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Sources of Challenges for Sustainability in the Building Design—The Relationship between Designers and Clients

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Abstract: Sustainability demands have changed the building design nature increasing the diversity of requirements, activities, agents, and tools. The aim of this paper is to investigate the sources of challenges in the relationship between architectural and engineering (AE) design firms and clients for promoting sustainability in the building design. Additionally, this study investigated the building information modeling (BIM) deployment by the firms that supports sustainability. The research method adopted is qualitative and participatory, based on focus groups. Two groups were interviewed, eight AE design firms and six developers and/or construction companies, gathering the points of view of service providers and their clients. The identified sources of challenges around sustainability include lack of communication and imprecision of definition, requirements, and scope. Additionally, management issues include performance evaluation, traditional work relationships, tools, and processes that do not support collaboration needs. In addition, AE design firms' organization affects the client relationship and design quality, including the consideration of sustainability issues in the design solutions. The sources are found in the AE design firm's processes of strategy planning, business and marketing, design, people, and knowledge management.

Keywords: design firm; sustainable design; stakeholder

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1. Introduction

Design is a critical stage when many decisions influencing the building performance are made; it is also instrumental in meeting the project sustainability goals [1]. The design stage has gained complexity due to the diversity of requirements, activities, agents, and tools regarding sustainability. It means more challenges in the interrelationships among the stakeholders, not only in the decision-making processes of each but also in their information exchange and market operation [2].

Frequently, sustainability has been related to technology as design solutions in terms of building and external environment, energy, water and materials efficiency, waste reduction, indoor air quality, thermal comfort, health, etc. More often, sustainability is discussed in the sustainability certification context. However, to achieve the sustainability goals, it must be considered that building design is the result of the interaction among different professionals from different firms. Each firm has its own structure, culture, procedures, and tools creating tensions that should be identified and managed to improve processes and products [3,4].

Correspondingly to sustainability, building information modeling (BIM) has been often reduced to technology but in terms of software potential as an isolated firm's tool for digital drawings generating information automatically [5,6]. According to [7], companies, managers, public authorities, researchers, etc. have focused most of their attention on technological innovation. They are not very interested in other forms of innovation, such as managerial innovation. However, managerial innovation is the main factor that explains the company's performance.

This paper considers the managerial facet of sustainability and BIM, the importance of managerial and organizational capabilities of the firms involved in the building project, and the relation among them. Thus, it aims to investigate the sources of challenges in the relation between architectural and engineering (AE) design firms and clients (developers or private individuals) for promoting sustainability in the building design. This study also investigates the BIM deployment by the firms that supports sustainability.

1.1. Sustainability and Management

Sustainable construction can be defined as "how the construction industry together with its product, the 'built environment', among many sectors of the economy and human activity, can contribute to the sustainability of the earth, including its human and non-human inhabitants" [8]. This definition addresses the concept of sustainable development from the Bruntland report in 1987 [9], which is considered the starting point of the sustainability era [10].

Sustainable building and green building can be distinguished as the first one addresses environmental, economic, and social requirements of sustainability while the other has mainly an environmental approach [11]. However, energy efficiency, building performances, and rating systems have been the key elements guiding the building design and management toward sustainability since 1990s [10]. While the technology advances to respond to the green requirements and the movement to environmentally friendly buildings can be recognized, it seems habitual modus operandi and tools have been used by many actors, rather than building new paradigms and new visions of the world [10]. Creating and using new worldviews, renovating design practices, and educating new professionals are some actions for leading toward the "true" sustainability [10].

The design firms have the role of translating requirements into design solutions. A successful design as service and product meets the clients' requirements, for example, developers, private individuals, or construction companies' requirements. In some cases, the term sustainable design is employed with an environmental emphasis denoting green design or related to high performance building [12,13]. However, it makes references to sustainable building and the three dimensions of sustainability—environmental, economic, and social [11].

Relating sustainability to management enables the discussion about how the set of firms' management processes, the modus operandi, and the relation among the firms affect sustainability in the building design process. The body of knowledge on sustainability integration in management of construction projects can be categorized into seven dimensions [14]: motivations, stakeholder orientation, organizational context, temporal orientation, benefits, barriers, and risks. This present paper can be associated to the dimensions of motivation (why designers, developers, and construction companies take initiatives for sustainability consideration); stakeholder orientation (initiatives of designers and clients for sustainability integration); organizational context, project personnel (how or at what level sustainability integration can happen in an organizational context; personnel or actors that need to be included in the project organization to facilitate the sustainability integration).

Building projects with sustainability goals require a high level of communication, integration, and coordination among the stakeholders [1,15]. Developers and construction companies define the building project goals and select the AE design firms. A request for proposal (RFP) or request for qualifications (RFQ) is recommended in the selection process providing a clear description of the design services, also addressing the needed qualifications in green design and sustainable design strategies [1,15]. Then, during the contract stage, an agreement describes the scope of services, roles and responsibilities, payment, insurance, and indemnification, along with other important provisions [1].

