Building Design in between Living and Manufactured: A Research on Terminology

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ABSTRACT
Due to recent technological advancements, technological transition through designing together with living organisms is a growing phenomenon in multiple disciplines as well as in building design. Within this technological transition period, a large number of concepts with varied terms and definitions introduce comprehensive aspects and possible impacts of the unity of living and manufactured components. While many concepts resonate in building design, a blanket term is missing in the existing literature. To identify suitable terms and definitions which either should be adopted or disregarded in the scope of the building design, this paper presents an overview of the existing terminology. In the framework of the research, firstly the descriptions of the innovations, exemplifying the incorporation of living components, were examined in eighty (80) cases related to building design. The most-used terms and definitions lead us to determine the scope of the literature review. Further on, expert opinions, (20) twenty practitioners professionally working with the innovations, were obtained. While the research clarifies the variety in the terminology, the paper underlines the critical importance of the phenomenon in terms of bringing substantial possibilities into building design through multiple functions, domains, disciplines.

Keywords: building design; terminology; biomimicry; biodesign; biobuilding

1. INTRODUCTION

Recent technological advancements enable designers to create designs with living organisms instead of fabricating products inspired by them (Deuerling et al., 2018; Shu et al., 2011). By presenting smart and sustainable solutions to the demands of contemporary society, the incorporation of living and manufactured components presents a recent phenomenon within multiple disciplines (Myers, 2018). Particularly in architecture, an increasing number of innovations are yet to infiltrate into everyday life as well as into the buildings by promising a wide range of solutions. Such as, The Growing Pavilion in Dutch Design Week 2019 demonstrates the unity of living and manufactured components (Fig. 01). While panels grown from mushrooms represents a "smart" way of decreasing the harmful environmental impacts of the construction industry (Url 01). As another example, self-healing concrete with bacteria targets to reduce the costs of concrete production and maintenance, as well as CO^2 emissions (Jonkers, 2007). These examples and many more present possible innovative and

sustainable solutions to today's problems with the incorporation of living components thereby underlines the critical potential of the phenomenon in building design.

Figure 01 The Growing Pavilion in Dutch Design Week, October 2019 (personal archive of Peyman Nafai)

The increasing number of innovations in multiple scales, domains, and functions have resonated with a growing interest in various platforms and researches on design with living components (Myers, 2018). However, there is a lack of a blanket term specified on the unity of living and manufactured components in the existing literature (Deuerling et al., 2018). Indeed, academic and popular literature overloaded with a large number of terms and definitions explaining different ways to bond with th

e elements of nature (Deuerling et al., 2018; Ivanić et al., 2015; Speck et al., 2017). The existing studies in the literature attempting to understand biology-derived technical developments examine a variety of terms and definitions along with their scopes and interchangeably use (Imani et al., 2017; Ivanić et al., 2015; Oguntona and Aigbavboa, 2017; Speck et al., 2017; Shu et al., 2011; Valdecasas and Wheeler, 2018). At this juncture, the variety of terminology represents the different extents and possibilities to incorporate with living components of nature for both design theory and practice. In the meantime, it raises a critical question: Which terms and definitions accurately describe this phenomenon in the framework of building design?

The goal of this research is to give an overview of the existing terminology, thus to specify the incorporation of living and manufactured components into building design within the wide extends of the concepts of nature and technology. The expected result of the paper is to determine certain terms and definitions which either should be adopted or disregarded in the scope of the building design.

Within the scope of the research, firstly, the descriptions of the cases, innovations exemplifying the incorporation of living and manufactured components, and related to different layers of a building, examined in eighty (80) examples. The most-used terms and definitions allowed us to determine the scope of the literature review. Further on, the literature review introduced concepts with the specific target area of use. Moreover, the research continued with collecting the opinions of twenty (20) experts who have professional experience in determined innovations not only for their developments and also their implementations into the buildings, and domestications into daily life. Overall, the research resulted in filtering the accurate use of particular terms, and common misunderstandings. In conclusion, the paper provides a better understanding of the phenomenon by giving insights on terminology within the technological transition shall place building design in between living and manufactured worlds.

The structure of the paper is divided into following sections. To begin with, *Background* section aims to give insights into the possible influences of the incorporation of living and manufactured components on building design. Thus, it presents a brief overview of the reflections of the concepts of nature and technology on architecture, thereby underlining the focus of the research within the vast bibliography. Further on, *A Research on terminology* is expected to answer the aforementioned research question with four (4) sections; *Case Studies, Literature Review, Expert Opinions,* and *Findings & Discussions.* Finally, the paper ends with *Conclusion* section along with the recommendations on future studies as well.

