6	7	8	9
12	Including interesting 2+ quotations Pt 2/3	1	2	3	4	5	6	7	8	9
13	Revised final draft per comments Pt 3	1	2	3	4	5	6	7	8	9
14	Overall, it is well written and well communicated in Pt 2/3	1	2	3	4	5	6	7	8	9

TOTAL SCORE: _____ / 150 pts

APPENDIX B
BDM SURVEY

Welcome! You are about to help further develop the Biophilic Design Matrix (BDM). This survey has four parts and should take around 30 minutes to complete. It will automatically save your answers and you can start and stop as often as you would like. Due to the length, it is recommended you take your time and take breaks as needed. You can move forward and backwards as needed.

INSTRUCTIONS

Viewing the Survey Photographs

The following survey contains photographs of a lobby/waiting room. It will be important for you to have a clear, enlarged view of the site images so that you will be able to notice the specific and unique details of each space.

Please complete the electronic survey on a **full-size laptop or desktop computer**. Please do not attempt to complete the survey using a tablet or smartphone, as the screen size will be too small. For optimum viewing of the site, we recommend that you consider one or more of the following to zoom in when you are viewing the electronic survey: On a PC, this can be done by pushing the CONTROL key and + on the keyboard. On a MAC, this can be done by pushing the COMMAND key (⌘) and + on the keyboard. This step can be repeated until the view is enlarged enough.

Completing the Survey

There are 4 parts to this survey: •In Part I, you will be asked to enter background information about yourself and your employment. •In Part II, you will be asked to complete a survey regarding your personal experience as a sustainability-focused interior designer. •Part III you will be provided images of the lobby and you are to reference the images on a separate screen. Please carefully look to get an overview of the space and then complete the 54-item survey related to that specific room. You will need to refer to the site (and have a clear, enlarged view) in order to answer the questions. Please select the perceived amount of the attribute in regard to the space if found at all in the interior. If you have any suggestions for modification of the attribute name or description provided, please make note of them and then include this in the modifications/suggestions question at the end of the survey. No need to add up the scale just submit and you will see your results at the end. •In Part IV, you will be directed to complete a separate survey to review your thoughts and opinions on the matrix and your experience with designing with nature.

For technical help please email me at blsmcgee@ufl.edu. Thank you!

By continuing you agree to participate and share your findings with the researchers and any future publications that may result. This is voluntary and no personal identifiers will be published. A copy of the consent form and study information is available: INFO SHEET.

Demographics

D1 How many years have you been involved with designing interior spaces?

- ○ Under 2 years
- ○ 2 - 5 years
- ○ 6 -10 years
- ○ 11- 15 years
- ○ 16 - 20 years
- ○ 21 - 25 years
- ○ 26 years or more
- ○ I do not design interiors

D2 Do you have a design degree from a CIDA (formerly FIDER) or NAAB accredited program?

- ○ Yes (1)
- ○ No (2)

D3 What related certifications or licensing do you have besides a design degree? Select all that apply.

- ○ AAHID
- ○ LEED
- ○ NCARB
- ○ NCIDQ
- ○ WELL
- ○ State License or Registration
- ○ Other_____

D4 If you have an area(s) of specialization what is it? Select all that apply.

- ○ Corporate
- ○ Healthcare
- ○ Hospitality
- ○ Institution
- ○ Residential
- ○ Other _____

Instructions Please complete the following survey regarding your personal experience.

Definition Biophilia is an innate (inherent) human need for nature so biophilic design is the deliberate attempt to translate that affinity for natural systems and processes into the built environment.

Pre1
How much do you see biophilia as being **important** to interior design?

	None at all (36)	A little (37)	A moderate amount (38)	A lot (39)	A great deal (40)
Biophilia importance (1)	○	○	○	○	○

Pre2
How much have you attempted to **apply** biophilia in any of your designs?

	None at all (20)	A little (21)	A moderate amount (22)	A lot (23)	A great deal (24)
Biophilia application (23)	○	○	○	○	○

Pre3
How **confident** are you in using biophilia in your designs?

	None at all (28)	A little (29)	A moderate amount (30)	A lot (31)	A great deal (32)
Biophilia confidence (6)	○	○	○	○	○

Pre4
How **knowledgeable** are you in biophilic design?

	None at all (42)	A little (43)	A moderate amount (44)	A lot (45)	A great deal (46)
Biophilia knowledge (3)	○	○	○	○	○

The room assessment starts next.
DIRECTIONS

Step 1) Open the Site Pictures
Right click on the link: **SITE PICTURES** to open another window **and** keep this window to complete the survey.

You can download the pictures if desired.

Step 2) Review the Site Pictures
Scroll through all the pictures initially to get familiar with the space.
You **can** refer back as needed to review the space to identify if a feature is present or not.

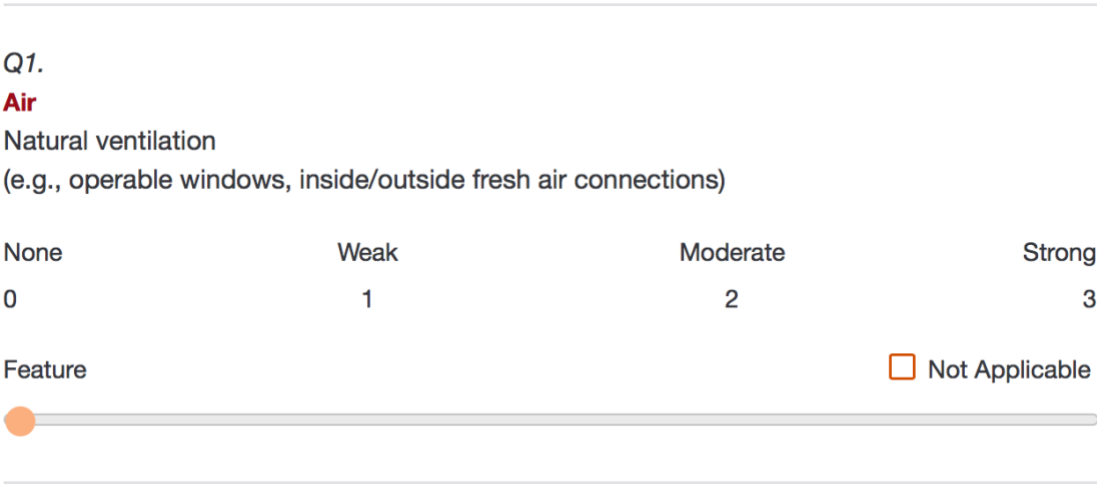
For technical issues, please email blsmcgee@ufl.edu or call 616-340-8706.