In turn, managerial and organizational capabilities of the AE design firms are determinants for meeting the client's needs in terms of design quality and sustainability goals. Analyzing [16] the influence of environmental sustainability on practices of architectural

design, consulting, and construction companies from France, management information was highlighted by interviewees as essential for developing projects with sustainable requirements [16]. In a study [17], experience and knowledge of green building, an organizational green culture, and innovation capability were ranked as the most important factors in projects with environmental objectives in achieving higher ratings in Green Mark, a certification system utilized in Singapore.

Sustainability competences have specific roles in the initial inspiration for eco-design, project development, and the involvement of stakeholders [18]. In that study [18], the most apparent competences were related to strategic management and action, diversity, interdisciplinarity, and interpersonal aspects, while systems thinking, foresighted thinking, and normative competences were not as recurrent in the research results.

Concerning the relationship among stakeholders, project delivery systems have a key role [1,15]. Ref. [19] found that project delivery systems influence the integration in the project team, affecting the achievement of building sustainability goals. Additionally, these authors highlighted the owner commitment, team characteristics, and starting point of stakeholder interaction as relevant aspects to the integration level in the project. They concluded that sustainable strategies increase project complexity and require increased interdisciplinary interaction, early involvement of stakeholders, and communication and collaboration through various methods [19].

The project stakeholders adopt different approaches to sustainability based on their own perceptions about what is considered sustainable and how to achieve it [4]. Those approaches are dynamic and create tensions impacting the initial project goals, project planning, and design phases. Processes in green building projects are influenced by four tensions that can either enhance or hinder collaboration and innovation: strategic–tactical, collaborative–competitive, participative–effective, and individual–collective [3]. Those tensions should be managed, contributing to the product and process performance.

The motivations that drive architectural designers to engage with sustainable design are mainly autonomous motivations of personal commitment and an ethical imperative, as well as self-identity, pursuit of quality, and awareness of the design work impact on people; and the influence of regulation and client demand [20]. Autonomous motivations align with sustainability principles, including design for durability, high standards, and technical expertise [20].

The adoption of sustainable solutions can be stimulated through public policies at the market level that can be positive or negative incentives (penalties and compensations) [21]. However, ref. [20] highlights the risks of reliance on extrinsic motivators, such as regulation for sustainability promotion: policy inconstancy, minimal requirements compliance, lack of responsibility engagement, restriction of creativity, and decrease in autonomous motivations. The authors suggest the importance of engaging professionals, especially designers considered agents of change. Ref. [22] states " . . . the architectural designer has primary responsibility in guiding clients toward greater environmental sustainability", but this responsibility and the role of sustainability in the firm's business development are not recognized by designers.

1.2. BIM, Management and Sustainability

BIM has a great potential to contribute to building quality and sustainability enabling the integrated design, performance simulations, life cycle assessment, and information use throughout the building life cycle. In addition, BIM can impact the performance, productivity, business sustainability, and competitiveness of the design firms.

However, some professionals have reduced BIM to technology in terms of software [5] employed by an isolated firm. Since BIM is not a tool or software, it is a set of interacting policies, processes, and technologies [23], a more favorable context for it depends not only on technical or technological solutions but also on organizational and managerial ones. BIM potential has not been fully achieved since there are many difficulties of implementation at the organizational level, and BIM demands changes in organizational business structure [6].

Despite the BIM 20-year progression in implementation, usage, and unquestionable results, it is still not clear how it affects project management and changes the roles in construction projects [24]. Some of the triggering factors of low satisfaction of construction professionals with the BIM adoption results are legal obstacles, as the obsolescence of contractual models; the evident need to renew roles and responsibilities; the limited educational and cultural basis; the collaboration and communication constraints; and the inertial management practice [24].

Regarding problems and challenges in the interactions of design teams of construction projects, four research trends can be pointed: collaboration and BIM, design teams in the construction industry, design management, and collaborative design methodologies and processes [25]. The relevant problems or challenges are related to communication, collaboration, coordination, trust, and role identification [25].

BIM itself will not solve the firms' managerial and organizational difficulties and deficiencies, but it may make them more evident. Providing an environment promoting the synergy between BIM and sustainability is essential for achieving its benefits, which means having suitable project delivery systems [19,26], companies and firms' capabilities in management, people, process, knowledge, and technology.

A successful consideration of sustainable aspects in the design solutions depends on that environment and a BIM plan including the modeling of sustainability information (defining what information, detail level, and its use for simulations, for example) producing the sustainability-related evidence according to the building project goals. In this regard, it is necessary to go through a progression path in interoperability, lifecycle performance assessment in the early planning phases, client (owner, developer) engagement in the BIM use and sustainability goals, BIM capabilities for sustainability, collaboration between scholars, and industry practitioners [26].