2. BACKGROUND

In a broad sense, the notion of nature and its scientific and philosophical debates throughout history have continuously associated with the critical aspects of architecture (Davies, 2011; Guy, 2010, Hagan, 2001). Since pre-modern architecture, symbolic, analogic, and metaphoric meanings of living and non-living elements of nature have taken place in architectural discourse (Özdemir & Selçuk, 2016). The understandings of "nature" and "natural" have been transcribed into architectural meanings, and these comprehensions gain spatial implications and materialized as spaces (Davies, 2011). Different aspects within this comprehensive and vast bibliography could be exemplified with the nature-inspired works of Antoni Gaudi, the harmony of nature-human in organic architecture drawn by Frank Lloyd Wright, metabolism in architecture suggesting continuity and growth of the city by Kisho Kurokawa, and many more.

While the concept of nature maintains its significance as a matter of discussion in the scope of the architectural discipline, its evolving relationship with emerging technologies is the focus of contemporary concepts. The need for buildings and the city to reconnect with the natural environment has received renewed interest in modern discourse with increasing demand for energy, resources, and raw materials from the developing world (Winn et al., 2012). Architectural design has been motivated to explore the concept of nature by understanding how the elements of nature technically work (Hagan, 2001). Meanwhile, technological developments, especially computation technology, have brought the possibilities of designing "vibrant, dynamic and living" structures (Allen, 2011; Ratti and Claudel, 2016). Thus, living and non-living components of nature have become the tools for resolving the environmental problems of today with increasing demand for energy, resources, and raw materials from the developing world (Farmer, 1999; Marshall and Lozeva, 2009).

Despite the deep history behind connecting with the elements of nature and technology in architectural design, recent nature related design studies have often evaluated under the concept of "biomimicry" which suggests applying forms, processes, and systems as sustainable solutions (Pawlyn, 2011). Janine Benyus is the pioneer that prompted "biomimicry" into the mainstream (Benyus, 1997). He underlines the three primary areas of the concepts; using nature as a model, applying as a standard of measure, and accepting as a mentor. The fundamental idea is to learn from nature and imitate it in the sense of ecological concerns similar to historical studies, whereas biomimicry highlights an "empirical" approach (Vincent, 2006).

What remarkable here, biomimicry has only recently achieved its popularity with the development of technological abilities, and particularly with the rise of computer technology (Ratti & Claudel, 2016). In other words, recent innovations incorporated with living components have demonstrated the bridges between living and artificial worlds (Antonelli, 2018; pp. 6-7). The unification of living and manufactured components may sound futuristic, obscure and unrealistic in the beginning, but pieces of evidence from everyday life insist that this merge has already started (Van Mensvoort, 2015). Many designers still consider nature as its idealized perfection and distinguish any design activity from the natural environment (Kleinert, 2018). On the contrary, the shifting

notions of nature relevant to the intensifying bonds with living and manufactured worlds have been manifested in the contemporary discussions within multiple disciplines, and particularly in architecture (Myers, 2018). Living components of nature in any scales, plants, animals, bacteria, and cells seem to become useful as architectural and interior elements (Myers, 2018; Ripley & Bhuskan, 2016). In this sense, recent technological developments of today have encouraged designers to reach further to the limits of biomimicry in design disciplines as well as in architecture (Myers, 2018).

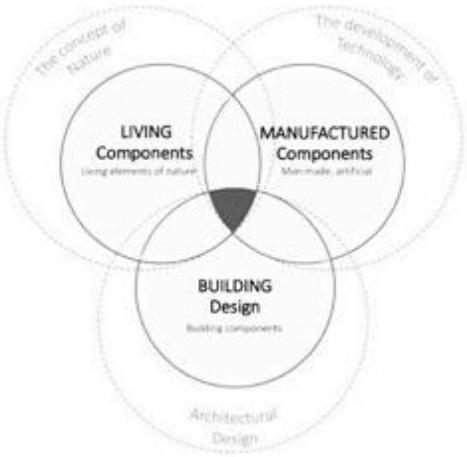

Figure 02 The scope of the research.

