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DESIGN OF GREEN OFFICE BUILDINGS TO PROMOTE GREEN OCCUPANTS

DISEÑO DE EDIFICIOS DE OFICINAS SUSTENTABLES PARA PROMOVER OCUPANTES SUSTENTABLES

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RESUMEN

Escasos son los trabajos que se enfocan en investigar el potencial de los edificios sustentables de promover sustentabilidad en sus ocupantes. Por ello, el siguiente estudio tiene como objetivo analizar el uso de créditos LEED para fomentar comportamientos pro-ambientales. La metodología utilizada es de carácter exploratoria y de lógica descriptiva, y analiza comparativamente edificios de oficinas certificados LEED [Argentina (n= 351), Chile (n= 494), Colombia (n= 432), Perú (n= 282)] en el período 2012-2020. Los resultados revelaron que los créditos más empleados fueron: "Acceso a Transporte Público" (99,34%), "Densidad del Entorno" (98,34%) y "Pautas de diseño y construcción para inquilinos" (96,53%); y los menos empleados: "Puesta en servicio mejorada" (44,30%), "Luz diurna" (31,31%) y "Controlabilidad de los sistemas" (7,53%). Se concluye, finalmente, que aquellos que optan por incluir al ocupante en el diseño, eligen intervenir en la cultura, mientras que quienes optan por no hacerlo, eligen la tecnología.

Palabras clave
diseño sustentable, edificios de oficinas, sistemas de certificación en la sustentabilidad, comportamiento pro-ambiental.

ABSTRACT

Few studies focus on researching the potential of sustainable buildings to promote the sustainability of their occupants. Therefore, this study aims at analyzing the use of LEED credits, with the intention of promoting pro-environmental behaviors. The methodology is exploratory in nature, with a descriptive logic, and comparatively analyzes LEED-certified office buildings [Argentina (n = 351); Chile (n = 494); Colombia (n = 432); and Peru (n = 282)], between 2012 and 2020. The results revealed that the most used credits were: "Access to Public Transportation", (99.34%); "Surrounding Density"; (98.34%); and, "Tenant construction and design guidelines", (96.53%); and the least used ones were: "Enhanced commissioning", (44.30%); "Daylight" (31.31%); and, "Controllability of systems", (7.53%). It is concluded that those who choose to include the occupant in the design, choose to intervene in the culture, while those who choose not to include them, choose technology.

Keywords
sustainable design, office buildings, green building rating systems, pro-environmental behavior.

INTRODUCTION

In the early 1990s, one of the most accepted proposals to progress towards meeting green development challenges was the creation of evaluation systems, ratings, and certification for the sustainability of buildings in their design, construction, operation, and maintenance stages (Chwieduk, 2003; R. Cole, 1999; 2002; Ding, 2008). These methods emerged to certify the sustainability of buildings through consensual and measurable indicators, that provided processes and practical guidelines to design and evaluate the building's performance, through an easy-to-use checklist (Gou, 2016). These sustainability certification systems promoted buildings with a low environmental impact (Chwieduk, 2003; R. Cole, 1999; Ding, 2008), but reality has shown that this greatly depends on occupant behavior and that it has been often distorted by construction mistakes, incorrect adjustments of equipment, and the excessive simplification of simulation models (van den Brom, Meijer & Visscher, 2016; Fabi, Andersen & Corgnati, 2011). Several studies have analyzed the gap between the expected performance of the building and the actual performance influenced by human factors (D'Oca, Hong & Langevin, 2018; Hong, Yan, D'Oca & Chen, 2017; Stazi & Naspi, 2018), but few studies have addressed the effect of green design on environmental awareness, attitudes, values, and knowledge, as predictors of pro-environmental behaviors of occupants (Mokhar & Wilkinson, 2015; Deuble & de Dear, 2012; 2009; Kirk, 2010; McCunn & Gifford, 2012; Rashid, Spreckelmeyer & Agrisan, 2012).

For this research, a "Green building" is defined as one designed to be accredited by a green certification system, validated by a third party. The most widely internationally known system is LEED, Leadership in Energy and Environmental Design, developed in the United States in 1998. LEED is prepared to rank all types of buildings based on consensual principles on energy and environmental matters, trying to reach a balance between known established practices and emerging concepts. It is mainly organized into 5 assessment categories: "Green sites"; "Water efficiency"; "Energy and Atmosphere"; "Materials and Resources"; and "Indoor environmental quality". Projects, in each one of their categories, must satisfy given "prerequisites" and earn points or credits. The "Prerequisites" establish the minimum requirements that all buildings must comply with to attain the LEED certification, and the credits, which distinguish the building. Apart from LEED, there are other methods with a global impact, such as BREEAM, HQE, Passivhaus, and so on. (Mattinzioli, Sol-Sánchez, Moreno, Alegre & Martínez, 2020). Each country has progressed in the development of its system, to include local criteria, such as the Green Rating for Integrated Habitat Assessment (GRIHA) in India, Green Building Rating System (SAGRS) in Saudi Arabia, and the Sustainable Building Certification (CES) in Chile, among others (Ahmed, Abul Hasan & Mallick, 2016). The importance of these systems for architectural design should be an aspect to be highlighted, as they affect the way designers think about and settle on their projects (Labartino, 2018). Due to the needs and requirements of occupants, most systems aim at a balance between environmental and social sustainability (Moezzi, 2009). Along this line, Heerwagen (2000) mentions that the benefits of green buildings arise when the building and its occupants are treated as an integrated system, and Lee (2010) argues that green buildings have the greatest chance of success if occupants are taught about sustainable motives and the principles of the organization behind the implementation of a sustainable certification system. There have been different comparative studies between green and conventional buildings, which seek to know the potential of the former to promote sustainability among occupants. Khasha et al (2015) concluded that the knowledge of the building's occupants about environmental problems could improve their behavior in pro of the environment. The work of Steinberg, Patchan, Schunn & Landis (2009) mentioned that a group of occupants that would be moved to green building stated having a greater willingness to change their behavior, than those occupants who would remain in a conventional building. Meanwhile, Mokhtar, Wilkinson & Fassman (2015) made clear that the occupants of green buildings adopt more changes in their behavior than the occupants of conventional buildings, due to the intervention strategies implemented by the organization in green buildings. Hill et al. (2019) explored other factors of the occupants, like environmental awareness, perceptions, and the ease or difficulty perceived about behaviors, to conclude that being in a green building affects occupants in terms of showing pro-environmental behaviors. Tezel and Giritli (2019) found that environmental values, beliefs, and awareness were, statistically, predictors of pro-environmental behavior in the workplace and that the occupants of green offices showed a greater awareness about the sustainable features of the buildings. Now, despite stating a greater awareness, the occupants of green offices showed less evidence of pro-environmental behaviors, compared to those who work in unsustainable office buildings, thus showing the need for greater efforts in training about sustainability issues in society.