Step 4) Refer to All of the Site Pictures to assess the following 54 features of the Biophilic Design Matrix (BDM).

Step 4) Assess Site for the Features: Assess those features that are in the Interior or viewed from the interior- regardless of the perceived intention of the design team.

Then select the strength of the feature in the space from Weak (1) to Strong (3), None if it is not found or Not Applicable if the photo images provided does not allow for assessment of that feature.

It will look like this:



Step 5) Get Started:
Go to the next page and start assessment.
First a little background info:
This site is located in Gainesville, Florida which has a dense tree-canopy with coniferous and deciduous trees, small lakes and is approximately an hour from the ocean. It is in a humid subtropical climate.

Instructions
There are 6 feature groupings.
Group 1 of 6
The first group of features are Actual natural features- actual (not images) of real nature characteristics in the interior

Using all the pictures provided, please choose the strength that each feature has in the space.

Q1 Air
Natural ventilation.
(e.g., operable windows, inside/outside fresh air connections)
Q2
Water
Any type of actual water feature in the interior.
(e.g., water fountain, sink, or fish tank
Q3 Plants
Actual plants in any form (alive or preserved) in the interior.
(e.g., potted plants or dried leaves in a shadow box)
Q4 Animals
Actual animals in any form (alive or preserved) in the interior.
(e.g., fish in a fish tank)
Q5 Natural materials
Materials extracted from nature.

(e.g., wood, stone, or paper)
Q6 Views and vistas
Exterior views of natural features such as vegetation.
(e.g., window view of Central Park)
Q7 Habitats & vistas
The interior of buildings and their landscapes that possess a close and compatible relationship to local habitats.
(e.g., views to locally appropriate landscape)
Q8 Fire
Fire providing comfort and civilization when controlled, includes color, warmth and movement.
(e.g., fireplace)
Instructions
Feature Group 2 of 6
The second group of features are Natural shapes and forms- nature representations and simulations

Q9 Botanical motifs
Representations of shapes, forms and patterns of plants and vegetative matter.
(e.g., painting of flowers)
Q10 Animal-like
Representations of animals, may be highly stylized.
(e.g., animal forms, claws or heads)
Q11 Shells and spirals
Representations of invertebrates.
(e.g., images or forms of shells and spirals, bees and their hives, butterflies, spiders and their webs)
Q12 Curves and arches
Representing curves found in nature like treelike shapes, ovals, semi curvilinear forms.
(e.g., egg and dart moulding, arching columns and domes)
Q13 Fluid forms
Shapes resisting straight lines and right angles that are flowing; they act as if they are adapting to forces found in nature.
(e.g., sinuous floor inlay)
Q14 Abstraction of nature
A simulation rather than replication of natural form or function; forms are vaguely reminiscent of those naturally found but use nature as a model.
(e.g., Monet painting of flowers, fleur de lis ironwork, Gaudi's Sagrada Familia)
Q15 Inside-Outside
Interior spaces that appear connected to the outside environment, embracing inside what's nearby outside near to the building.
(e.g., interior gardens, ocean motif used if located at the beach, same flooring used both inside and outside)
Instructions
Feature Group 3 of 6

The third group of features are Natural patterns and processes- properties derived from natural features and process

Q16 Sensory richness
Information richness can include complexity in visual, sound, touch, smell and/or taste for a sensuous and intellectually challenging environment.
(e.g., assortment of patterns, texture and color for sensory variety)
*Base this assessment upon the visual richness, typically in person observation would be needed
Q17 Age, change and the patina of time
Showing age or change, such as in wear or growth, particularly by organic forms like wood but even inorganics like stone.
(e.g., use of plants that have obviously grown over time and "taken over", farmhouse table of weathered wood)
Q18 Area of emphasis
An area of reference or interest in a space, central focal point.
(e.g., fireplace or grand staircase)
Q19 Patterned wholes
Unique individual parts become organized in a pattern, variety united.
(e.g., tile floor mosaic inlay)
Q20 Bounded spaces
A delineated space with clear boundaries or borders.
(e.g., walled room with a sense of enclosure)
Q21 Linked series and chains
Spaces connected that bring you from one space to another in a series.
(e.g., coordinated design tying together a series of rooms, clear glass walls separating adjoining spaces)
Q22 Integration of parts to wholes
Individual similar components come together to create a greater whole.
(e.g., small wood planks can make up a wood floor, glass mullion pattern, subway tile backsplash)
Q23 Complementary contrasts
The blend of contrasting features or opposites.
(e.g., light and dark areas, open and closed space, high and low ceilings)
Q24 Dynamic balance and tension
Shapes, forms or materials that are both balanced and show a degree of tension.
(e.g., symmetrically balanced ceiling mobile, view of a balancing sculpture)
Q25 Natural ratios and scales
Patterns such as natural arithmetic or geometric ratios or scales.
(e.g., golden ratio, golden sections, golden proportion, golden spiral, and Fibonacci's sequence: 0,1,1,2,3,5,8,13,21,34..., these can be highly complex patterns yet seem organized like a sunflower patterned fabric or artichoke light fixture)
Instructions
Feature Group 4 of 6
The fourth group of features are Color and Light- color, light and material qualities and space relationships with nature