In summary, to bond with the elements of nature has influenced architecture through history. While recent technological developments enable designers to incorporate with living components, triggers a technological transition that has already influenced multiple disciplines as well as architecture. This paper concentrates on this particular phenomenon as shown in Figure 02. To be able to explore the phenomenon in building design, it seems necessary to clarify a wide range of terms and definitions within the vast bibliography of nature, technology, and architecture. Therefore, the paper confined itself with the research on terminology by providing a better understanding of the phenomenon.

3. A RESEARCH ON TERMINOLOGY

The research was provided an overview on the existing terminology with three stages; *Case studies, Literature review, Expert opinions* (Figure 03). Each stage allowed us to specify the scope of the phenomenon more explicitly by determining similar terms, certain categories and preferences of the professionals. Applied methods, analysis, findings and the results of each stage of the research explained within three main sections. Later on, overall findings were elaborated in *Findings & Discussions*.

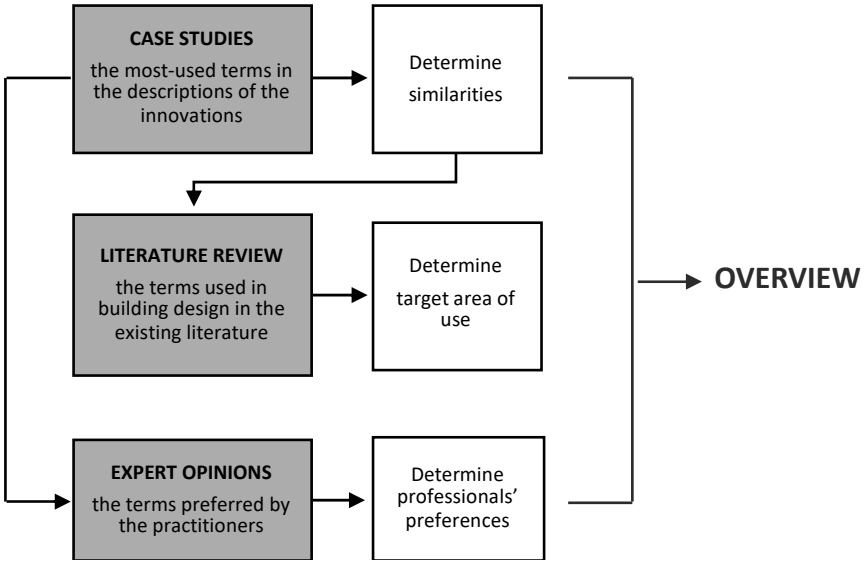

Figure 03: The organization of the research

3.1 Case Studies

Firstly, the innovations, as the case studies in the research, were determined with the following criteria.

To incorporate; the unity of living and manufactured components.
To live; Living organisms continue to live, change, grow and die after they merged with the manufactured components.
To advantage; bringing superior advantages with the contribution of natural elements to the existing technologies.

In addition, all living components of nature is embraced in the selected cases including bacteria, plants, fungi, animals, human and many more.

Further on, to specify the relationships between the innovations and building design, the theory of Brand (1994) used as an assistive tool. Brand (1994) emphasizes the heterogeneity in architecture by embracing architectural and interior design as one unified entity. He (1994; 31-55) specifies the layers in a building; "site," "structure," "skin," "service," "space plan," "stuff". Site layer purposely excluded, since the research limited to building scale by eliminating the relationship between the building and its urban environment is excluded. The examples of the innovations related to building design determined with Brand layers are demonstrated on the below (Fig. 04).

