# Chapter 26
# Emergence and progression of knowledge on design management: the case of Brazil

**Silvio Melhado**
ORCID No: 0000-0002-2295-6527

**Abstract**

The role of construction design managers remains under-recognised, particularly in developing countries where "on-site" roles are prioritised over "in-office" functions. Additionally, in practice, the emphasis on the use of digital tools as opposed to process improvement contradicts recommended design management methodologies. This study examines the evolution of design management in Brazil, highlighting progress in certifications, standards, and technology adoption while emphasising the continued lack of consolidation in professional practice. The research suggests that early involvement in design processes is more closely linked to procurement strategies than technological advancements. Future research should focus on improving building design management, thus strengthening the role of design managers, sharing knowledge at a national level about innovative design and management techniques, adoption of collaborative contracts and early-stage decision-making frameworks, and affordable, local artificial intelligence applications. A limitation of this study is that it is influenced by the author's personal experience in Brazil, which may shape the perspectives presented.

**Keywords**: Brazil, building design, design management, digital construction, professional skills, research agenda.

## 1. INTRODUCTION

According to Emmitt (2014), it was during the 1960s that design management gained prominence in the United Kingdom, with the publication in 1962 of the RIBA report "The Architect and His Office" and subsequent publication of many guides, such as the RIBA Plan of Work. The author stated that growing interest in the design management was followed by the emergence of design management literature and the evolution of the design manager role within the fields of architecture and construction.

In the "building design world", there are three culturally different worlds, brought temporarily together through a building project, with a significant difference in understanding between the design professionals, clients and contractors: from the perspective of the client, who hires designers and contractors to develop their project, design is a means to an end; the focus of designers is linked to

valuable design creation and fee generation; and, in the case of contractors, making profit and generating value to the client constitute the aim (Emmitt, 2014). Therefore, there are three possible dimensions of design management: (1) the clients are responsible for the product development design, which is mainly explained by market demands and economic-financial viability issues; (2) in the design process itself, hard work on co-ordination enables the synergistic integration of the increasingly numerous actors of the multi-disciplinary team; and (3) internal to each discipline, design management is an integral part of the environment of design and consultancy firms. All those three dimensions of design management (product development, design co-ordination and internal to each discipline) need to be integrated with a view to improving quality, performance and sustainability.

Given the above reasoning, and with a special interest in the reality of developing countries, this chapter aims to reflect on the changes in design management since the 1990s, taking as a case study the scenario of the evolution of building construction in Brazil. From the case study, some relevant points are extended to other developing countries, and an agenda for academic research on the topic is proposed.

The perspective of three decades of research in the field of design management in construction shows a recurrence of approaches that are inspired by corresponding developments in the manufacturing industry. Clearly, caused by prevailing trends at a local and global level, over the last 30 years there have been research waves that prioritise certain themes and approaches. Within each new wave, not only do concepts adapted from industrial experience emerge and re-emerge, but their essence is covered by new terms and new guises, thus making the interpretation and consolidation of the adopted concepts and principles difficult. Thus, the progression of knowledge in compromised.

In this context, this chapter aims to discuss the main research waves that influenced design management research and practices in Brazil, showing the recurrence of certain fundamental elements and proposing an alignment between concepts and terms used. The aim is to show, from a historical perspective limited to a relevant geographic area, that the research methods most used today can disguise the knowledge produced and delay the evolution of research in the field studied. As result, research themes are proposed, focusing on the reality of developing countries.

A desirable holistic approach, as proposed by several improvement initiatives based on industrial experience, conflicts with the fragmented character of the construction industry. The principles brought in from project management in the manufacturing industry are repeatedly presented as necessary paths to increase the quality, productivity and performance of product development in the building industry:

process management; multi-disciplinary teamwork; early technology selection; integration, collaboration and communication among stakeholders; performance simulation and assessment; design for production; manufacturability/constructability; and sustainability in the product life cycle, just to name a few examples, all of which facing barriers arising from deep-rooted practices such as: traditional forms of procurement; dispersion of responsibilities; low level of innovation; high risk aversion; subjective decision-making; and low recognition of professionals.

Regardless of all these factors, slow changes have been observed in models, methods, and practices of design management in building construction over time. There is still a long way to go, but the relevance of improving design management seems to be clear to everyone interested in the evolution of the construction industry. Therefore, intending to contribute to a broad understanding of the research agenda in building design management, with an emphasis on the reality of developing countries, this chapter aims to help define strategies to deal with design management in the future of the construction industry, which becomes more globalised over time, even though the consideration of local issues remains mandatory.