Composition
Color, light and materials applied as a composition through unity and or variety connecting with nature.
(e.g., variety of natural materials used throughout with a unified color scheme)
Q27 Communication
Color, light and materials used to connect people with the site or locale; concepts symbolize identity to send a message.
(e.g., color selection coming from the site for communing with the surrounding nature)
Q28 Preference
Color, light and materials reflecting the time, place, and circumstances in which we live.
(e.g., a designer/firm signature style, market trends such as the Pantone color of the year)
Q29 Response
Natural inspired color, light and materials integrated for physiological, psychological and or behavioral responses.
(e.g., light fixtures that mimic sunrise/sunset patterns)
Q30 Pragmatics
Color, light and materials selection based upon maintenance, life cycle cost, existing conditions, external weather and/or environmental choices.
(e.g., sustainable flooring choice for high traffic area)
Q31 Natural light
Daylight/ sunlight access.
(e.g., window, clearstory, skylight)
Q32 Filtered light
Modulated daylight, reduces glare.
(e.g., blinds, shades, tinted glazing)
Q33 Reflected light
Light reflecting off surfaces.
(e.g., reflective surfaces that may provide sparkle)
Q34 Light pools
Pools of connected light in a series on the floor or wall drawing you from one area to another, often surrounded by darker areas.
(e.g., high contrast lighting environment)
Q35 Warm light
Warm and inviting lighting, 2,000 to 3,000 K color temperature.
(e.g., incandescent lighting, candle light)
Q36 Light as shape and form
Natural light manipulated to create stimulating, dynamic and/or sculptural form.
(e.g., light shaft)
Q37 Spaciousness
Openness or feeling of large expanse.
(e.g., a high ceiling)
Q38 Spatial variety
Variance in the interior space
(e.g., different ceiling heights or room widths)
Q39 Space as shape and form
Space that is manipulated into a natural inspired form or shape.

(e.g., Sydney Opera House)
Q40 Spatial harmony
Coherence in the interior space.
(e.g., repetition of design elements for coherence)
Instructions
Feature Group 5 of 6The fifth group of features are Place-Based Relationships- culture together with ecology, rooted in geography
Q41 Geographic connection to place
Emphasizing geographic features such as climates, countries, people and/or natural resources within the interior environment.
(e.g., photograph of a well-known local natural landmark)
Q42 Historic connection to place
Relation to the past through the marking of the passage of time, linking the past to the present, fostering a culture's collective memory.
(e.g., historical portrait)
Q43 Ecological connection to place
Emphasizing ecological features within the interior environment of forest, grassland, desert, tundra, freshwater or marine.
(e.g., interior bamboo garden)
Q44 Cultural connection to place
Integrating cultural identities.
(e.g., regional decorative craft)
Q45 Integration of culture and ecology
A social center that fosters community building.
(e.g., sustainable artwork)
Q46 Spirit of place
A metaphorical place given life, when a place becomes cherished by people it gives rise to and sustains human culture and ecology over time.
(e.g., Mount Vernon, gothic cathedral)
*May need in person assessment
Instructions
Feature Group 6 of 6The sixth group of features are Human-Nature Relationships- paired biological needs with nature
Q47 Prospect/Refuge
A place with the ability to survey the distance in a place of security/ a view of the entire space AND a place of protection/ separated from spaciousness.
(e.g., view from an alcove to a larger space, interior view of spacious landscape)
Q48 Order/Complexity
Designs that meld order AND stimulate the desire for variety in a controlled manner, a balance of structured organization with intricacy of detail that together appears orderly.
(e.g., bookshelves)
Q49 Curiosity/Enticement
Spaces that elicit exploration, discovery or mystery AND draws you farther in.
(e.g., space planning that draws you around the corner to view more)
Q50 Mastery/Control
Respectful mastery of nature which expresses ingenuity and cleverness AND user ability to

manipulate the environment.
(e.g., occupant control of air, light or sound quality; furniture with ergonomic adjustments)
Q51 Attraction/Attachment
Appealing natural designs AND affection for features together can create a lasting loyalty.
(e.g., beautiful wishing fountain)
Q52 Exploration/Discovery
The desire for further inquiry AND revealing a sensory rich interior.
(e.g., nature themed play structure)
Q53 Fear/Awe
Design integrating a feeling of peril AND feelings of wonder or delight.
(e.g., rock climbing wall, bridge with see-through flooring)
Q54 Reverence/Spirituality
Affirming the human need for establishing meaningful relationships to creation AND reverential feelings of connection vs. the aloneness of a single person isolated in space and time.
(e.g., tall stain glass windows)
*May need in person assessment

Please complete the following post assessment survey.

Post1 When might you use the above list of features? Select all that apply.

- ○ Conceptual design (1)
- ○ Programming (2)
- ○ Design development (3)
- ○ Post occupancy (4)
- ○ All of the above (6)
- ○ None of the above (5)

Post2 Please explain how you see yourself using this list of features (BDM) in the future if available?

Post3 Do you see biophilia as being important to interior design now that you have used the BDM assessment?

	Definitely not (42)	Probably not (43)	Might or might not (44)	Probably yes (45)	Definitely yes (46)
Biophilia is a design aid (1)	○	○	○	○	○

Post4 Please describe after having used the BDM any change in your knowledge of biophilia.
Post5 If any, please describe what biophilic features listed earlier are being requested by clients?
Post6 Please describe how you include biophilia through color, light and materials into your projects?
Post7 When trying to include color, light or materials in biophilic features, please describe what issues you have come across?
Post8 How would you rate the quality of the BDM as an interior design tool in the following categories (5 stars being the highest and a strength of the tool and one being the lowest and a weakness of the tool)

Clarity of instructions (2)	
Clarity of attribute definitions (3)	
Clarity of the attribute names (4)	
Answer options (5)	
Comprehensiveness of 54 choices (6)	
Overall clarity (1)	
Helpfulness as a design tool (9)	

Post9 Please describe any way the BDM can be improved for designing an interior environment.
Thank you for participating in testing the Biophilic Design Matrix, please leave any additional comments you might have here:

APPENDIX C
COGNITIVE INTERVIEW MANUAL

Cognitive testing round #, Date, Time, Location, Time start_____ stop_____

1. Introductions

Introduce yourself, thank the interviewee for coming, and show him/her where to sit.