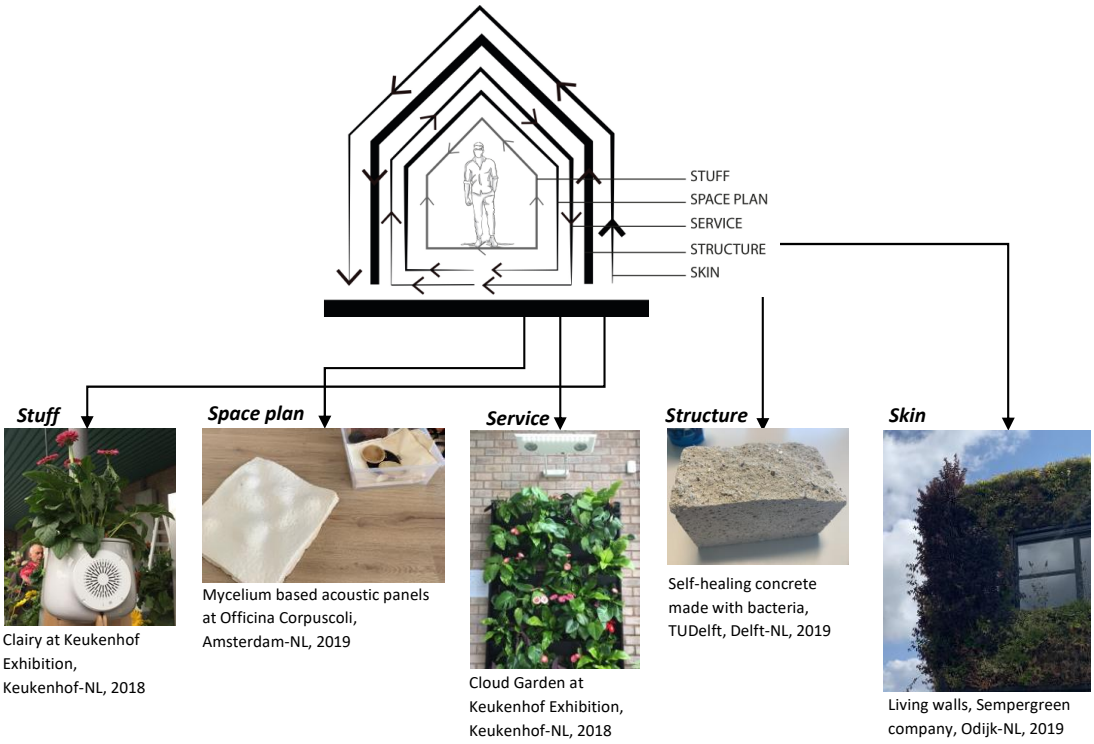

Figure 04 Examples of the Case Studies in between living and manufactured in each building layers
(Based on Brand, 1994)
(Photos: personal archive of the authors)

With the determined selection criteria, eighty (80) cases were collected as shown in Figure 03. Later, the descriptions within scholarly and non-scholarly sources drawn by the developers/designers of the cases were examined.

The prevailing terms were; "bio", "smart", "living", "growing", and the others were; "eco", and "organic" (Fig. 05). It revealed that 34% of the cases were described through the customized term with "bio" prefix like "bio concrete", "bio brick", "bio lamp", "bio glow", and many more. Moreover, these innovations were connotated with the popular concepts in the literature such as; "biomimicry," "biofabrication," "biodesign" and "biophilia". Secondly, 20% of the cases were expressed with their "smart" features as such smart clothing, smart lamp, smart facade. Thirdly, in 18% of the cases were defined with the term "living", like a living wall, living façade. Fourthly, in 17% of the cases, terms related to "growing", as such "growth", "self-growing" were determined. In addition to all, 22.5% of the cases were explained with an emphasis on their sustainable features.

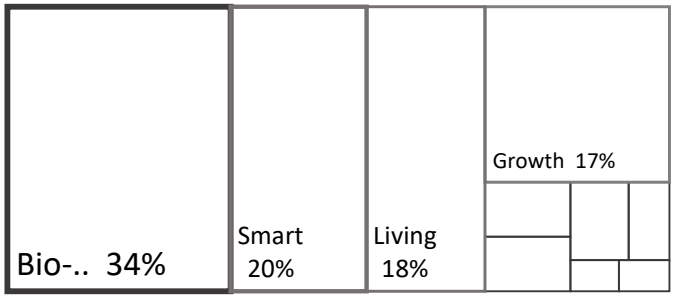

Figure 05 The most used terms in the description of the innovations selected with certain criteria.

Overall, the terms of "bio," "living" and "growing" were mainly used to emphasize the use of living components and sustainable solutions brought by them whereas the term "smart" was chosen to stress the superior advances with the way of manufacturing. While, "bio" prefix mainly covered different ways of bridging the elements of living and manufactured, living and growing were used interchangeably to make an emphasis on the use of living components. Furthermore, the terms derived with the "bio" prefix were also associated with particular concepts in the literature. All in all, the scope of the literature review in the following part was decided to be limited with particular terms with "bio" in the existing literature.