## 2. THE PROGRESSION OF KNOWLEDGE IN CONSTRUCTION: RESEARCH WAVES AND THE DESIGN MANAGEMENT

It is widely recognised that the collaboration between stakeholders is rarely ideal in construction projects and, as a result, the production process becomes fragmented. Starting with preliminary design often based on poor information, leading to the complexity of design co-ordination, which is bogged down by checking and updating information from multiple authors. In this context, changes to design solutions throughout project development are frequent and numerous, resulting in significant risks, production errors and rework. Faced with this scenario, researchers went through several waves of trending subjects involving the study and implementation of approaches to achieve more efficient and effective design management practices in construction projects.

In **Figure 26.1**, the timeline presented intends to highlight the main challenging waves that have affected the practices in building design management, from the 1990's or before to the present date. The majority of the components of the figure have appeared in both local and global contexts, although with differences in the timing of their occurrence. In the figure, dates represented are only estimated and are not supposed to be exactly indicating the appearance of each conceptual or technological approach.

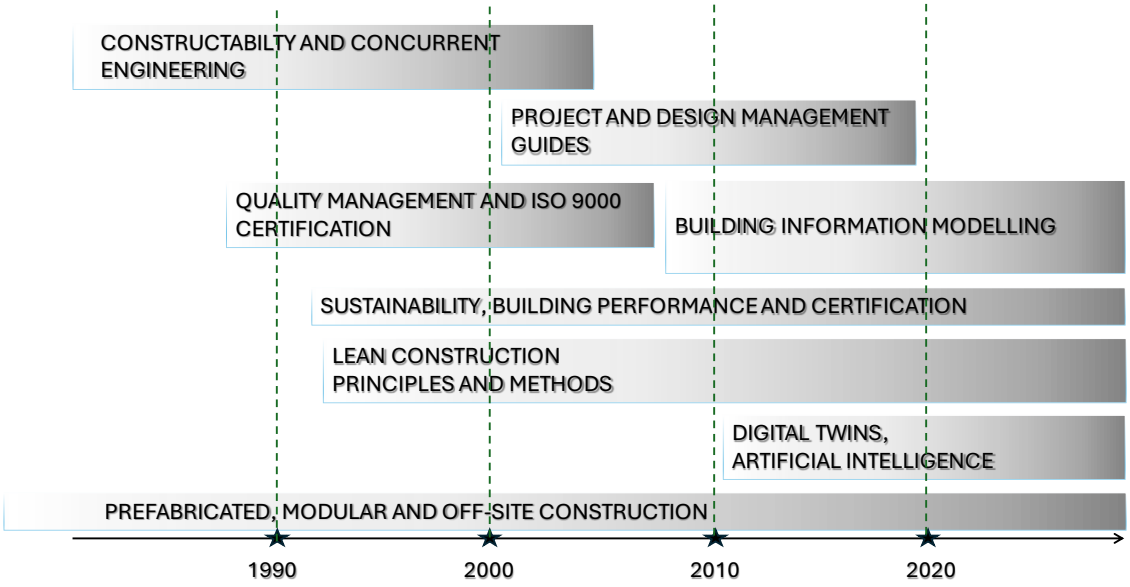


**Figure 26.1 – Timeline: research waves of trending subjects in building design management**

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The main waves of evolution identified did not only affect academic work, but it also had significant impacts over the demand for professional skills, definition of processes, and technology adoption. A crossed influence between academic and professional trends is noticeable, which can be explained by several factors, which are exemplified by the case study of Brazil, presented later in this chapter. Despite all those waves of improvement, always bringing relevant proposals for integration between agents and activities in the building production cycle, the development of a construction project continues to be clearly divided into phases or stages, in which, given their different strategies and objectives, the various actors involved tend to create conflict rather than collaboration.

In the next section, the case study presented is intended to exemplify the changes in design management methods, trying to improve the performance of the building industry in Brazil, following international trends, although in a specific local context.