2. Rapport building

Establish rapport with the interviewee to ease anxiety that s/he may have about participating in the pre-interview and cognitive interview.

3. Purpose overview

Remind the interviewee about the purpose of the project and tell him/her you are interested in hearing what s/he has to say about the materials.

4. Start time recording

5. Authorization consent sheet noted. Is audio recording this ok?

6. Answer any questions

7. Intro

"Thinking aloud may be new and unfamiliar to you, but please know there are no wrong answers. I am only interested in knowing what is going through your mind. Any information you provide during this pre-interview will not be used in the project; this session is merely to help you become familiar and comfortable with the 'think aloud' process."

8. Warm-up

"Before we begin the actual pre-interview, I'd like to ask you a 'warm-up' question to introduce you to the think aloud process."

"Try to visualize the place where you live and think about how many windows there are in that place. As you count the windows, tell me what you are seeing and thinking about." (Willis, 1994) Proceed to the pre-interview instructions after the interviewee has completed the warm-up question.

If without difficulty respond “That’s great. Thinking out loud like this is just what I need.”

“Good. Your comments help me understand what you’re thinking about.”

If there is difficulty ask “Tell me what you are thinking.”

“What thoughts are going through your mind right now?”

9. Probe suggestions:

- “Tell me what you’re thinking.”
  “What are you thinking about right now?”
- “I see you hesitate. Can you tell me why?”
- “Is that question clear?”
- “Does that definition make sense to you?”
- "What specifically are you thinking about right now?”
- “What thoughts came to mind just now?”

Other notes:

10. Intro: I need help to make sure this thing will "work" for participants -- that the order is right, the topics make sense, etc. Please feel free to be candid and open to saying whatever pops into your head, good or bad. It is all helpful.

11. Pre and Post survey will be completed if time available, or asked to be completed outside of this interview

Connect to survey and follow prompts

Pre-survey notes

Survey responses noted per section

12. Instructions

13. Demographics

14. Pre-Assessment Survey

15. Pictures

16. Environmental Features

17. Natural shapes and forms

18. Natural patterns and processes

19. Light and Space

20. Place-base relationships

21. Human-nature relationships

22. Scoring/ Post Assessment Survey/ Conclusion

Pre-survey notes

Closing "Thank you for taking time to develop this instrument with me. What questions do you have? Answer any questions, record the stop time on the beginning of this recording form.

Additional Notes

APPENDIX D
DESIGNER'S CHECKLIST

BIOPHILIC DESIGN MATRIX CHECKLIST

Research supports including a variety of nature-based design features in interior design. You don't need to include every feature. It is important to use thoughtful integration appropriate to the project, context and culture. Use this list as a reminder for how you're attempting biophilic variety. For more info visit: WWW.REDGATORDESIGN.WIXSITE.COM/BIOPHILICDESIGN

actual natural features- actual (not images) of real nature characteristics in the interior

- ○ 1 air
- ○ 2 water
- ○ 3 plants
- ○ 4 animals
- ○ 5 natural materials
- ○ 6 views & vistas
- ○ 7 habitats
- ○ 8 fire

natural shapes & forms- representations of nature and simulations

- ○ 9 botanical motifs
- ○ 10 animal-like
- ○ 11 shells & spirals
- ○ 12 curves & arches
- ○ 13 fluid forms
- ○ 14 abstraction of nature
- ○ 15 inside-outside

natural patterns & processes- properties derived from natural features & processes

- ○ 16 sensory richness
- ○ 17 age, change & the patina of time
- ○ 18 area of emphasis
- ○ 19 patterned wholes
- ○ 20 bounded spaces
- ○ 21 linked series & chains
- ○ 22 integration of parts to wholes
- ○ 23 complementary contrasts
- ○ 24 dynamic balance & tension
- ○ 25 natural ratios & scales

color and space- color, light and material qualities & space relationships to nature

- ○ 26 composition
- ○ 27 communication
- ○ 28 preference
- ○ 29 response
- ○ 30 pragmatics
- ○ 31 natural light
- ○ 32 filtered light
- ○ 33 reflected light
- ○ 34 light pools
- ○ 35 warm light
- ○ 36 light as shape & form
- ○ 37 spaciousness
- ○ 38 spatial variety
- ○ 39 space as shape & form
- ○ 40 spatial harmony

place-based relationships- culture together with ecology, rooted in geography

- ○ 41 geographic connection to place
- ○ 42 historic connection to place
- ○ 43 ecological connection to place
- ○ 44 cultural connection to place
- ○ 45 integration of culture and ecology
- ○ 46 spirit of place

human-nature relationships- paired biological needs of the human relationship to nature

- ○ 47 prospect/refuge
- ○ 48 order/complexity
- ○ 49 curiosity/enticement
- ○ 50 mastery and control
- ○ 51 attraction/attachment
- ○ 52 exploration/discovery
- ○ 53 fear/awe
- ○ 54 reverence/spirituality

APPENDIX E
EMAIL INVITATION

Please try out a **new design tool** to help make nature-based design easier for interior design.

TIME: ~½ hour

LINK: Biophilic Design

(https://ufl.qualtrics.com/jfe/form/SV_80sYXrYHIUSaD65)

SHARE: <u>Please</u> forward to anyone you know who is an interior designer or architect in the USA.