3.2 Literature review

A wide range of terms with "bio" prefix has been using interchangeably to explain the ways as such to connect, inspire, utilize and merge with the living components of nature as such; "bioinspired" design, "biomimesis", "bioinspiration", "bioanalogous" design, "biognosis", "bionics", "biomorphy", "biotemplating", "bioanalogous", "biophilia", "biomineralization", "biocentric", "biomediated", "bionic" and many more (Deuerling et al., 2018; Imani et al., 2017; Ivanić et al., 2015; Oguntona and Aigbavboa, 2017; Shu et al., 2011; Speck et al., 2017, Valdecasas and Wheeler, 2018). The variety in the terminology motivated us to start with clarifying unrelated terms within the categories of *synonyms*, *disciplines*, and *misuse*. After the elimination of several terms, the terms to be included in the scope of the research were determined, and furtherly elaborated.

Synonyms

The terms with "bio" have presented numerous studies along with many synonyms. For instance, the common synonyms of "biomimicry" are "biomimesis", "biomimetic", "bionics", "biognosis", "biomimetic design", "bioanalogous" design", "bioinspired", "bioinspiration", and "biologically inspired design" (Shu et al., 2011). Indeed, minor differences could also be found between these synonyms. For example, bioinspiration Indicates transfer of aesthetic and morphological aspects, whereas in biomimetics functional aspects play a key role (Gruber, 2013). Likewise, **"**bionics**",** often used similar to biomimetics, is more related to "cybernetics" (Papanek, 1974), and artificial intelligence (Vogel 1998). In the scope of the research, only the terms of "biomimicry", "bioinspiration", and "bionics" were included while the minor differences between the other terms were disregarded and discussed under "biomimicry" term.

Disciplines

The disciplines bordering with biological studies have been respected with "bio" prefix as such "bioengineering", "biogenetics", "biomedical", "biomechanics", "biomedical engineering", "biological engineering", "biotechnical engineering", "bioarchitecture", and many more. These terms were excluded, since they represent the intersection of specific domains with the advantages of biology. Only "bioarchitecture" was furtherly elaborated as if it might be suitable for the scope of the research.

Misuses

Unfortunately, it seems possible to encounter common misuses both in academic and popular literature. For example, "biomorphology" or "biomorphic design", and "biomorphism" are more related to the imitation of the forms in the nature (Speck, 2017), yet the terms could be mistakenly used as "biomimicry". In addition, the term of "biotechnology" might sound as the combination of biology and technology, therefore it might seem suitable to describe the unity of living and manufactured components. However, biotechnology means any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use. (UNEP, 2011). Thus, both "biomorphology" and "biotechnology" found unsuitable for the scope of the research.

After filtering the terms above, Table 01 consists of "bio" terms that might be suitable to describe innovations incorporated with living components in the framework of building

design. The "bio" terms included in Table 01 cover as follows; concepts found in the explanations in the examples, concepts in the scholarly sources explicitly focusing on the subjected phenomenon, concepts attempted to be translate designing with living components into building design.

Table 01 Terms in the literature exemplifying the unity of living and manufactured components with "bio" in building design

Terms	Approach	Scope
Bioarchitecture	Architectural design with non-living and living elements of nature (Ripley & Bhuskan, 2016).	Specified to architectural design, mainly used to determine the relationships between nature and built environment. (Eryildiz, S., Mezini, L., 2011; Pourjafar, M. R., 2011; Ripley & Bhuskan, 2016).
Biocentric	Represents a moral attitude in terms of rethinking the human-nature relationship (Mathews, 2011).	Design thinking proposal to consider human as a part of nature (Mathews, 2011).
Biodesign	Hybrid forms in architectural design as the intersection of biology and technology (Myers, 2018)	General term proposed for all design disciplines (Myers, 2018).
Biofabrication	Production with living organisms (Gallo, 2013).	Commonly used in Material science and fabrication (Forgacs and Sun, 2013), and also in healthcare as such tissue engineering (Raman and Bashir, 2017).
Bioinspiration	Transfer of aesthetic and morphological aspects of nature (Gruber, 2013).	Stimulation of biological paradigms to non-biological science and technology (Deuerling et al., 2018).
Biomediated	Living organisms mediated to the formation of hierarchical composite materials (Deuerling et al., 2018).	Indicated the guidance of living organisms in material science (Deuerling et al., 2018).
Biomimicry	A creative form of technology learning from the forms, processes and strategies of nature (Benyus, 1997).	Comprehensive concept used to describe inspiration from nature for sustainable solutions in multiple disciplines (Aziz and El Sherif 2016).
Bionic	Application of biological function to provide engineering solutions (Wahl, 2006).	More specifically used to work on artificial intelligence (Vogel, 1998).
Bioutilization	The direct use of nature for beneficial purposes (Kshirsagar et al., 2017)	Leverages organisms or biological materials (Montana-Hoyos & Carlos Fiorentino, 2016)
Biophilia	Aims to bond human with natural environment (Caperna, 2017).	Related to design studies supporting environmental sustainability (Caperna, 2017).