## 3. CASE STUDY – DESIGN MANAGEMENT IN BRAZIL

Brazil is a country of 203,080,756 inhabitants in a territorial area of 8,510,417.77 km2, with 7 percent of the population being illiterate, according to the last official census (IBGE, 2024). The largest country in South America, its GDP of USD2173.67 billion in 2023 (USD10,043 *per capita*) and a low Human

Development Index (HDI) of 0.760 in 2022 define it as an underdeveloped country, even though it is classified among the ten largest economies in the world (United Nations, 2024). Considered as a part of the group of emergent countries offering highest investment opportunities, Brazil, as well as Russia, India, China, and South Africa, has a huge construction industry, combining formal and informal construction markets. Apart from the informal construction, the prevailing construction culture and institutional framework surrounding construction projects play a decisive role in the way buildings are designed and constructed. In Brazil, the last decades have brought significant changes in terms of standardisation, diverse construction requirements, available technology and access to innovations. However, how much of these changes have been consolidated and effectively changed design management practices in Brazil?

## 3.1 THE DESIGN PROCESS EVOLUTION AND THE DESIGN MANAGER'S ROLE

The design managers' mission can be defined as "to analyse the project context and respond to the project deliverables in a timely and consistent manner" (Emmitt, 2014 p.22).

In Brazil, during the 1990's, a set of national standards was published to establish typical procedures concerning building design. However, those standards were not largely diffused or adopted, and, among practitioners, the notions of design process and design management were not clear. In practice, some private clients, especially real estate developers, have begun to create new design management models which have, albeit partially or globally, dissociated design management from design authorship. The resulting management configuration often includes changes in responsibility throughout the project stages, moving from a focus on the product to a focus on technical solutions and construction methods, often without a clear integration between the different stages and teams involved in the project (Melhado, 1994).

During the 2000's the most usual management model, whether in private or public projects, focused on document delivery and did not have a clear plan for design activities. In an attempt to improve results, in the design detailing phase, some private clients started to organise design co-ordination meetings centralising design decisions. Also in this sense, some of these clients produced guidance manuals by project specialty, largely aimed at standardising technical solutions. However, academic research has, through case studies, highlighted several weaknesses in the design processes adopted that often result in poor design quality and delays in design delivery (Grilo, 2002; Grilo; Melhado, 2002; Manzione; Melhado, 2007).

A big concern with the quality and productivity of construction works, often limited by the adoption of artisanal or poorly detailed technical solutions, gradually leads to the emergence of a wide range of services offered by specialists in detailing construction methods and processes. These specialists are called production designers, who have become part of increasingly larger multi-disciplinary project teams. It then becomes very common to have around 20 or more different design specialties in private projects. On the other hand, the public sector is slower to adopt changes in the way in which constructed items are designed and co-ordinated (Melhado et al., 2005).

In this context, the support of project extranets, based on internet services, associated with the use of document management systems, began to be gradually adopted by clients. The management teams are either in-house or outsourced, depending on the number of projects. With the need to verify the many documents produced by architectural or engineering design professionals, as well as the compatibility of information between them, outsourced verification services have become common – this is the so-called design compatibility analysis, whether it is associated with design co-ordination services or not (Rodríguez; Heineck, 2003; Rodríguez, 2005; Manso; Mitidieri, 2007; Silva; Novaes, 2008).

Souza; Melhado (2008) analysed the scientific production concerning the design process in Brazil from 1995 to 2007 through a collection of papers published at the main Brazilian conferences on the subject. As part of their conclusions, they made these observations:

- From 1995 to 1998, there were no articles on sustainability, but since 2000, there has been an increase in the number of articles on this topic;
- The same thing happened with information technology, where the number of papers increased during the period;
- The opposite occurred in terms of works on quality, as the number of papers published decreased until 2004, when no papers were published on this matter; and
- Comparing the papers in Brazil to those presented at international conferences, a gap was identified in the Brazilian research connecting building design management to information and communication management.

An evolution in the design manager's profile was observed during the entire period, but it did not proceed at the same speed in different parts of the country. Geographically speaking, with a few exceptions, design management practices in Brazil have evolved most quickly in the Southeast and South regions of the country. It would still take many years to achieve similarity in design management practices, which became much more similar all over the country throughout the 2010s, although it has been far away from a

definitive framework of reference (Nóbrega Júnior; Melhado, 2013). Additionally, Nóbrega Júnior and Melhado (2013) pointed out that a growing presence of female managers has been noticed in the design management environments in Brazil. Although it would be going too far to consider this as indicating a gender equity evolution, the presence of women is as big as it is at the lowest levels of the management hierarchy. Xavier (2020) carried out a survey involving 237 Brazilian construction professionals, being 189 female and 48 male respondents, and revealed a portrait of strong prejudice and gender inequality with respect to job and promotion opportunities.