QUESTIONS: Contact me with questions or comments, Beth McGee, Ph.D. candidate

m.s. | leed ap | ncidq #24263

The University of Florida
College of Design, Construction, and Planning
Phone: 616-340-8706

	Study type	n	Population type/building	Qualitative Measurement	Quantitative Measurement	Results	Limitations
1	case study/ longitudinal	12	office workers	interviews, observation, photographs and video footage	n/a	enhanced collaboration amongst staff, including across teams, improved morale, and mitigation against stress	Short term, involvement with initial worker bee, subjective measures only
2	creative product design	44	college students	interviews	n/a	students were able to create nature inspired stools and changed their perceptions about design and nature	no detailed methods or explanation of results
3	case study	n/a	n/a	n/a	HOK measured Lavasa biomimetic designs	HOK using biologize in design process and other products, show interior design should include it in design process	measurements not detailed, no reliability measures noted
4	exploratory	42	college students	pattern elements	PCA method analysis of number of components of abstract design	color changes reactions to patterns, variety of color important to patterns, color more impactful than the other design elements	who rated the patterns not specified with inter rater reliability
5	Instrument developme nt	n/a	n/a	Light calculations	Colour Quality Assessment Tool (CQAT)n/a	Regardless of the luminaire colour temperature, the blue interior finishes have a greater effect on the biorhythm of an observer than that of the red finishes.	Daylight effect not calculated
8	experiment	97	not color blind	bipolar semantic differential rating scales	n/a	red lighting least comfortable and least spacious, white light most spacious, higher quality, green and red more aesthetic	CRI of the lights varied

	Study type	n	Population type/building	Qualitative Measurement	Quantitative Measurement	Results	Limitations
6	quasi-experiment	282	rehab patients, lung and heart	self-report measures of health, subjective well-being, and emotion.	n/a	subjective wellbeing in pulmonary patients improved red lighting the space was perceived to	pre-existing differences between the group could ex
7	experiment	97	not color blind	bipolar semantic differential rating scales	n/a	be least comfortable and least spacious, white light most spacious, higher quality, green and red more aesthetic	CRI of the ligh varied
8	simulation	251	college students	architectural design	n/a	design included a range of biophilic features for wellbeing	no analysis of design or interviews or u feedback
9	exploratory	65	young adult millennial students	n/a	9-point bipolar scales	plants and posters and tidiness seen as more positive, females had a stronger reaction	details about poster content not included
10	case study	3 schools, 41 teachers	daylit schools, teachers	n/a	overall room-light estimation, readability by figure to ground value contrast, Munsell hue notations	older adults perceived the higher color temperature light source as less cool than younger adults, older adults rated comfort and preference higher than younger, higher color-rendering light sources provide better readability, older adults have more difficulty with warmer lighting when value contrasts were reduced	controlled sett limits representing fi conditions, old adults with lon exposure to condition may affect visual ta

	Study type	n	Population type/building	Qualitative Measurement	Quantitative Measurement	Results	Limitations
11	exploratory	30	college students	photo documentation of good design	photo documentation with list of design elements	education was needed regarding natural light and high reflectance surfaces specified	
12	experiment	82	42 older adults and 40 younger adults	end-user Likert scale surveys	field study	natural light and views satisfaction parallel classrooms satisfaction, control of daylight key need, blinds were closed more for south facing	reason behind classroom arrangement neutrality not explored
13	experiment	77	college students		10-item bipolar adjective scale, stress arousal checklist,	participants perceiving less stress in the room with the indoor plants	actual user perceptions missing
14	exploratory	25, 28	students	questionnaire	window occlusion: Foster and Oreszczyn's method, sunshine index	light shelf zone led to a lower window occlusion and energy savings	questionnaire during full daylight not included
15	experiment	98	not color blind, adults, 49 Caucasian-American subjects and 49 Korean subjects	questionnaires	n/a	four lighting conditions: arousal varied by culture (Americans more) and higher color temperature more arousing, color rendering varied by culture, 3k more pleasurable but less approachable	did not include emotional state of arousal and the color quality of light in a retail store environment
			patients, not blind or		(1) length of stay, (2) BP, (3) digestive condition, (4) acute stress, (5) state anxiety, (6) pain intensity, (7) sleep		

	Study type	n	Population type/building	Qualitative Measurement	Quantitative Measurement	Results	Limitations
16	experiment	181	patients, not blind or mentally compromised	n/a	(1) length of stay, (2) BP, (3) digestive condition, (4) acute stress, (5) state anxiety, (6) pain intensity, (7) sleep quality, and (8) environmental satisfaction.	Salutogenic benefits of photographic sky compositions	need to extend patient population type
17	exploratory	60, 20	college students, high school students	Q sort	The Torrance Test of Creative Thinking	greater perceived creativity: (a) complexity of visual detail, (b) view of natural environment, (c) use of natural materials, (d) with fewer cool colors used, and (e) less manufactured materials.	diverse populations need to be studied
18	case study	62	residents 15 yr. Hamedan, Iran	actual recording, surveying and questionnaires	correlation through investigating the case studies	it is recommended that in addition to including green spaces in the built-up areas, rooted norms, natural elements and contextual features of place should be also taken into considerations	demographics not included
19	focus group, randomized and quasi-experiment	12 9,4 8,4 8	four age groups of students, four age groups of pediatric patients and parents	art discussion/interview	De-stress, emotional state, Parent Proxy Report, heart rate and respiratory rate	Representational nature art was clearly indicated as the highest preferred art image for all age groups	time with intervention and non-chronic patients may have impacted results

APPENDIX G
GUEST EXPERIENCE ASSIGNMENT

IND 4226

ADVANCED ARCHITECTURAL INTERIORS I

UNIVERSITY OF FLORIDA

COLLEGE OF DESIGN, CONSTRUCTION and PLANNING

DEPARTMENT OF INTERIOR DESIGN

PROJECT 1:

Designing the Guest Experience

Individual
10 weeks: January 8 - March 25
THE PROJECT

The project entails the rebranding and renovation of a boutique hotel located at 55 Wentworth Street in Charleston, South Carolina. The 4-story building completed in the summer of 2015 was originally designed by Reese, Vanderbilt and Associates and is situated within Charleston's historic downtown. Currently, this building houses a 4-star boutique hotel that operates under the umbrella of Marriott's Autograph Collection. Along with 50 guestrooms, the hotel features a variety of venues that include retail, food and beverage, as well as rentable meeting spaces. The restaurant on the fourth level is undergoing a mild renovation to better compete with the Charleston market.

For the purpose of this studio project, you are tasked with reimagining the entire hotel along with developing your own brand, guest experience, and original design. Your hotel should align with the overall values of Marriott's Autograph Collection and reflect the characteristics that they look for in their collection of boutique hotels.