2. Materials and Methods

The research method adopted is qualitative and participatory based on the focus group. The focus group was chosen since a group effect could guide the research to an investigation field expanding the researcher's perceptions from the participants' experience sharing [27,28]. A focus-group interview is conducted through guided group discussion, questions and answers, and interactive dialogue with 3 to 12 participants [28]. The present research has followed the stages recommended by [27] for conducting the focus group: planning, participant recruitment, implementation of discussion sessions, data organization, result analysis, final report, and dissemination.

The aims of the focus group were to encourage the participants to share design experiences with sustainability concerns; to lead participants in reflecting on unfavorable aspects and enablers for sustainability in the building design process; to investigate if there are problems or challenges whose causes are related to a design firm's management; to investigate if BIM is being used and whether it relates to the firm management or sustainability.

Two-hour synchronous interviews with one moderator and interviewer, one rapporteur, and one observer were conducted using the Zoom platform in August and September 2021. Two groups were interviewed: eight AE design firms (GF1) and six developers and/or construction companies (GF2). The firms and companies operate in the building subsector (residential, commercial, industrial, and/or social) of Brazil. The participants were selected from the register of the Management Development Program for Design Firms (Research Line of Management Design, Department of Civil Construction Engineering, University of Sao Paulo) and analyzed on the website LinkedIn. In addition, in the case of GF2, a ranking of the most active developers and construction companies from the Metropolitan Region of Sao Paulo was consulted (Top Real Estate Award, partnership between the Brazilian Company for Heritage Studies—EMBRAESP and the newspaper O Estado de S. Paulo, Base Year 2020, https://embraesp.com.br/premios/, accessed on 25 August 2021).

An unstructured pilot interview was conducted with an architectural firm about sustainability and management identifying a set of questions. Then, the questions were discussed among the researchers, including a professional with focus group experience, deriving four open-ended questions to guide the focus group interviews: (1) When you hear the term "sustainability of design", what design situations or experiences come to your mind? (2) What aspects do you consider unfavorable for sustainability in the design process? (3) What aspects do you consider enablers for sustainability in the design process? (4) Would you have suggestions for promoting sustainability in the design process?

An online profile questionnaire was also developed on the Google Forms platform collecting the firm's characteristics. The data were collected from the interview recordings and rapporteur's and observer's reports. Statements and fact checking supported the data analysis; fact checking is the review of the interview or transcripts for accuracy [28]. The statements were formed from the categorization of the participants' position in the interactive discussion, and the recordings were revisited to check the composition of the statements. An online collaborative whiteboard platform called Miro was used to organize and analyze the findings since the interviews also respected the discussion course in the groups, in addition to addressing the questions above. By clustering the themes on Miro, some patterns of responses among the participants were founded. Although the findings cannot be generalized about the building subsector, the participants have a relevant experience in the market and important research evidence was found and then discussed through the literature.

3. Results and Discussion

3.1. Characteristics of the Groups

The following characteristics were collected from the online profile questionnaire answered by the participants before the interview. Regarding the GF1, six out of eight (6/8) participants are architects while the other two are engineers (civil and electrical engineers, respectively); one (1/8) has completed a master's degree. Half of the participants (4/8) have more than 23 years of design experience while the other half (4/8) have between 7 and 14 years of experience. Except for one participant who is a design coordinator, all the others are firm founders. The AE design firms' characteristics are shown in Table 1. The firms are located in Sao Paulo, but five out of eight (5/8) also operate in other Brazilian states.

Table 1. AE design firms (GF1).

Firms	Design Specialty	Years of Operation	Number of Employees	Market Segment	Type of Client
1	Architecture, Residential Renovation	2.5	4	R	P
2	Mechanical, Electrical and Plumbing	9	10	R, C, I	D, C
3	Architecture	1.4	2	R, C	P, O
4	Landscaping, Exterior Architecture	20	8	R, C, I, S	P, D, C, O
5	Architecture	26	4	R, C, S	P, D, C, PI
6	Architecture, Design, Illustration	16	3	R, C, I, S	P, D, C, O, PI, B
7	Architecture	7	5	R, C	D, C
8	Mechanical, Electrical and Plumbing	51	20	R, C	D, C

Legend: R—residential; C—commercial; I—industrial; S—social; P—private individuals; D—developers; C—construction companies; O—other private companies; PI—public institutions; B—banking institutions.

In six out of eight (6/8) AE design firms, clients have demanded sustainability aspects in the building design (Table 2). Half of the firms (4/8) have experienced sustainability certification processes, mostly AQUA-HQE, then LEED, Selo Procel, or Fitwell (Figure 1). Interesting to notice is that despite having sustainability demands from clients, two (2/6) firms do not have any certification. As can be seen in Figure 2, all the firms have experienced BIM in some level.