In contrast, other studies have shown that green buildings, in general, do not promote pro-environmental behaviors among occupants, when compared to conventional or unsustainable buildings.

For example, Hostetler and Noiseux (2010) concluded that new residents do not show pro-environmental knowledge, attitudes, or behaviors to make sustainable communities work, with the sustainability goals projected in the design. According to McCunn and Gifford (2012), neither environmental commitment nor attitudes are correlated with the green attributes of buildings. According to Rashid et al. (2012), there is no evidence of direct effects of the architectural attributes of a building on environmental awareness and the organizational image of occupants. In this sense, there is research that has looked further into some of the reasons. One of these showed that when recycling was available, people increased their use of free products (office paper, toilet paper, etc.), creating adverse effects on sustainability (Catlin & Wang, 2013). This type of behavior could be explained by the fact that a green building can be considered as a type of offset to relieve negative emotions, like the blame associated with wasteful behavior (Bamberg y Möser, 2007).

A building's sustainability can also look like a rectification, which deteriorates the perceptions of risk of occupants and increases their intentions to use more energy (Bolton, Cohen & Bloom, 2006). In other words, occupying a green building could be considered as compensation for occupants, and give them a license for a less environmentally friendly behavior, as they may perceive and have the feeling that the sustainability strategies in the building offset their environmentally unfriendly behavior. Under this premise, certain authors propose the notion of "Robust Design" (Buso, Fabi, Andersen & Corgnati, 2015; Karjalainen, 2016, O'Brien, 2013; Palme, Isalgue, Coch-Roura, Serra & Coch, 2006), based on the fact that "the occupants do not understand the operation principles of buildings, and use systems in a less-than-optimal way or even, in an unsuitable way from the energy point of view" (Karjalainen, 2016, p. 1,257).

The expression "Green Occupant" (GO) appears for the first time in the work of Browne and Frame (1999), where they conclude that "green buildings need green occupants", starting from the basis that technology in itself is not enough to achieve the sustainability goals proposed in building design, and that the occupants should be included in the process. Later, said conception was considered in other research (Deuble, 2007; Deuble & de Dear, 2012; 2009; Wu, 2016; Wu, Green, Chen, Tang & Yang, 2015; Wu, Greaves, Chen & Grady, 2017; Wu, Kim et al., 2017). Deuble (2007) looked further at the notion of GO, ending up defining this occupant as one that understands green strategies in the building and that, at the same time, one that has a high level of environmental awareness; aspects that can be measured with the "New Ecological Paradigm Scale" (NEP-R) (Dunlap, Van Liere, Mertig & Jones, 2000; Dunlap & Van Liere, 1978). However, some authors describe "gray" occupants in green buildings due to the "Rebound Effect" (Catlin & Wang, 2013; Frondel, 2004; Sorrell, 2007). Under this logic, it could be argued that occupants with high levels of environmental awareness in unsustainable buildings, could offset the absence of green strategies in the building and, therefore, behave in pro of the environment. Starting from this framework, here the GO will be conceived as an occupant with pro-environmental behavior (PEB) in the building, and in parallel, to the "pro-environmental behavior", as one "that consciously looks to minimize the negative impact of oneself in the natural and built world (for example, minimizing energy and resource consumption, the use of non-toxic substances, the reduction of waste production)" (Kollmuss & Agyeman, 2002, p. 240).

Other works have focused on the use of the green building as a promoter of sustainability, through the concept "Teaching Green Building" (L. Cole, 2014; 2018; L. Cole & Hamilton, 2019), which they exemplify with the case of the LEED certification system, that offers credit for planners that use the green school building as a teaching tool (L. Cole, 2013). Likewise, the "communication of sustainability" has been studied through the architectural attributes present in the building (Cranz, Lindsay, Morhayim & Lin, 2014; Wu, 2016; Wu et al, 2015; Wu, Greaves et al., 2017; Wu, Kim et al., 2017), to conclude that the use of educational signage in the design of green buildings must continue being promoted – a measure that ended up being, in one of the cases (Wu, Kim et al., 2017), the most effective communicator of sustainability-, and also to encourage more analyses on the innovative use of green building design, as effective communicators to promote education on sustainability among the building's occupants.

According to what has been said, what has been researched, regarding the design of green buildings and their effect on developing sustainability among the occupants, is not enough. Therefore, the general purpose of this work is to explore the relationship of the green building and the occupant, through the analysis, identification, and ranking of the associated criteria, to promote PEB among said occupants, through a sustainability certification system, based on a theoretical model – which corresponds to Specific Goal 1 (SG1). As a result, a comparative analysis is made about LEED-certified office buildings in Argentina, Chile, Colombia, and Peru, between 2012 and 2020, which corresponds to Specific Goal 2 (SG2).