You will need to consider the local culture and context of the historic downtown as well as how to develop venues that will compete well within the Charleston market. Examine precedent to identify components and characteristics of successful venues in the hospitality market in order to develop functional spaces within your original and creative designs. As you develop your hotel, also reflect on biophilia and sustainability issues and how to thoughtfully incorporate these topics into your final design solutions.

THE CLIENT

Marriott Autograph Collection Hotels
https://autograph-hotels.marriott.com/about-autograph/

The *Autograph Collection Hotels* became a part of Marriott's extensive portfolio in 2010 and includes a collection of highly original boutique hotels from around the world. Marketing for the franchise includes the catch phrase, "Exactly like *nothing* else." The Autograph Collection looks for independent boutique hotels that reflect strong and original personalities, relate to the local context, and incorporate human-centered design with close attention to the details.

METHODS OF WORKING

To simulate the actual design process the project will be divided into 3 phases:

Phase 1: Pre-Design Research (2 week)
Phase 2: Design Development Completed (4 weeks)
Project Review with Juries: Friday, February 16, 2018
Phase 3: Final Design Presentation (4 weeks)
Project Presentations with Juries: Monday and Wednesday, March 26 – 28, 2018

Through the use of story boards, animation, rapid visualization and/or perspectives your designs should tell a story of a guest stay. Design shall include primary spaces that a guest encounters including check-in/ lobby, food and beverage venues, meeting spaces, guest room corridor, and guest room. You must execute a dynamic, creative, cutting edge design utilizing the very best products and technologies which encompass appropriate products/materials and construction practices.

APPENDIX H
HOSPITALITY STUDIO PRE AND POST SURVEYS

Pre-Project Assessment Survey

Please complete the following survey regarding your personal experience. Your responses are voluntary and anonymous and not part of your grade for the class.

Definition: Biophilia is an innate (inherent) human need for nature so biophilic design is the deliberate attempt to translate that affinity for natural systems and processes into the built environment.

- Pre1 How did you first learn about biophilia?
- Pre-2 Discuss your approach to using nature inspired features (biophilic features).
- Pre-3 How would you like more help with biophilic integration?
- Pre-4 Do you see biophilia as an approach that can aid you in making design decisions? 1-7 scale, strongly agree to strongly disagree
- Pre-5 Do you feel confident in designing with biophilia? 1-7 scale, strongly agree to strongly disagree
- Pre-6 Describe how you approach adding color, light and materiality in a project.

Post-Project Assessment Survey

Welcome! You are about to help further develop the Biophilic Design Matrix (BDM). This survey has four parts and should take around 30 minutes to complete. It will automatically save your answers and you can start and stop as often as you would like. Due to the length, it is recommended you take your time and take breaks as needed. You can move forward and backwards as needed.

INSTRUCTIONS

Viewing the Survey Photographs

The following survey contains photographs of a lobby/waiting room. It will be important for you to have a clear, enlarged view of the site images so that you will be able to notice the specific and unique details of each space. Please complete the electronic survey on a full-size laptop or desktop computer. Please do not attempt to complete the survey using a tablet or smartphone, as the screen size will be too small. For optimum viewing of the site, we recommend that you consider one or more of the following to zoom in when you are viewing the electronic survey: On a PC, this can be done by pushing the CONTROL key and + on the keyboard. On a MAC, this can be done by pushing the COMMAND key (⌘) and + on the keyboard. This step can be repeated until the view is enlarged enough.

Completing the Survey

There are three parts to the survey. Part 1 is the pre-survey about your own views and opinions. Part 2 is the BDM assessment. You will reference your studio project and then complete the 54-item survey related to that specific project. Please select the perceived amount of the attribute in

regard to the space if found at all in the interior. If you have any suggestions for modification of the attribute name or description provided, please make note of them and then include this in the modifications/suggestions question at the end of the survey. No need to add up the scale just submit, and you will see your results at the end. Part 3 is the post-survey and you will review your thoughts and opinions on the matrix and your experience with designing with nature. For technical help please email me at blsmcgee@ufl.edu. Thank you!

By continuing you agree to participate and share your findings with the researchers and any future publications that may result. This is voluntary, and no personal identifiers will be published. A copy of the consent form and study information is available: INFO SHEET. Please include your name here to indicate your consent.

Please complete the following survey regarding your personal experience. Your responses are not part of your grade.

Definition Definition: Biophilia is an innate (inherent) human need for nature so biophilic design is the deliberate attempt to translate that affinity for natural systems and processes into the built environment.

Start of Block: Pre-assessment survey

- Post1 Do you see biophilia as being important to interior design? Scale 1-5, definitely not, to definitely yes
- Post2 How confident are you in using biophilia in your designs? Scale 1-5, none at all, to a great deal
- Post3 How knowledgeable are you in biophilic design? Scale 1-5, none at all, to a great deal
- Post4 Please describe how you approached integrating biophilia into your project. Specifically note three things: 1) how did you decide what features to include, 2) what did you find the most helpful for including biophilia and 3) what was the most challenging? Please use a minimum of 500 characters.

Start of Block: Pictures

Pictures
DIRECTIONS

Step 1) Review your Site Pictures
You **can** refer back as needed to review the space to identify if a feature is present or not.
For technical issues, please email blsmcgee@ufl.edu or call 616-340-8706.
Step 4) Refer to Site Pictures to assess the following 55 features of the Biophilic Design Matrix (BDM).
Step 4) Assess Site for the Features: Assess those features that are in the Interior or viewed from the interior- regardless of the perceived intention of the design team.
Then select the strength of the feature in the space from Weak (1) to Strong (3) **or None if it is not found.**
Step 5) Get Started:

Go to the next page and use your project to assess if a feature listed is present and what strength it is present.

Start of Block: Post assessment survey pt. 1

Please complete the following post assessment survey. Your responses are voluntary and not part of your grade for the class.