Table 2. Demands of sustainability aspects.

Firms	Clients' Demands of Sustainability
2	Certification—AQUA-HQE, Procel, Edge
3	Natural lighting, cross-ventilation, and landscape as a thermal and visual comfort strategy
4	"Unfortunately, we did not notice a real concern of the clients about the sustainability topic; they just seek meeting the certification requirements". Main demands: specification of native species with less maintenance, low water consumption and non-invasive, slab use for green roofs, light colors for floors reducing heat emission
5	Water saving, demands related to HVAC, and maintenance in general
7	Waste destination and storage, demands related to energy, construction
8	Management of water and energy, water reuse, consumption measurement, resources use

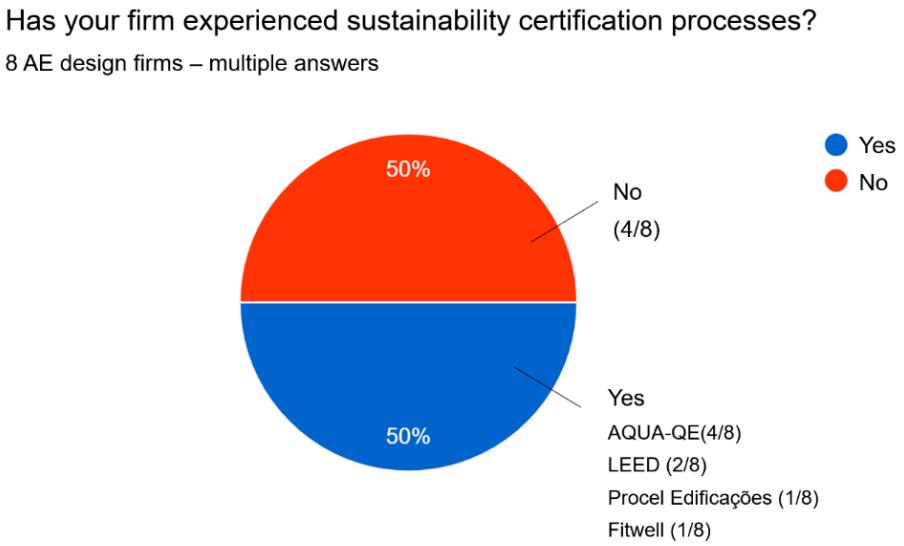

Figure 1. Design firms' experiences with sustainability certification processes.

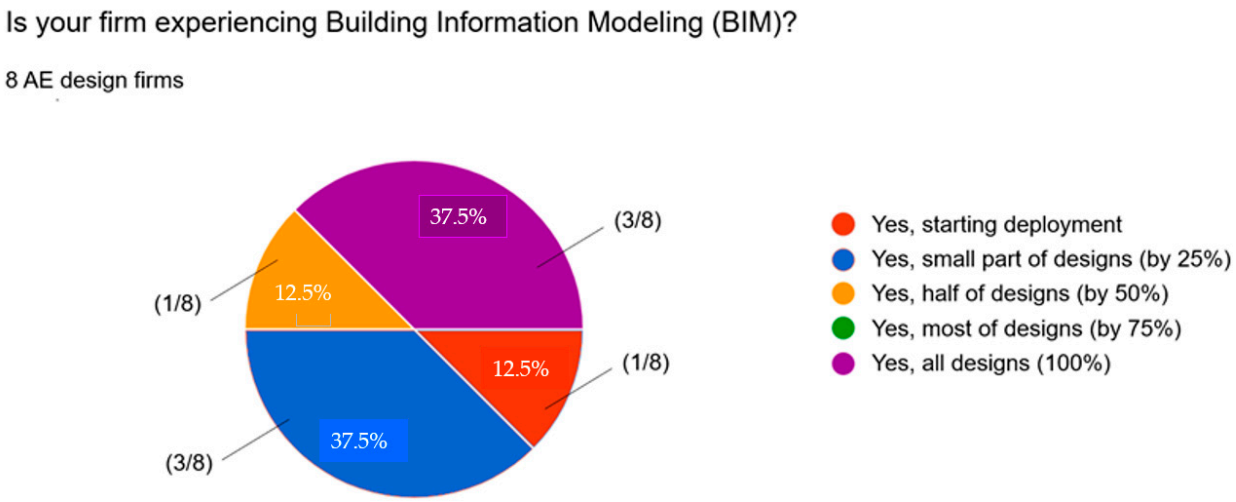

Figure 2. Design firms' experiences with BIM.

Regarding GF2, four out of six (4/6) participants have completed a postgraduate level while the other two are a civil engineer and a business administrator. Except for one participant, who has a 10-year experience in the civil construction field, all the others (5/6)

have 20 years or more of professional experience. Over half of the participants are managers (4/6) in the areas of project, business, or quality; while two are a design coordinator and an architect, respectively.