METHODOLOGY

This research is exploratory (Hernández Sampieri, Fernández & del Pilar, 201), as it entails one of the few approaches to the phenomenon of design strategies in a green building, to promote sustainability (more

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specifically, PEB) among the occupants. Design strategies are represented in the LEED requirements (credits). The selection method of the cases is non-probabilistic and the types of samples (systems and countries) are of the "guided by one or several purposes" type (Hernández Sampieri et al., 2010, p. 396). As this study is part of an ongoing doctoral thesis in Chile, the selection criterion of the certification system is the highest number of projects registered in the country. The same logic is applied for the selection of the version of the system as well as the function of certified buildings. Regarding the choice of countries, these are chosen considering a similar number of projects to those registered in Chile, under the argument of "operational collection capacity" (Hernández Sampieri at al., 2010, p. 402). The assessment by experts was used as a validation method for the analysis, identification, and ranking of credits of the certification system to generate PEB among occupants (Garrote & Rojas, 2015). As for the use of credits in certified buildings in the selected countries, a comparative analysis was made, by describing the averages of LEED credits obtained in each case/country and the standard deviation of LEED credits obtained in each one.

As theoretical support, to analyze, identify, and rank LEED credits that had the potential of promoting PEB among occupants, the LEED credits with the variable "Possibilities of acting in a pro-environmental way" were used, from the "Ecological behavior model" (Fietkau & Kessel [1981], cited in Kollmuss & Agyeman, 2002), where the variable is defined as external factors (infrastructure or economic) that allow or make it difficult for people to live pro-environmentally. The other variables of the theoretical model are: "Attitude and values"; "Behavior incentives"; "Feedback perceived on pro-environmental behavior"; and "Knowledge", - a variable that does not have a direct impact on behavior, but that rather acts as a modifier of attitudes and values.

The specialized literature has identified the relationship between socio-psychological factors and PEB through theoretical conceptualization or empirical case studies, like the Planned Behavior Theory (Ajzen, 1991; Harland, Staats & Wilke, 1999), the Norms Activation Model (NAM) (Lindenberg & Steg, 2007), the Value-Belief Norm (VBN) (Stern, 2000), the New Environmental (or Ecological) Paradigm (Dunlap et al., 2000; Dunlap & Van Liere, 1978), and the Place Attachment Theory (Ramkisson, Weiler & Smith, 2012). Bamberg and Möser (2007) state, in this sense, that pro-environmental behavior is probably best seen as a mix of own interests (for example, to follow a strategy that minimizes one's health risks) and interest towards other people, the next generation, other species or complete ecosystems (for example, preventing air contamination that can cause risks for the health of others and/or the global climate). This combination of own interests and pro-social motives is seen in the formulation of the "Ecological Behavior Model", a complementary criterion for the selection of the model.

The methodological layout of the research is graphed in Figure 1.

SAMPLE:

SG1: Green certification systems in Chile.

SG2: Countries with a similar number of certified projects of the green certification system chosen in SG1.

CLASS:

SG1/SG2: Non-probabilistic or directed

ANALYSIS:

SG1:Descriptive
SG2: Descriptive and comparative.

Figure 1: Methodological layout. Source: Preparation by the authors.

RESULTS AND DISCUSSION

RESULTS

The certification system with the highest number of projects registered in Chile is LEED, with 494 registered projects (Chile GBC, 2020). Other certification systems present in the country are EDGE, Excellence in Design for Greater Efficiencies; WELL, from the International WELL Building Institute; and the national system, CES, Sustainable Building Certification. The countries with a similar number of projects to those registered in Chile, in the LEED certification system are Argentina (n=351), Colombia (n=432), and Peru (n=282) (Chile GBC, 2020). This information, as well as that for the rest of Latin America, can be seen in Table 1.

Country	Registered
Brasil	1589
México	1217
Chile	494
Colombia	432
Argentina	351
Perú	282
Costa Rica	228
Guatemala	91
Ecuador	40
Uruguay	36
Paraguay	14
Bolivia	6

Table 1. LEED registered projects in Latin American countries up to December 2020. Source: Preparation by the authors, based on Chile GBC (2020).

	Argentina	Chile	Colombia	Perú
Office Buildings	84 (100,00)	121 (100)	89 (100)	65 (100)
LEED-CS 1.0 Pilot	0 (0,00)	1 (0,83)	0 (0,00)	0 (0,00)
LEED-CS 2.0	3 (3,57)	8 (6,61)	1 (1,12)	0 (0,00)
LEED-CI 2.0	0 (0,00)	0 (0,00)	2 (2,25)	1 (1,54)
LEED-NC 2.2	0 (0,00)	2 (1,65)	3 (3,37)	0 (0,00)
LEED-CS v2009	24 (28,57)	69 (57,02)	50 (56,18)	38 (58,46)
LEED-NC v2009	24 (28,57)	23 (19,01)	12 (13,48)	3 (4,62)
LEED-CI v2009	15 (17,86)	15 (12,40)	11 (12,36)	7 (10,77)
LEED-EB:OM v2009	13 (15,48)	1 (0,83)	2 (2,25)	7 (10,77)
LEED v4 O+M: EB	0 (0,00)	1 (0,83)	0 (0,00)	0 (0,00)
LEED v4 BD+C: NC	1 (1,19)	0 (0,00)	1 (1,12)	0 (0,00)
LEED v4 ID+C: CI	4 (4,76)	1 (0,83)	6 (6,74)	9 (13,85)
LEED v4.1 O+M: Interiors	0 (0,00)	0 (0,00)	1 (1,12)	0 (0,00)

Table 3. Different versions of LEED in "Office Buildings" Source: Preparation by the authors. (The figures in parenthesis represent the percentage [%]).

	Argentina	Chile	Colombia	Perú
TOTAL LEED Registered	348 (100,00)	490 (100,00)	428 (100,00)	281 (100,00)
NOT Certified + Confidential	206 (59,20)	256 (52,24)	270 (63,08)	184 (65,48)
PT: NOT Office	58 (16,67)	113 (23,06)	69 (16,12)	32 (11,39)
PT: Offices	84 (24,14)	121 (24,69)	89 (20,79)	65 (23,13)

Table 2. LEED projects registered in Argentina, Chile, Colombia, and Peru, classified into: "NOT Certified", "Confidential", and "Project Type (PT)". Source: Preparation by the authors. (The figures in parenthesis represent the percentage [%]).