The terms in the table demonstrate the approach and scope of the concepts. "Biofabrication", "biomediated", and "bioutilization" are related to material science and technology. Moreover, they explicitly indicate the incorporation of living and manufactured components. Thus, they might also tend to describe the phenomenon.

On the other hand, the concepts of "biomimicry", "biocentric", "bioinspiration", and "biophilia" represent design methods leading designers to reconsider the relationships between nature, technology, and human. These terms were already used to determine the recent innovations in between living and manufactured worlds. However, they indicate wider concepts of which the recent innovations indeed were misunderstood. Therefore, despite the popularity and critical importance, the term "biomimicry" cannot be considered as a blanket term, since the main goal of biomimicry is to translate biological processes into technologies not indicate using biological materials (Marshall and Lozeva, 2009). Likewise, "bioinspiration" includes simulation of the research in non-biological science and technology (Speck et al., 2017). While "biocentric" mainly focus on the relationship between the natural environment and human (Mathews, 2011), "biophilia" aims to satisfy the emotional and biological needs of human by connecting with nature (Caperna, 2017). In other words, the scope of these concepts seems too broad to specify recent bonds between the living and manufactured components with these terms.

Moreover, Table 01 underlines the lack of transformed terminology in architectural discourse as such "biobuilding" or "biospace". Bioarchitecture, on the other hand, encompasses emulation from both non-living and living elements of nature (Ripley&Bhuskan, 2016). The term embraces various relationships between nature and built environment while its scope might indicate bias in different sources (Eryildiz, S., Mezini, L., 2011; Pourjafar, M. R., 2011; Ripley & Bhuskan, 2016). At this juncture, "biodesign" might seem more relevant to building design although the term indicates a wider approach suitable for all design disciplines. Moreover, Myers (2018) explains the fusion of biology and technology with the term "biodesign" suggesting a new concept enriches beyond the approach of biomimicry. In this sense, biodesign might also seem a relevant term.

Overall, the literature review clarifies the variety in the terminology by narrowing down to the certain terms to be used or disregard. Surely, the number of "bio" terms can be extended, nonetheless, the literature review could not provide a blanket term that is widely accepted in academic and popular literature. On this sense, the research continues with expert opinions. Since, the phenomenon indicates contemporary technologies still in development, the experts can state their professional preferences in terminology with this technological transition period.

3.4 Expert Opinions

The practitioners who are the experts working on the development, implementation and domesticating of the innovations uniting living and manufactured components. The sample group included people with various professional backgrounds; architects, interior designers, product designers/developers, biologists, academicians, engineers, fashion designers. For the selection of the experts groups snowballing strategy is applied. Within eighty examples (80), firstly eight (8) experts were reached out, further on (7), and then four (4) experts were asked on their preferences on terminology.

They were asked to express their preferences in the terminology, and explain the reason behind their choices. All of the experts were underlined the confusion and multiplicity in the terminology, while none of them could answer the question with a singular term. They underlined that the terminology will develop further through the years, what is really import is for them to make best practice examples within this transition period. Indeed, the experts chose to answer this question with their preferences, way of thinking on the problem in the terminology, and with an emphasis on their disregarded terms as show in Table 02.