- Q1 Do you see biophilia as an approach that can aid you in making design decisions? Scale 1-5, strongly disagree to strongly agree
- Q2 Describe any change you might make in your next design in how you approach adding color, light and materiality since you are now familiar with the Biophilic Design Matrix and will have access to it.
- Q3 How challenging was it to use biophilic features to fulfill your design **concept/strategy**? Scale 1-5, none at all to a great deal
- Q4 Please explain further.
- Q5 How challenging was it to use biophilic features in the **design development**? Scale 1-5, none at all to a great deal
- Q6 Please explain further.
- Q7 When might you use the BDM list of features: Select all that apply: Conceptual design, Programming, Design development, Post occupancy, and None of the above
- Q8 Please explain how you see yourself using this list of features in the future if available?
- Q9 Do you see biophilia as being important to interior design now that you have used the BDM assessment? Scale 1-5, definitely none to definitely yes
- Q10 Please describe after having used the BDM any change in your knowledge of biophilic design.
- Q11 How do you see the BDM aiding your future design decisions?
- Q12 Please describe how you included biophilia through color, light and materials in your project?
- Q13 How would you rate the quality of the BDM as an interior design tool in the following categories? (5 stars being the highest and a strength of the tool and one being the lowest and a weakness of the tool)

Clarity of instructions (2)	☆	☆	☆	☆	☆
Clarity of attribute definitions (3)	☆	☆	☆	☆	☆
Clarity of the name of attributes (4)	☆	☆	☆	☆	☆
Answer choices (5)	☆	☆	☆	☆	☆
Comprehensiveness of 55 choices (6)	☆	☆	☆	☆	☆
Uniqueness of each of the 55 choices (7)	☆	☆	☆	☆	☆
Clarity overall (1)	☆	☆	☆	☆	☆
Helpfulness as a design tool (9)	☆	☆	☆	☆	☆

- Q14 Please describe any suggestions you may have regarding the BDM for its future use in other studio projects.
- Q15 Thank you for participating in testing the Biophilic Design Matrix, please leave any additional comments here:

*** Additional questions for Group 1**

- * Q16 How helpful was using the BDM for incorporating biophilic design into your design **concept/strategy**? Scale 1-5, none at all to a great deal
- *Q17 Please explain further.
- *Q18 How helpful was the given list of biophilic features during **design development**? Scale 1-5, none at all to a great deal
- *Q19 Please explain further.
- *Q20 Please describe your experience using the BDM to assist you with including biophilic design into your project.

APPENDIX H
INFORMATION SHEET (BID-R)

Biophilic Interior Design Reference Sheet

There are 6 feature groupings.
Group 1 of 6
The first group of features: Actual natural features- actual (not images) of real nature characteristics in the interior

#1 Air
Natural ventilation.
(e.g., operable windows, inside/outside fresh air connections)
#2 Water
Any type of actual water feature in the interior.
(e.g., water fountain, sink, or fish tank
#3 Plants
Actual plants in any form (alive or preserved) in the interior.
(e.g., potted plants or dried leaves in a shadow box)
#4 Animals
Actual animals in any form (alive or preserved) in the interior.
(e.g., fish in a fish tank)
#5 Natural materials
Materials extracted from nature.
(e.g., wood, stone, or paper)
#6 Views and vistas
Exterior views of natural features such as vegetation.
(e.g., window view of Central Park)
#7 Habitats and vistas
The interior of buildings and their landscapes that possess a close and compatible relationship to local habitats.
(e.g., views to locally appropriate landscape)
#8 Fire
Fire providing comfort and civilization when controlled, includes color, warmth and movement.
(e.g., fireplace)

Feature Group 2 of 6: The second group of features are Natural shapes and forms- nature representations and simulations

#9 Botanical motifs
Representations of shapes, forms and patterns of plants and vegetative matter.
(e.g., painting of flowers)
#10 Animal-like
Representations of animals, may be highly stylized.
(e.g., animal forms, claws or heads)
#11 Shells & spirals

Representations of invertebrates.
(e.g., images or forms of shells and spirals, bees and their hives, butterflies, spiders and their webs)
#12 Curves and arches
Representing curves found in nature like treelike shapes, ovals, semi curvilinear forms.
(e.g., egg and dart moulding, arching columns and domes)
#13 Fluid forms
Shapes resisting straight lines and right angles that are flowing; they act as if they are adapting to forces found in nature.
(e.g., sinuous floor inlay)
#14 Abstraction of nature
A simulation rather than replication of natural form or function; forms are vaguely reminiscent of those naturally found but use nature as a model.
(e.g., Monet painting of flowers, fleur de lis ironwork, Gaudi's Sagrada Familia)
#15 Inside-Outside
Interior spaces that appear connected to the outside environment, embracing inside what's nearby outside near to the building.
(e.g., interior gardens, ocean motif used if located at the beach, same flooring used both inside and outside)

Feature Group 3 of 6: The third group of features are Natural patterns and & processes-properties derived from natural features and process

#16 Sensory richness
Information richness can include complexity in visual, sound, touch, smell and/or taste for a sensuous & intellectually challenging environment.
(e.g., assortment of patterns, texture and color for sensory variety)
*Base this assessment upon the visual richness, typically in person observation would be needed
#17 Age, change and the patina of time
Showing age or change, such as in wear or growth, particularly by organic forms like wood but even inorganics like stone.
(e.g., use of plants that have obviously grown over time and "taken over", farmhouse table of weathered wood)
#18 Area of emphasis
An area of reference or interest in a space, central focal point.
(e.g., fireplace or grand staircase)
#19 Patterned wholes
Unique individual parts become organized in a pattern, variety united.
(e.g., tile floor mosaic inlay)
#20 Bounded spaces
A delineated space with clear boundaries or borders.
(e.g., walled room with a sense of enclosure)
#21 Linked series and chains
Spaces connected that bring you from one space to another in a series.
(e.g., coordinated design tying together a series of rooms, clear glass walls separating adjoining spaces)