The public file of the U.S. Green Building Council (https://www.usgbc.org/) was used to filter the information and obtain the certified projects. Table 2 shows a summary of the ranking made from the information by registered projects, filtered by the content: "NOT Certified+ Confidential" projects, to date, registered as confidential and not certified; "NOT Office", projects certified and registered with roles/types different to Office; and "Offices", projects certified and registered with Office role/type in the base file, in the column ProjectTypes.

The version with the highest number of registered projects with the LEED-CS v2009 "Core and Shell" (v3), on being the most used in the database between 2012 and 2020, as expressed in Table 3.

Once the version with the highest number of projects registered was chosen, the credits were ranked in three groups: "Direct", "Indirect", and "Others". "Directs", because, in the description of "Intent" in the manual, the intentionality of promoting PEB among occupants is directly established, as happens, for example, in the alternative transportation credits: SSc4.1; SSc4.2; SSc4.3m SSc4.4: "To reduce pollution and land development impacts from automobile use". "Indirect", because in the description of the "Intent", the intentionality of promoting PEB among occupants is not directly established, but rather in another part of the credit descriptions, like in activities that are requested to obtain scores, for example, that of preparing surveys for the occupants, in the case of the credit "IEQc3: Enhanced Commissioning", or in that of credit "SSc9: Tenant design and construction guidelines", where writing a manual with instructions of the green strategies there are in the building is requested, to instruct future tenants and occupants about the building's green strategies. The category "Others" was considered as justified by the revision

LEED Environmental Category	LEED Code	LEED Identification		Credit Category – LEED / Study (*)		
			Prerequisite	Direct (*)	Indirec (*)	Other (*)
Materiales y Recursos *(Materials and Resources)*	MRp1	Storage and collection of recyclable items.	✓			
Parcelas Sustentables *(Sustainable Sites)*	SSc2	Surrounding density and diverse uses		✓		
	SSc4.1	Alternative transportation: public transportation access		✓		
	SSc4.2	Alternative transportation: bicycle storage and changing rooms.		✓		
	SSc4.3	Alternative transportation: low emitting and fuel-efficient vehicles.		✓		
	SSc4.4	Reduced parking footprint.		✓		
	SSc5.2	Site development. Maximize open space.			✓	
	SSc9	Tenant construction and design guidelines.			✓	
Energía y Atmósfera *(Energy and Atmosphere)*	EAc3	Enhanced commissioning			✓	
Calidad Ambiental Interior *(Indoor Environmental Quality)*	IEQc6	Controllability of systems – thermal comfort			✓	
	IEQc8.1	Daylight and views – Daylight			✓	
	IEQc8.2	Daylight and views – views			✓	
Innovación en el Diseño *(Innovation in Design)*	IDc1	Innovation in Design				✓

Table 4 below, presents the LEED credits with the potential to promote PEB among the occupants, following the LEED Manual CS v 2009 "Core and Shell" (v3) in its English version (USGBC, 2016). Table 4. LEED credits with the potential to promote PEB among occupants.Source: Preparation by the authors. (*) Note. These credits belong to a category different from the "Prerequisites" determined by LEED, which establish the minimum requirements that all buildings must comply with to achieve LEED certification. The former, however, are defined as "those which distinguish (the)

of the literature and the validation of experts, which sees innovation credits in the design as additional opportunities to promote sustainability among the occupants.

To obtain information on the use of LEED-C3 v2009 "Core and Shell" credits in office buildings in Argentina (AR), Chile (CL), Colombia (CO), and Peru (PE), with a potential to promote PEB, the information was collected from the scorecards of each project. Table 5 illustrates the percentage use of each credit with the potential to promote PEB among occupants in the four countries, as well as the average use of each credit by countries, to rank them, and the standard deviation of each credit, to compare them.

The credits that obtained the top three places in use, according to the average, were:

1) "SSc4.1: Access to Quality Public Transportation", with 99.34%;
2) "SSc2: Surrounding Density and Diverse Uses", with 98.34%; and
3) "SSc9: Tenant construction and design guidelines", with 96.53%.

The last three places were:

9) "EAc3: Enhanced commissioning", with 44.30%;
10) "IEQc8.1: Daylight and visits – Daylight", with 31.31%; and

LEED Environmental Category	LEED Credit Code	COUNTRY (%)				Average (%)	Standard Deviation
		AR	CL	CO	PE		
Parcelas Sustentables (Sustainable Sites)	SSc2	100,00	100,00	96,00	97,37	98,34	1,99
	SSc4.1	100,00	100,00	100,00	97,37	99,34	1,32
	SSc4.2	100,00	86,96	88,00	92,11	91,77	5,92
	SSc4.3	83,33	88,41	92,00	94,74	89,62	4,93
	SSc4.4	75,00	56,52	40,00	39,47	52,75	16,81
	SSc5.2	66,67	68,12	88,00	47,37	67,54	16,60
	SSc9	100,00	100,00	94,00	92,11	96,53	4,08
Energía y Atmósfera (Energy and Atmosphere)	EAc3	91,67	14,49	50,00	21,05	44,30	35,15
Calidad Ambiental Interior (Indoor Environmental Quality)	IEQc6	4,17	8,70	12,00	5,26	7,53	3,55
	IEQc8.1	8,33	59,42	18,00	39,47	31,31	22,82
	IEQc8.2	58,33	79,71	70,00	71,05	69,77	8,78

Table 5. Result of the analysis Source: Preparation by the authors.

11) "IEQc6: Controllability of the systems", with 7.53%.

Regarding the result of the standard deviation calculation, the two highest values appeared in the following LEED credits:

- "IEQc8.1: Daylight and visits – Daylight", with a deviation of 22.82 points. Argentina had the lowest average use of this credit (8.33%) and Chile, the highest (59.43%).