Table 02 The answers of the experts on terminology

WHICH TERMINOLOGY DO YOU PREFER TO REFER YOUR DESIGNS?			
NO PREFERENCE		P03	*"…it was being kidnapped…"*
		P05	*"I am talking about contextual knowledge and technology that can contextualize and contextual data."*
		P06	*"I do not always use just one terminology. I normally try to explain like I got my inspiration from biologist the way how they look into natural systems and their works and how we can integrate this. I can combining them."*
		P10	*"There are such terms that are very much recognized by generic public so depend on context I really changed the terminology."*
		P12	*"Maybe we talk about biofeedback as a whole term."*
		P13	*"I always say that I am a bio designer, maybe it is one thing. I like to use the word innovation and nature."*
		P18	*"… the word does not carry the meaning. While we are communicating people do not understand what we do. I think I need to think about it.. Because it is hard to find one single word to describe everything."*
		P19	*"…there are a lot of terms out there, if you are in the field, could mean number of different things."*
PREFERED TERMS	**SMART**	P01	*"For me the important thing is customer to understand it."*
		P07	*"Smart means something is clever. This is I just mentioned, is not only we want to use biology to lower the environmental effects but also to improve as a structural and all the performance properties of our building industry."*
		P08	*"For me smart and e-heath. I also use many different terminologies. It does not matter so much."*
		P15	*"We know see that the smartness is not integrated textile anymore, also because it has huge sustainability issues. But actually smartness is in production."*
	BIOPHILIA	P04	*"I use biophilic architecture as a starting point which makes clear out main goal to make balance with nature."*
		P20	*"Biophilia is a word that I came across just so soon. But it resonates with me because it actually explains what I am thinking what I am feeling over the last months. Because for me it is all about life. What is life we do not know still."*
	LIVING	P11	*"It must be living, this that. What I always say, we do there is nothing greener than what we do."*

	BIODESIGN	P14	*"Biodesign term covers work of design it is for or with biology. That is kind of helpful distinction that I found based on intent I had."*
	BIO-SMART	P17	*"I am using it to make my point."*
DISREGARDED TERMS (AVOID TO USE)	**SUSTAINABILITY**	P02	*"It is a word that almost as lost its meaning despite the important value that it owns. But sustainability is so easily misinterpreted beside using as a green washing flag."*
		P04	*"Sustainability does not saying anything on what you are doing. Because it is so broad that everybody can claim their projects are sustainable."*
		P07	*"..sustainable still has in politics."*
	BIO-BASED	P09	*"I am very explicit in the terminology we use. So you will not hear bio-based. Because bio-based is basic concept to find something from nature and to organize it, and propose in such a way to fit existing synthetic technology."*
		P16	*"Bio-based is not always something very well to nature. It can have a part that is biologically done. It is not degradable as fast as everybody thing."*

The eight (8) experts declared that they do not have any preferences in the use of terminology (P03, P05, P06, P10, P12, P13, P18, P19). They claimed that even though technologies indeed in transition, there is no certain term to express the potential of the unity of living and manufactured components. Therefore, the priority of the them was to resonate with their audience and make people understand.

The nine (9) experts answered the question by stating their preferred terms. P01, P07, P08, P15 underlined the importance of the concept of smart, thus smart terms can provide people a better understanding. Experts, P04 and P20 stated that the term biophilia is useful in terms of emphasizing the relationship between people and nature. P11 stated that the term of living is the one we should emphasize. P14 emphasized that he came up with the term "biodesign" since it covers to design with biological organisms. P17 suggested combining bio and smart as bio-smart to emphasize the technologies become smart with the use of living organisms even though the term of bio-smart mainly use to describe wearable technologies as such smart watches and bracelets.

Furthermore, five (5) experts answered the question with the terms they avoid to use. P02, P04 and P05 stated that sustainability is a broad term which lost its meaning as a result of its attachment to politics. Therefore, using the term of sustainability to describe the recent innovations can cause misunderstandings. P09 and P16 expressed that bio-based is also a term which should be avoided. Anything can be bio-based as being adopted from future, this does not mean the unity of living and manufactured components.

Hereby, the experts underline the ambiguity in the terminology with the lack of blanket term. Therefore, they use contextual terminology in terms of using various terms and definitions to make their points. At this juncture, the experts give insights us on which terms could be used and the which ones shall be disregarded.

3.4Findings & Discussions

All in all, Figure 6. demonstrates that all terminology is covered under the relationships between nature, technology, and architecture but it has two clusters as case studies in building design and expert reviews. There is a slight difference between how case studies define the terminology in innovations incorporated with living components, and how experts who rise these innovations.

The examination of the cases shows that the terms with "bio" play crucial role on the description of the novelty of the innovations, therefore the scope of the literature review is determined with the terms with "bio". However, the number of concepts related with "bio" is tremendous. Firstly the focus of the literature review is determined by eliminating synonyms, terms dedicated to specific disciplines, and misused. The terms could be used to explain the unity of living and manufactured components in building design were listed as "bioarchitecture", "biocentric", "biodesign", biofabrication", bioinspiration", "biomediated", "biomimicry", bionic, "bioutilization", and "biophilia". "Biodesign", "biofabrication", "biomediated" and "bioutilization" seem suitable to express the incorporation with living organism in building design even though they are attached to multiple disciplines. Nevertheless, the terms of biomimicry, "biocentric", "bionic", "bioarchitecture", "bioinspiration" and "biophilia" indicate wider concepts, therefore to specify them on the recent phenomenon can cause misunderstandings.