The companies' characteristics (GF2) can be seen in Table 3. They are located in Sao Paulo; two of them also operate in other Brazilian states. Nearly all the companies (5/6) have been demanding sustainability aspects when contracting building designs (Table 3). All the companies have at least one sustainability certification, for example, LEED, AQUA-HQE, Selo Casa Azul CAIXA, and Etiqueta PBE Edifica.

Table 3. Developers and/or construction companies (GF2) and sustainability demand.

N.	Company Type	Years of Operation	Number of Employees	Market Segment	Demand of Sustainability Aspects When Contracting Designs
1	Developer and construction	35	65	R, C, S	Resources reuse, area for clean transport (bicycle), material reuse during the construction stage
2	Developer	86	20	R, C	-
3	Developer and construction	60	8000	R, C	Resource optimization (expected inputs), demand optimization (for calculations in all disciplines), rationalization in all design disciplines
4	Developer and construction	40	500	R	Rainwater reuse, solar heating, waste selective collection for users
5	Developer and construction	27	300	R	Individualized measurement of water and gas, rainwater reuse
6	Construction	45	2500	C, S	Dimensioning of glass and facades, water reuse, solar energy, air conditioning

Legend: R—residential; C—commercial; I—industrial; S—social.

Four in six (4/6) companies have employed BIM in a small part (25%) of the building projects (Figure 3); among them, three have employed BIM in the design and construction stages while one has only employed it in the design stage. Two (2/6) companies have not employed BIM in any stage (Figure 4).

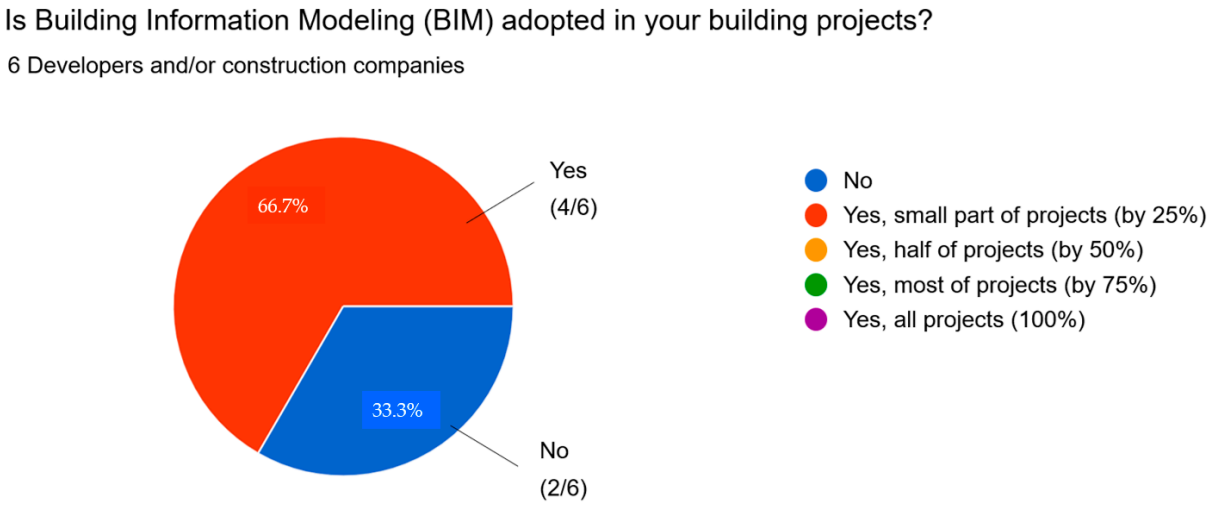

Figure 3. BIM adoption in developers and/or construction companies.