- "EAc3: Enhanced commissioning", with a deviation of 35.15 points. Chile had the lowest average use of this credit (14.49%), and Argentina, the highest (91.67%).

DISCUSSION

The first two LEED credits in the use of green office buildings in Argentina, Chile, Colombia, and Peru, between 2012 and 2020, with the potential to promote PEB among occupants, were "SSc4.1: Access to Quality Public Transportation" (99.34%) and "SSc2: Surrounding Density and Diverse Uses" (98.34%). Both look to promote a reduction in vehicle use, a pro-environmental behavior solution at an urban, city scale. In third place was the LEED credit, "SSc9: Tenant construction and design guidelines" (96.53%), whose purpose is educating tenants about the implementation of green construction and design features in the building. These construction and design guidelines look to support the tenants on the design and building of green interiors and so that they also adopt green construction practices, which opt to include the occupant in the design of green buildings, on referring to behavioral and cultural factors, that are crucial for sustainability, and to promote the level of awareness of all stakeholders (clients, designers, contractors, tenants, and occupants) about sustainable development concepts and sustainable buildings (Zuo & Zhao, 2014). This credit also shows the new challenges of including the occupant in the design solution of green buildings since, according to Hoffman & Henn (2008), the new obstacles "are no longer technological and economic, but rather social and psychological" (p. 391). Likewise, a change could be foreseen in the paradigm of occupant-focused certification systems, specifically in the IWBI WLL, Fitwel, and Living Building Challenge (California Polytechnic State University, 2020) systems. In addition, this trend could lead to an interest in studies that identify credits involved in diverse evaluation categories or occupant-focused dimensions (Gou, 2019; Gou, Prasad & Siu-Yu Lau, 2013; Ollankoon, Tam, Le & Shen, 2017), or as Wen et al (2020) suggest, of the considerable increase that, in the last three decades, the weight of the social category has been acquiring in the analyzed systems. Alongside this, a small increase in the weight of the economic category has been noted, and an ongoing reduction of the environmental one. It is worth adding, following Xue, Lau, Gou, Song, and Jiang (2019), that the design of buildings with certification systems should move from the engineering approach, focused on the construction, to a biophilic approach, based on the human being.

The least used LEED credit in the four countries was the "IEQc6: Controllability of the systems" (7.53%). Said figure may be associated with the intention of not including the occupant in the architectural design to comply with the sustainability goals in the building, on minimizing the impact of occupant interaction with the building through personal

control. Two terms are linked to this trend, the "Rebound effect" (Frondel, 2004; Grossman, Galvin, Weis, Madlener & Hirschl, 2016; Sorrel, 2007) and the "Robust Design" (Buso et al., 2015; Karjalainen, 2016, O'Brien, 2013; Palme et al., 2006). Research related to occupant interaction with the building through personal control and other topics, like thermal comfort, in the effect on energy savings (Nagy, Yong, Frei & Schlueter, 2015; Wagner, Gossauer, Moosmann, Gropp & Leonhart, 2007), and productivity in labor environments (Leaman & Bordass, 2001), showed that the relation of a greater direct individual control leads to greater thermal comfort (De Dear & Brager, 2002; Karjalainen & Koistinen, 2007), and greater satisfaction (Brager & Baker, 2009; Fountain, Brager & de Dear, 1996). From a psychological point of view, other studies observed that personal control is an important factor to increase the satisfaction and productivity of the occupant (Samani, 2015; Vine, Lee, Clear, DiBartolemeo & Selkowitz, 1998).

As for the figures recorded from the standard deviation calculation -35.15 of the LEED credit "EAc3: Enhanced commissioning", and 22.82 of "IEQc8.1: Daylight and visits – Daylight"-, which showed the spread of the values between the cases of Argentina and Chile, it can be stated that getting to know the possible causes of this represents a valuable research opportunity. From this perspective, as future works, it is foreseen to analyze the cases of Brazil and Mexico, on being the countries with the highest number of LEED-certified buildings in the region, but also the local system of Chile, CES. The methodology proposed can be replicated in both studies, and the results can, therefore, be compared.

CONCLUSION

In the relationship of the green building and the occupant, in the design framework of office buildings that seek to attain sustainable goals, the most used credits in the chosen countries opt to include the occupant in the use and promotion of alternative transportation, which contributes towards reducing the impact on the environment at an urban level, a solution that the three groups proposed in Hopwood, Mellor & O'Brien (2005) would support to face the challenges of sustainable development. Another alternative to include the occupant in the design, referring to the LEED credit that looks to instruct the occupant on the green strategies present in the building, also intervenes in society, but through culture; a term that is associated with the action of cultivating or practicing something. And a final solution, that looks to restrict occupant interaction in the building, to achieve energy efficiency (as a sustainability measurement), contributes to society, this time, through technology, that is to say, from applying science to solve specific problems.

Finally, it has to be stated that identifying criteria, through credits in a certification system to promote sustainability among the occupants -in the PEB-, is in line with the emergence of new certification systems, focused on social sustainability, towards the occupants, instead of focusing on environmental sustainability, energy efficiency, and the use of technologies in buildings. For this reason, this work represents a contribution to the phenomenon of the relationship between green buildings and their occupants.