#22 Integration of parts to wholes
Individual similar components come together to create a greater whole.
(e.g., small wood planks can make up a wood floor, glass mullion pattern, subway tile backsplash)
#23 Complementary contrasts
The blend of contrasting features or opposites.
(e.g., light and dark areas, open and closed space, high and low ceilings)
#24 Dynamic balance and tension
Shapes, forms or materials that are both balanced and show a degree of tension.
(e.g., symmetrically balanced ceiling mobile, view of a balancing sculpture)
#25 Natural ratios and scales
Patterns such as natural arithmetic or geometric ratios or scales.
(e.g., golden ratio, golden sections, golden proportion, golden spiral, and Fibonacci's sequence: 0,1,1,2,3,5,8,13,21,34..., these can be highly complex patterns yet seem organized like a sunflower patterned fabric or artichoke light fixture)

Feature Group 4 of 6: The fourth group of features are Color and Light- color, light and material qualities & space relationships with nature

#26 Composition
Color, light and materials applied as a composition through unity &/or variety connecting with nature.
(e.g., variety of natural materials used throughout with a unified color scheme)
#27 Communication
Color, light and materials used to connect people with the site or locale; concepts symbolize identity to send a message.
(e.g., color selection coming from the site for communing with the surrounding nature)
#28 Preference
Color, light and materials reflecting the time, place, and circumstances in which we live.
(e.g., a designer/firm signature style, market trends such as the Pantone color of the year)
#29 Response
Natural inspired color, light and materials integrated for physiological, psychological &/or behavioral responses.
(e.g., light fixtures that mimic sunrise/sunset patterns)
#30 Pragmatics
Color, light & materials selection based upon maintenance, life cycle cost, existing conditions, external weather and or environmental choices.
(e.g., sustainable flooring choice for high traffic area)
#31 Natural light
Daylight/ sunlight access.
(e.g., window, clearstory, skylight)
#32 Filtered light
Modulated daylight, reduces glare.
(e.g., blinds, shades, tinted glazing)

#33 Reflected light
Light reflecting off surfaces.
(e.g., reflective surfaces that may provide sparkle)
#34 Light pools
Pools of connected light in a series on the floor or wall drawing you from one area to another, often surrounded by darker areas.
(e.g., high contrast lighting environment)
#35 Warm light
Warm and inviting lighting, 2,000 to 3,000 K color temperature.
(e.g., incandescent lighting, candle light)
#36 Light as shape and form
Natural light manipulated to create stimulating, dynamic and/or sculptural form.
(e.g., light shaft)
#37 Spaciousness
Openness or feeling of large expanse.
(e.g., a high ceiling)
#38 Spatial variety
Variance in the interior space
(e.g., different ceiling heights or room widths)
#39 Space as shape and form
Space that is manipulated into a natural inspired form or shape.
(e.g., Sydney Opera House)
#40 Spatial harmony
Coherence in the interior space.
(e.g., repetition of design elements for coherence)

Feature Group 5 of 6: The fifth group of features are Place-Based Relationships- culture together with ecology, rooted in geography

#41 Geographic connection to place
Emphasizing geographic features such as climates, countries, people and/or natural resources within the interior environment.
(e.g., photograph of a well-known local natural landmark)
#42 Historic connection to place
Relation to the past through the marking of the passage of time, linking the past to the present, fostering a culture's collective memory.
(e.g., historical portrait)
#43 Ecological connection to place
Emphasizing ecological features within the interior environment of forest, grassland, desert, tundra, freshwater or marine.
(e.g., interior bamboo garden)
#44 Cultural connection to place
Integrating cultural identities.
(e.g., regional decorative craft)

#45 Integration of culture and ecology
A social center that fosters community building.
(e.g., sustainable artwork)
#46 Spirit of place
A metaphorical place given life, when a place becomes cherished by people it gives rise to and sustains human culture and ecology over time.
(e.g., Mount Vernon, gothic cathedral)

Feature Group 6 of 6: The sixth group of features are Human-Nature Relationships- paired biological needs with nature

#47 Prospect/Refuge
A place with the ability to survey the distance in a place of security/ a view of the entire space AND a place of protection/ separated from spaciousness.
(e.g., view from an alcove to a larger space, interior view of spacious landscape)
#48 Order/Complexity
Designs that meld order AND stimulate the desire for variety in a controlled manner, a balance of structured organization with intricacy of detail that together appears orderly.
(e.g., bookshelves)
#49 Curiosity/Enticement
Spaces that elicit exploration, discovery or mystery AND draws you farther in.
(e.g., space planning that draws you around the corner to view more)
#50 Mastery/Control
Respectful mastery of nature which expresses ingenuity and cleverness AND user ability to manipulate the environment.
(e.g., occupant control of air, light or sound quality; furniture with ergonomic adjustments)
#51 Attraction/Attachment
Appealing natural designs AND affection for features together can create a lasting loyalty.
(e.g., beautiful wishing fountain)
#52 Exploration/Discovery
The desire for further inquiry AND revealing a sensory rich interior.
(e.g., nature themed play structure)
#53 Fear/Awe
Design integrating a feeling of peril AND feelings of wonder or delight.
(e.g., rock climbing wall, bridge with see-through flooring)
#54 Reverence/Spirituality
Affirming the human need for establishing meaningful relationships to creation AND reverential feelings of connection vs. the aloneness of a single person isolated in space and time.
(e.g., tall stain glass windows)

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BIOGRAPHICAL SKETCH

Beth McGee received her Ph.D. from the University of Florida in the summer of 2018 from the College of Design, Construction and Planning in Interior Design. She also has an Interior Architecture M.S. degree from the University of North Carolina Greensboro with a concentration in product design and a B.F.A. from Kendall College of Art and Design. Each included a focus on healthy environments. She is a LEED AP, has passed the NCIDQ exam and is licensed to practice interior design in Florida. She was recently published in Health Environments Research and Design Journal (2015) regarding her innovative Biophilic Design Matrix (BDM), developed to facilitate interior nature integration for optimal wellness. There was a further look at the BDM through the views of child life specialists regarding their perceptions of optimal hospital play rooms in an article in the Journal of Interior Design (2017). Her PhD, teaching and practice work include an interest in integrating biophilia with sustainable/ restorative design, communication, and organizational ecology.