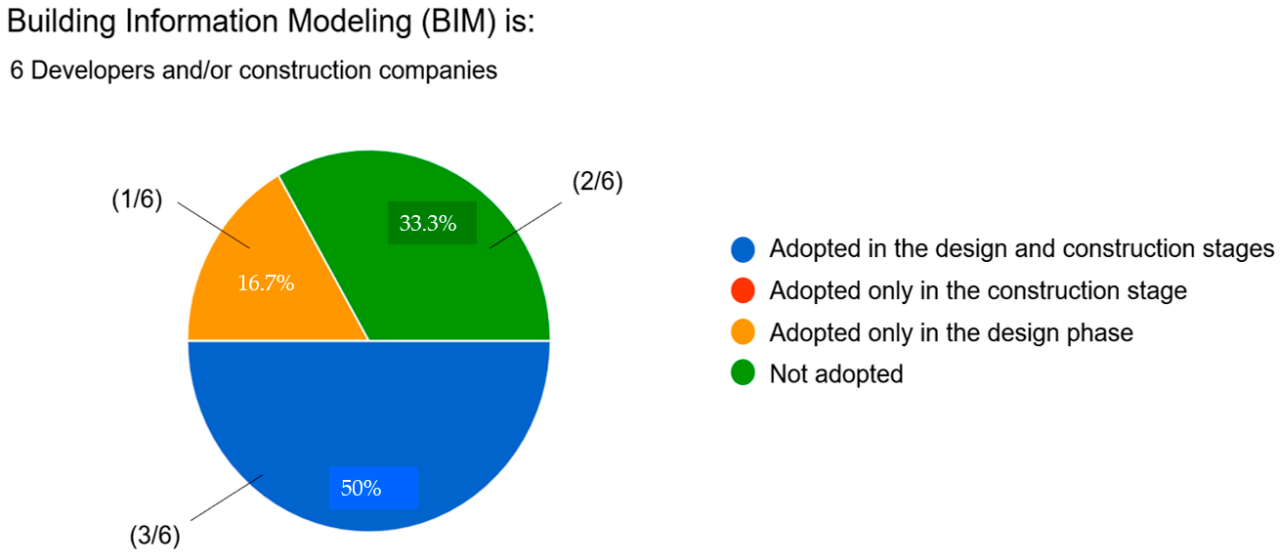

Figure 4. Stages in which BIM is adopted by developers and/or construction companies.

3.2. Statements According to the Group Interviews

The following statements (S) were established from the data analysis of the focus groups GF1 and GF2 for discussion in this paper.

GF1, S1—Designers expressed a feeling of frustration about how sustainability has been considered in the building design process. At the beginning of the interview, when the participants were asked about situations or experiences regarding "sustainability of design", the first reaction was "what kind of stories do you want to hear; is it about consulting?" Among the participants, there was a sense that sustainability is related to marketing purposes in civil construction.

The sustainability concept is not limited to a certification or consulting; it can be understood as an intrinsic aspect of the design building that includes analysis of the location, the climate conditions, the materials needed, and the construction process [29]. However, it was found that greenwashing is a present concern leading the designers to question if a certified building is a sustainable building. Teaching design incorporating sustainability to architecture students is a challenge because of "the trend to label every design as sustainable or green even though it is not different from a more traditional one" [29].

GF1, S2—The type of client affects how sustainability is considered in the building design process. Two types of clients were found among the AE design firms: developers and private individuals. While the building as a real estate market product is previously defined by developers and then designers develop the design solutions, in the case of private individuals, designers are hired for guiding them in understanding users' needs, converting the latter into design solutions. The clients' purposes are different; while developers are concerned about profit margins and risks, private individuals are the end-users concerned about comfort and needs (relation environment-user). Thus, designers have more freedom and power to influence the clients and express creativity in the second situation, including their responsibility in influencing sustainability aspects [22]. In the first situation, in many cases, designers are limited to product definitions provided by developers in a sequential design process.

That first scenario probably explains the designers' frustrations since their motivations toward sustainable design [20] have been affected. That also indicates tensions [3,4] among designers and developers affecting how sustainability is considered in the design solutions, especially as an intrinsic aspect of the product. In addition, the project delivery system does not seem to provide the suitable needed collaboration for sustainable designs, as remarked by [1,15,19].

GF1, S3—The firm's organization directly and indirectly affects how sustainability is considered in the building design process. It was discussed that a firm's founding architect or engineer has two roles: designer and manager. Usually, AE design firms have a small work structure, and the activities are centralized in the founding figure. Apart from technical knowledge, a firm demands knowledge and efforts in many areas (strategy, marketing, finance, people management, etc.); the founder can thus be overloaded if the firm does not have a suitable process organization. The challenge for small design firm owners to accumulate roles was also found in our previous research [30,31].

According to the participants, time is a critical aspect in the firms; also, there is a lack of training and knowledge management. The firms can be easily affected by the economic scenario, making knowledge loss through dismissals a risk for them. The pandemic scenario was a challenge for the firms: one participant has operated the firm with a reduced structure sharing the physical space with other professionals; one participant stopped signing new agreements to organize the activities in that new scenario; communication and information exchange were affected in one of the firms, and management tools and work processes were implemented for meeting needs perceived more clearly due to the pandemic.

The participants highlighted the need for organization and review of management processes in the AE design firms since the firm's managerial context affects the design quality and sustainability. The firm's management should support the sustainable design development through people, time management, training, management knowledge, physical space, agreements and strategy, management tools, work processes, etc. Additionally, if the sustainability concept is expanded, the conditions in which the design is developed should be questioned.

GF1, S4—Defining and trusting the strategies is the way. It was pointed out that having strategies in terms of the firm's mission, vision, and values can guide the founders and help them to deal with the coexistence of the roles of designer, manager, and entrepreneur. Focusing on the strategies would help the founders spend resources only on what they want without getting into the cycle of running out of time due to demands that are not the firm's core business. It means selling the firm's design process, declining some clients who are not aligned to the strategies, and not making sudden decisions that are not profitable in the long-term. This finding corroborates our previous research alerting about the risk of making sudden decisions [30] and providing guidelines on strategic planning [32]. Participating in discussion forums was pointed out as a helpful way for thinking out of the box, making the firm evolve.