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BIBLIOGRAPHICAL REFERENCES

Ahmed, M., Abul Hasan, M. y Mallick, J. (2016). World Green Building Rating Systems: A Comparative Study. En *International Conference Cum Exhibition On Building Utilities 2016*. Recuperado de https://www.researchgate.net/publication/323771840

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. DOI: https://doi.org/https://doi.org/10.1016/0749-5978(91)90020-T

Bamberg, S. y Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, *27*(1), 14–25. DOI: https://doi.org/10.1016/j.jenvp.2006.12.002

Bolton, L. E., Cohen, J. B. y Bloom, P. N. (2006). Does Marketing Products as Remedies Create "Get Out of Jail Free Cards"? *Journal of Consumer Research*, *33*(1), 71–81. https://doi.org/10.1086/504137

Brager, G. y Baker, L. (2009). Occupant satisfaction in mixed-mode buildings. *Building Research and Information*, *37*(4), 369–380. DOI: https://doi.org/10.1080/09613210902899785

Browne y Frame, I. (1999). Green buildings need green occupants. *Eco-Management and Auditing*, *6*(2), 80–85. DOI: https://doi.org/10.1002/(sici)1099-0925(199906)6:2<80::aid-ema102>3.0.co;2-#

Buso, T., Fabi, V., Andersen, R. K. y Corgnati, S. (2015). Occupant behaviour and robustness of building design. *Building and Environment*, *94*, 694–703. DOI: https://doi.org/10.1016/j.buildenv.2015.11.003

Catlin, J. R. y Wang, Y. (2013). Recycling gone bad: When the option to recycle increases resource consumption. *Journal of Consumer Psychology*, *23*(1), 122–127. DOI: https://doi.org/10.1016/j.jcps.2012.04.001

Chile GBC (2020). *Reporte Construccion Sustentable Chile GBC - Diciembre 2020*. Recuperado de www.chilegbc.cl

Chwieduk, D. (2003). Towards sustainable-energy buildings. *Applied Energy*, *76*(1–3), 211–217. DOI: https://doi.org/10.1016/S0306-2619(03)00059-X

Cole, L. B. (2013). The Green Building as a Medium for Environmental Education. *Michigan Journal of Sustainability*, *1*. DOI: https://doi.org/10.3998/mjs.12333712.0001.012

Cole, L. B. (2014). The Teaching Green School Building: a framework for linking architecture and environmental education. *Environmental Education Research*, *20*(6), 836–857. DOI: https://doi.org/10.1080/13504622.2013.833586

Cole, L. B. (2018). The Teaching Green Building: Five Theoretical Perspectives. En W. Leal Filho, R. W. Marans y J. Callewaert (Eds.), *Handbook of Sustainability and Social Science Research* (pp. 107–125). Springer International Publishing. DOI: https://doi.org/10.1007/978-3-319-67122-2_6

Cole, L. B. y Hamilton, E. M. (2019). Can a green school building teach? A pre- and post-occupancy evaluation of a teaching green school building. *Environment and Behavior*, *52*(10), 1047-1078. DOI: https://doi.org/10.1177/0013916518825283

Cole, R. J. (1999). Building environmental assessment methods: Clarifying intentions. *Building Research and Information*, *27*(4–5), 230–246. DOI: https://doi.org/10.1080/096132199369354

Cole, R. J. (2002). Emerging trends in building environmental assessment methods. *Building Research & Information*, *26*(1), 3–16. DOI: https://doi.org/10.1080/096132198370065

Cranz, G., Lindsay, G., Morhayim, L. y Lin, A. (2014). Communicating Sustainability: A Postoccupancy Evaluation of the David Brower Center. *Environment and Behavior*, *46*(7), 826–847. DOI: https://doi.org/10.1177/0013916513475449

D'Oca, S., Hong, T. y Langevin, J. (2018). The human dimensions of energy use in buildings: A review. *Renewable and Sustainable Energy Reviews*, *81*, pp. 731–742. DOI: https://doi.org/10.1016/j.rser.2017.08.019

De Dear, R. J. y Brager, G. (2002). Thermal comfort in naturally ventilated buildings: Revisions to ASHRAE Standard 55. *Energy and Buildings*, *34*(6), 549–561. DOI: https://doi.org/10.1016/S0378-7788(02)00005-1

Deuble, M. P. (2007). *Green Occupants for Green Buildings*. Macquarie.

Deuble, M. P. y de Dear, R. J. (2012). Green occupants for green buildings: The missing link? *Building and Environment*, *56*(56), 21–27. DOI: https://doi.org/10.1016/j.buildenv.2012.02.029

Deuble, M. P. y de Dear, R. J. (2009). Do green buildings need green occupants? En *Proceedings of Healthy Buildings 2009* (pp. 843–846). Recuperado de https://researchers.mq.edu.au/en/publications/do-green-buildings-need-green-occupants

Ding, G. K. C. C. (2008). Sustainable construction-The role of environmental assessment tools. *Journal of Environmental Management*, *86*(3), 451–464. DOI: https://doi.org/10.1016/j.jenvman.2006.12.025

Dunlap, R. E. y Van Liere, K. D. (1978). The "new environmental paradigm". *Journal of Environmental Education*, *9*(4), 10–19. DOI: https://doi.org/10.1080/00958964.1978.10801875

Dunlap, R. E., Van Liere, K. D., Mertig, A. G. y Jones, R. E. (2000). New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. *Journal of Social Issues*, *56*(3), 425–442. DOI: https://doi.org/10.1111/0022-4537.00176

Fabi, V., Andersen, R. y Corgnati, S. (2011). Description of occupant behaviour in building energy simulation: state-of-art and concepts for improvements. *Building Simulation 2011: 12th Conference of International Building Performance Simulation Association, Sydney, 14-16 November*, 2882–2889.

Fountain, M., Brager, G. y de Dear, R. (1996). E IEl GY AHD BUILDIPIG Expectations of indoor climate control. *Energy and Buildings*, *24*(3), 179-182.

Frondel, M. (2004). Guest editorial: Energy conservation, the rebound effect, and future energy and transport technologies: An introduction to energy conservation and the rebound effect. *International Journal of Energy Technology and Policy*, *2*(3), 203–208.

Garrote, P. R. y Rojas, M. del C. (2015). La validación por juicio de expertos: dos investigaciones cualitativas en Lingüística aplicada. *Revista Nebrija de Lingüística Aplicada a la Enseñanza de Lenguas*, *18*, 124–139.