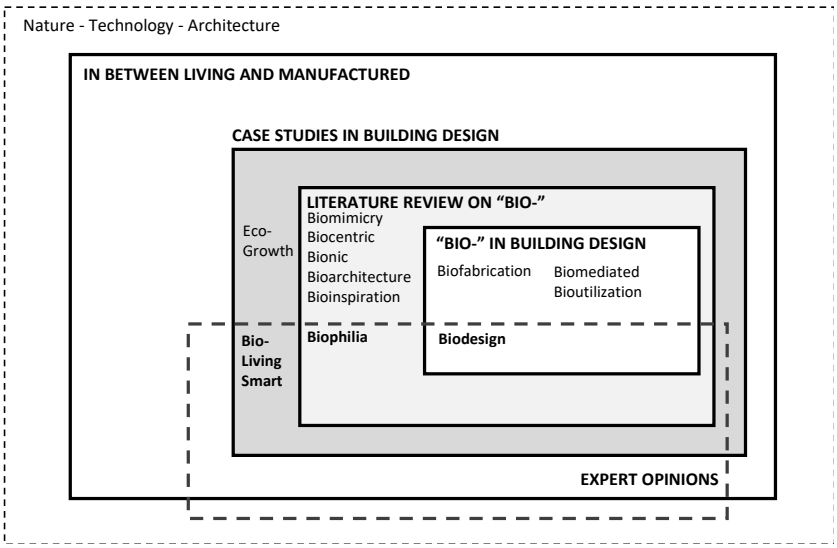

Figure 06 The findings of the research on terminology

The answers of the experts once more indicate the variety in the terminology with the lack of a blanket term. There might be several reasons behind ambiguity in terminology, but the main reason is that recent technologies are connected with the complex and wide concepts of nature and technology. Therefore, the experts explain the novelty of the phenomenon with its wider extents and greater possibilities.

4. CONCLUSION

The recent technologies at the intersection of living and manufactured components reveal the critical potential for building design, and also on our daily life in the near future. On the other hand, the number of studies gathering these examples together and exploring an overall understanding is limited as a result of the ambiguity in the terminology. The extensive concept of nature, natural elements, mechanisms, process and numerous solutions on one side, and different interpretations of the discipline and technique in multiple disciplines on the other side concluded with the appearance of various terms in academic and popular literature. Despite the novelty of the phenomenon, the terminology is kidnapped within this variety of terms and definitions. This makes difficult to understand the phenomenon and carry out further studies and discussions.

The variety in the terminology on the unity of living and manufactured components can be explained with the extensive aspects of this phenomenon. In the literature review, the findings of the research underline that "bio" comes one step forward. However, within a variety of terms, there is a lack of bio terms connotated with building design and building components. In that sense, these innovations incorporated with living components can be entitled as "biobuilding" to emphasize their potential role in the domain of building design, thereby they will infiltrate into the buildings.

Experts reviews, on the other hand, lead this paper to discuss the practical implications of the phenomenon. What is important for the experts is to increase the understandability of the phenomenon. Therefore, they use variety of terms to highlight the importance of these new technologies. It might seem possible to conclude some specific terms from the literature review. However, the expert views reveal that the transition of technology continues, therefore the phenomenon, despite its critical importance, is not ready to degrade into specific terms. Through time, the phenomenon might infiltrate into familiar terms as such, smart or biomimicry along with the normalization of the technological possibilities to incorporate living components. But within this current technological transition, scholars need to be explicit on their terms and definitions by being careful about the ambiguity in the terminology.

A variety of studies conducts a literature review and specify several keywords (Deuerling, et. al., 2018; Speck et al., 2017). However, this paper provides a better understanding of the phenomenon by gathering case studies, conducting a literature review and most importantly gathering expert opinions. In this sense, the paper bridges theoretical and practical aspects of the phenomenon. At this juncture, this research is limited to twenty (20) experts in the Netherlands, further studies with wider sample groups and experts from different contexts are required.

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