GF1, S5—BIM. The investments' costs were pointed out as a barrier for implementing BIM. Conversely, BIM was recognized by the users as a worthy investment due to its global benefits. [33] found that BIM developmental and operational costs are not equally distributed among the stakeholders and that architectural firms must bear the majority of the costs and risks related to BIM implementation. According to the author, architectural firms must overcome three BIM barriers: human, infrastructural, and business.

A clear relation between BIM and sustainability was not found. BIM is in its early stages in the firms; it has not yet reached the maturity level for carrying out sustainability and performance analysis. It is important to discuss the lack of management in the firms and stakeholders' conflicts creating a favorable environment for BIM in order to achieve its benefits, including the information modeling (model uses) for sustainability and performance purposes.

GF2, S1—Sustainability depends on the building class or interests of the company. It was observed that the way participants expressed themselves about sustainability is related to the building class or interests of the companies they work in. Sustainability was linked to the following: durability and efficiency in the case of high-income housing buildings; cost in the context of low-income housing buildings; operation in the company that owns buildings, interested in long term advantages; rationalization indicating interests in financial saving through resource saving, also sustainability certification was linked to sales margin (for example, certification was not understood as a differential by residential building clients,

the unit sales did not increase in certified buildings; this is the reason why the company no longer seeks the certification in this segment).

Different approaches to sustainability can be seen among the participants [4]; thus, the company's culture or strategy has an impact on how sustainability is considered in the buildings. It also leads to the question "Is sustainability for everyone?" since sustainability as durability and efficiency seems more present in the case of high-income housing buildings.

GF2, S2—There is a gap between the product conception and the design stage. As mentioned by GF1, it was also pointed out by GF2 that the building product is previously defined by developers in a sequential process affecting the decision timing and then limiting changes in the design stage. It was argued that designers have a passive behavior in the relations, also, a lack of qualification, experience, awareness, and training in the AE design firms.

Analyzing the participants' speeches of GF1 and GF2, it is not clear if the designers have a passive behavior because of the lack of freedom in the design activity, prioritizing the developers' demands—also, considering developers and construction companies are big and powerful and it could inhibit the participation of small firms—or if AE design firms are not prepared to meet clients' requirements affecting their position in the building project team. However, that scenario is a point of conflict related to both project delivery systems (sequential process) and communication (a RFP or RFQ could help in the needed qualifications definition, as recommended by [1,15]).

GF2, S3—Building design with sustainability certification purposes is more expensive. A participant argued that if sustainability is an intrinsic aspect of the design (design feature), why is it more expensive when the design has certification purposes? Other participants raised the issues of more hours worked and consultants contracting by the AE design firms in the case of a certification. It can be questioned if the AE design firm's activities including those aimed at certification have not been clear to the client (scope of contract) or if the client has depreciated the activities. The clear differentiation between the design solutions development and certification activities are critical in the scope and communication between the stakeholders, avoiding conflicts.

According to a participant, regarding Selo Azul da Caixa, the designers have been familiar with the design solutions adopted, and there have not been changes in their activities due to the label. However, as the participant said, there remains the doubt if the solutions are really sustainable. It seems there is a risk of only complying with minimal requirements [20] for meeting, for example, Selo Azul da Caixa, which is a government incentive for sustainability in the case of low-income housing buildings. Sustainability was linked to cost by the participant, leaving the question "Can sustainable solutions be implemented through intrinsic goals of the building project without necessarily increasing the design or building cost?"

GF2, S4—Factors that stimulate sustainability. According to the participants, the following factors stimulate sustainability: the technology advancement becoming more affordable; the appropriate legislation; the demands for the Brazilian performance standard, Selo Azul da Caixa; and the subsidies for meeting sustainability requirements.

GF2, S5—BIM. Although BIM has been considered a trend, its deployment has been modest among the participants, as can be seen in some of their speeches: "we are modeling our part"; "a future that never comes"; "we are starting". Thus, BIM for sustainability was not an issue raised in GF2.

4. Conclusions

This paper investigates the sources of challenges in the relation between AE design firms and clients for promoting sustainability in the building design. Analyzing the research findings, a source of challenges that could be pointed out is the lack of definition and communication about the stakeholders' sustainability approach bringing them into conflicts or affecting their motivation. Moreover, the lack of a more detailed design scope and required qualifications by the clients and the lack of business management and firm's

performance evaluation processes by designers may hinder the relation between them, as well as sustainability promotion.