Gou, Z. (2016). Green building for office interiors: challenges and opportunities. *Facilities*, *34*(11–12), 614–629. DOI: https://doi.org/10.1108/F-04-2015-0022

Gou, Z. (2019). Human Factors in Green Building: Building Types and Users' Needs. *Buildings*, *9*(1), 17. DOI: https://doi.org/10.3390/buildings9010017

Gou, Z., Prasad, D. y Siu-Yu Lau, S. (2013). Are green buildings more satisfactory and comfortable? *Habitat International*, *39*, 156–161. DOI: https://doi.org/10.1016/j.habitatint.2012.12.007

Grossmann, D., Galvin, R., Weiss, J., Madlener, R. y Hirschl, B. (2016). A methodology for estimating rebound effects in non-residential public service buildings: Case study of four buildings in Germany. *Energy and Buildings*, *111*, 455-467 DOI: https://doi.org/10.1016/j.enbuild.2015.11.063

Harland, P., Staats, H. y Wilke, H. A. M. (1999). Explaining Proenvironmental Intention and Behavior by Personal Norms and the Theory of Planned Behavior. *Journal of applied social psychology, 29*(12), 2505-2528. DOI: https://doi.org/10.1111/j.1559-1816.1999.tb00123.x

Heerwagen, J. (2000). Green buildings, organizational success and occupant productivity. *Building Research and Information*, *28*(5–6), 353–367. DOI: https://doi.org/10.1080/096132100418500

Hernández Sampieri, R., Fernández Collado, C. y del Pilar Baptista Lucio, M. (2010). *Metodología de la Investigación*. México D.F: McGraw Hill.

Hill, A., Han, Y., Taylor, J. E., Shealy, T., Pearce, A. y Mohammadi, N. (2019). Empirical examination of pro-environmental behaviors in traditional, green featured and LEED certified buildings. *Energy Procedia*, *158*, 3982–3987. DOI: https://doi.org/10.1016/j.egypro.2019.01.843

Hoffman, A. y Henn, R. (2008). Overcoming the Social and Psychological Barriers to Green Building. *Organization & Environment*, *21*(4), 390–419. DOI: https://doi.org/10.1177/1086026608326129

Hong, T., Yan, D., D'Oca, S. y Chen, C. (2017). Ten questions concerning occupant behavior in buildings: The big picture. *Building and Environment*, *114*, 518–530. DOI: https://doi.org/10.1016/j.buildenv.2016.12.006

Hopwood, B., Mellor, M. y O'Brien, G. (2005). Sustainable development: Mapping different approaches. *Sustainable Development*, *13*(1), 38–52. DOI: https://doi.org/10.1002/sd.244

Hostetler, M. y Noiseux, K. (2010). Are green residential developments attracting environmentally savvy homeowners? *Landscape and Urban Planning*, *94*(3–4), 234–243. DOI: https://doi.org/10.1016/j.landurbplan.2009.10.008

Illankoon, I. M. C. S., Tam, V. W. Y., Le, K. N. y Shen, L. (2017). Key credit criteria among international green building rating tools. *Journal of Cleaner Production*, *164*, 209–220. DOI: https://doi.org/10.1016/j.jclepro.2017.06.206

Karjalainen, S. (2016). Should we design buildings that are less sensitive to occupant behaviour? A simulation study of effects of behaviour and design on office energy consumption. *Energy Efficiency*, *9*(6), 1257–1270. DOI: https://doi.org/10.1007/s12053-015-9422-7

Karjalainen, S. y Koistinen, O. (2007). User problems with individual temperature control in offices. *Building and Environment*, *42*(8), 2880–2887. DOI: https://doi.org/10.1016/j.buildenv.2006.10.031

Khashe, S., Heydarian, A., Gerber, D., Becerik-Gerber, B., Hayes, T. y Wood, W. (2015). Influence of LEED branding on building occupants' pro-environmental behavior. *Building and Environment*, *94*, 477–488. DOI: https://doi.org/10.1016/j.buildenv.2015.10.005

Kirk, J. L. (2010). *Sustainable environments and pro-environmental behavior*. University of Nebraska at Lincoln. Recuperado de http://digitalcommons.unl.edu/arch_id_theseshttp://digitalcommons.unl.edu/arch_id_theses/2

Kollmuss, A. y Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *8*(3), 239–260. DOI: https://doi.org/10.1080/13504620220145401

Labartino, I. (2018). *Building certification as a driver in green building design: The holistic apporach of WELL*. Stockholm: KTH, School of Architecture and the Built Environment.

Leaman, A. y Bordass, B. (2001). Assessing building performance in use 4: The Probe occupant surveys and their implications. *Building Research and Information*, *29*(2), 129–143. DOI: https://doi.org/10.1080/09613210010008045

Lee, Y. S. (2010). Office layout affecting privacy, interaction, and acoustic quality in LEED-certified buildings. *Building and Environment*, *45*(7), 1594–1600. DOI: https://doi.org/10.1016/j.buildenv.2010.01.007

Lindenberg, S. y Steg, L. (2007). Normative, Gain and Hedonic Goal Frames Guiding Environmental Behavior. *Journal of Social Issues*, *63* (117-137). DOI: 10.1111/j.1540-4560.2007.00499.x

Mattinzioli, T., Sol-Sánchez, M., Moreno, B., Alegre, J. y Martínez, G. (2020). Sustainable building rating systems: A critical review for achieving a common consensus. *Critical Reviews in Environmental Science and Technology*, *51*(5), 512–534. DOI: https://doi.org/10.1080/10643389.2020.1732781

McCunn, L. J. y Gifford, R. (2012). Do green offices affect employee engagement and environmental attitudes? In *Architectural Science Review*, *55*(2), 128–134. DOI: https://doi.org/10.1080/00038628.2012.667939

Moezzi, M. (2009). Are comfort expectations of building occupants too high? *Building Research and Information*, *37*(1), 79–83. DOI: https://doi.org/10.1080/09613210802611009

Mokhtar, N. S. y Wilkinson, S. (2015). Motivation Factors in Energy Saving Behaviour between Occupants in Green and Conventional Buildings — Malaysia Case Study. *International Journal of Environmental Science and Development*, *6*(7), 491–497. DOI: https://doi.org/10.7763/ijesd.2015.v6.643

Mokhtar, N. S., Wilkinson, S. y Fassman, E. (2015). Strategies for improving energy saving behaviour in commercial buildings in Malaysia. *Engineering, Construction and Architectural Management*, *22*(1), 73–90. DOI: https://doi.org/10.1108/ECAM-04-2014-0054

Nagy, Z., Yong, F. Y., Frei, M. y Schlueter, A. (2015). Occupant centered lighting control for comfort and energy efficient building operation. *Energy and Buildings*, *94*, 100–108. DOI: https://doi.org/10.1016/j.enbuild.2015.02.053

O'brien, W. (2013). Occupant-proof buildings: can we design buildings that are robust against occupant behaviour. *13th Conference of International Building Performance Simulation Association, Chambéry, France, August 26-28* (pp. 746–1754).