Some other sources of challenge are the traditional project delivery systems, traditional work relationships, tools, and processes that do not support the collaboration needs. Additionally, AE design firm organization affects the client relationship and design quality including the consideration of sustainability issues in the design solutions. Analyzing the cited challenges by the participants, the sources are found in the AE design firm's processes of strategy planning, business and marketing, design, people, and knowledge management. Table 4 presents some management guidelines for tackling the sources of challenges and embracing sustainability in the firms' processes using BIM. Those guidelines show some openings in the processes for generating sustainability value using BIM.

Efforts of developers, construction companies, and AE design firms are required when implementing sustainable solutions through the intrinsic goals of the building project without necessarily increasing the design or building cost. Those goals cannot be achieved by traditional management solutions. As designers are primarily involved with design solutions influencing clients with technical arguments considering the society's environmental, social, and economic concerns, and as the sources of challenges are related to management, further research will be carried out about managerial and organizational capabilities of AE design firms for achieving successful designs in the digital transformation through BIM.

Table 4. Management guidelines for sustainability and BIM (based on ref. [32,34,35]).

Management Processes	Working Points
Strategic planning	1. Defining the firm's strategic positioning in the market about sustainable buildings and BIM 2. Identify strengths, weaknesses, threats, and opportunities about sustainable buildings and BIM 3. Identifying BIM strategic objectives and developing implementation strategies considering the model uses for sustainability and performance analysis
Organizational structure	1. Analyzing the firm's structure and needs for performing the sustainable design work supported by BIM 2. Identifying the organizational changes necessary for instigating, monitoring, and improving BIM adoption for sustainability and performance
Business management and marketing	1. Understanding the client requirements defining the building sustainability objectives 2. Analyzing the client requirements with regard to available resources • Can the firm deliver what is being requested in terms of team, competence, technology, and time? • Does it require hiring people or external services? (Considering the required sustainability and performance studies and how people and studies will be managed) 3. Identifying contractual elements based on the scope of the sustainable design. If applicable, defining the scope of the sustainability certification services 4. Drawing up technical and commercial agreements appropriate for meeting the building sustainability objectives identifying stakeholders (roles and responsibilities); environmental, economic and social constraints of the building project; risks and opportunities 5. Administering the contractual documentation underlying collaborative BIM projects and workflows 6. Employing BIM and sustainability as product and service differentiation creating competitive advantages. At the same time, prospecting clients and partners aligned to the firm's strategic goals 7. Initiating partnerships and alliances with other organizations based on BIM deliverables and workflows

Table 4. *Cont.*

Management Processes	Working Points
Design process	1. Mapping the sustainable design process including activities, agents, and tools 2. Generating and maximizing sustainability value from BIM tools and workflows 3. Employing a strategy for sustainability and performance studies defining BIM model uses, considering performing or outsourcing the studies 4. Identifying the basic requirements and main deliverables expected from using BIM tools and workflows 5. Preparing the documentation necessary to enable model-based collaboration between project participants
Aggregate services to design	1. Systematizing the sustainable design delivery 2. Monitoring the construction (site visits) to maintain the projected performance of the building 3. Defining the owner's responsibilities regarding building operation and maintenance 4. Seeking and analyzing post-occupancy evaluation data taking the required actions
Financial management	1. Planning, allocating, and monitoring the costs associated with BIM adoption and sustainability-related demands (e.g., hiring professionals, training, software acquisition) 2. Seeking financial resources, incentives, and innovation programs, especially for small and medium firms 3. Pricing the sustainable design fairly (as product and service)
Information system	1. Defining the information flow and managing internal and external information in the sustainable design process 2. Defining communication and collaboration tools 3. Managing and maintaining BIModels generated using standardized processes, protocols, and specifications 4. Using document management systems or something similar to store, manage, and share files and BIModels
People management	1. Drawing up professional profiles covering sustainability and BIM identifying the required competences, attitudes, and training 2. Developing a responsibility assignment matrix, including sustainability and BIM-related activities 3. Analyzing if distinct "sustainability" and BIM positions are required 4. Considering sustainable design and BIM knowledge for selecting and recruiting people
Performance evaluation	1. Analyzing if the sustainable design complies with the client requirements, sustainability objectives, and building project program 2. Assessing organizational BIM capability/maturity for generating sustainability value
knowledge management	1. Managing data and information generating and keeping knowledge in the firm 2. Promoting lessons-learned sessions in the firm 3. Employing the knowledge in the design process and strategy planning

Successful BIM implementation and progression depend on the firm's capabilities in strategy, people, process, information, business management and marketing, finance, and performance evaluation and also on collaboration and partnership among different firms and companies. Therefore, BIM could be a reason for improving the firm's management processes toward a digital transformation and, consequently, improving the design quality toward sustainability. Although BIM usage is currently modest in some firms and companies, it is important to evolve having a plan and recognizing the challenges in order to achieve more collaborative ways to produce buildings [36].

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