Palme, M., Isalgue, A., Coch-Roura, H., Serra, R. y Coch, H. (2006). Robust design: A way to control energy use from the human behaviour in architectural spaces. En *PLEA 2006 - 23rd International Conference on Passive and Low Energy Architecture, Conference Proceedings, September* (pp. I311–I316).

Pierson, L. (2020). *Building for Wellness-Healthy Building Course for Cal Poly SLO CM Department*. Recuperado de https://digitalcommons.calpoly.edu/cmsp/365/

Ramkissoon, H., Weiler, B. y Smith, L. D. G. (2012). Place attachment and pro-environmental behaviour in national parks: The development of a conceptual framework. *Journal of Sustainable Tourism*, *20*(2), 257–276. DOI: https://doi.org/10.1080/09669582.2011.602194

Rashid, M., Spreckelmeyer, K., & Angrisano, N. J. (2012). Green buildings, environmental awareness, and organizational image. *Journal of Corporate Real Estate*, *14*(1), 21–49. DOI: https://doi.org/10.1108/14630011211231428

Samani, S. A. (2015). The impact of personal control over office workspace on environmental satisfaction and performance. *Journal of Social Sciences and Humanities*, *1*(3), 163-175. Recuperado de http://www.aiscience.org/journal/jssh

Sorrell, S. (2007). The rebound effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency. *Australian family physician*, *42*(4). UK Energy Research Centre. DOI: https://doi.org/1-903144-0-35

Stazi, F. y Naspi, F. (2018). *Impact of Occupants' Behaviour on Zero-Energy Buildings*. Cham: SpringerBriefs in Energy.

Steinberg, D., Patchan, M., Schunn, C. y Landis, A. (2009). Determining Adequate Information for Green Building Occupant Training Materials. *Journal of Green Building*, *4*(3), 143–150.

Stern, P. C. (2000). Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues*, *56*(3), 407–424.

Tezel, E. y Giritli, H. (2019). Understanding pro-environmental workplace behavior: a comparative study. *Facilities*, *37*(9–10), 669–683. DOI: https://doi.org/10.1108/F-12-2017-0134

USGBC (2016). *LEED 2009 for Core and Shell Development Rating System*. Recuperado de https://www.usgbc.org/resources/leed-2009-core-and-shell-current-version

Van den Brom, P., Meijer, A. y Visscher, H. (2016). Reducing the performance gap by analysing specific combinations of occupant and building characteristics. En *4th European Conference on Behaviour and Energy Efficiency (Behave 2016)*, *September*, *8–9*. Recuperado de http://pure.tudelft.nl/ws/files/10412927/Brom_Meijer_Visscher.pdf

Vine, E., Lee, E., Clear, R., DiBartolomeo, D. y Selkowitz, S. (1998). Office worker response to an automated venetian blind and electric lighting system: a pilot study. *Energy and Buildings*, *28*(2), 205–218.

Wagner, A., Gossauer, E., Moosmann, C., Gropp, T. y Leonhart, R. (2007). Thermal comfort and workplace occupant satisfaction-Results of field studies in German low energy office buildings. *Energy and Buildings*, *39*(7), 758–769. DOI: https://doi.org/10.1016/j.enbuild.2007.02.013

Wen, B., Musa, N., Onn, C. C., Ramesh, S., Liang, L. y Wang, W. (2020). Evolution of sustainability in global green building rating tools. *Journal of Cleaner Production*, *259*. DOI: https://doi.org/10.1016/j.jclepro.2020.120912

Wu, S. R. (2016). *Green buildings and green users: an assessment of using green building environments to communicate sustainability to users*. Michigan: Michigan State.

Wu, S. R., Greaves, M., Chen, J. y Grady, S. C. (2017). Green buildings need green occupants: a research framework through the lens of the Theory of Planned Behaviour. *Architectural Science Review*, *60*(1), 5–14. https://doi.org/10.1080/00038628.2016.1197097

Wu, S. R., Green, M., Chen, J., Tang, Y. y Yang, A. (2015). Green building design and visual persuasion on occupants' pro - environmental behaviours. *Living and Learning: Research for a Better Built Environment, 49th International Conference of the Architectural Science Association*, 133–142.

Wu, S. R., Kim, S.-K., Park, H., Fan, P., Ligmann-Zielinska, A. y Chen, J. (2017). How do green buildings communicate green design to building users? A survey study of a leed-certified building. *Journal of Green Building*, *12*(3), 85–100. DOI: https://doi.org/doi.org/10.3992/1943-4618.12.3.85

Xue, F., Lau, S. S. Y., Gou, Z., Song, Y. y Jiang, B. (2019). Incorporating biophilia into green building rating tools for promoting health and wellbeing. *Environmental Impact Assessment Review*, *76*, 98–112. DOI: https://doi.org/10.1016/j.eiar.2019.02.004

Zuo, J. y Zhao, Z. Y. (2014). Green building research-current status and future agenda: A review. *Renewable and Sustainable Energy Reviews*, *30*, 271–281. DOI: https://doi.org/10.1016/j.rser.2013.10.021