## 3.2 CONCURRENT DESIGN, CONSTRUCTABILITY AND LEAN CONSTRUCTION

Since the 1970's, the academic literature has stressed the importance of anticipating the consideration of construction knowledge to the first stages of a building project design. The original concept proposal is quite old and came from the analysis of the potential impact of early decision taking in the total project costs. **Figure 26.2** illustrates the concept according to Paulson (1976). Similar concepts, always highlighting the importance of anticipating decisions, would be presented a number of times, associated with either project quality or other performance parameters.

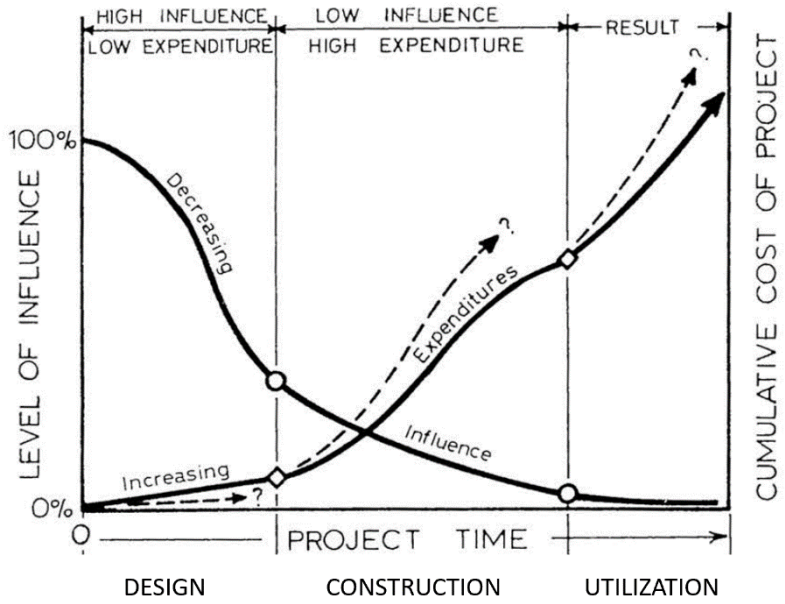


**Figure 26.2 – Level of influence versus cumulative cost of the project along project time (Paulson, 1976)**

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Constructability was defined originally as “the optimum use of construction knowledge and experience in different project stages to achieve overall project objectives” (CII, 1986, p. 4). In Brazil, the concept of constructability has only been partially adopted in the design and execution of construction projects since the end of 1980’s. Some academic works mention the concept, which has inspired proposals to improve the quality and productivity of housing projects (Melhado, 1994). Some years after, in a similar way but more structured way, in the 1990s, lean construction emerged as a strong wave among Brazilian researchers, mainly focusing on improving construction planning and reducing waste in construction processes. Melhado (1998) described a case study regarding a research project involving a private Brazilian construction company, carried out during a 12-month collaborative programme bringing together teams from the university and the company. The main findings are analysed under the framework of lean design principles.

Tzortzopoulos and Formoso (1999), based on case studies in Brazil, observed that one of the primary reasons why building projects continue to have issues is an overemphasis on the conversion approach used in the design process. Indeed, 25 years after this statement, the design process remains, in general, one that is divided in several subcontracts carried out by design specialists taking decisions that are not so integrated. Ballard (2002, p.1) clearly defined the weakness of the traditional approach of design: “Developed in manufacturing, theories and techniques of managing production focus almost entirely on the task of making multiple copies of a single design. Management of project-based production systems lies at the intersection of these two disciplines, is enormously important, and has been until recently almost entirely undeveloped.” This author advocates the adoption of an integrated design and construction approach, based on concurrent engineering and the last planner system.

Other authors equally stress the benefits of an integrated approach drawn from lean construction: “The company’s design and technical specs sector held meetings with its designers to develop production-driven designs, reducing the time it takes for the production teams to understand the plans and reducing eventual mistakes and rework during construction” (Conte and Gransberg, 2001 p.14). Several years after, Rodriguez and Heineck (2003), writing about constructability in the building design process, concluded that the design co-ordinator would be the professional best suited to manage the application of technical knowledge and construction experience throughout the design process, both at a general and detailed level. On the other hand, concurrent design, an application of concurrent engineering principles that originated from the manufacturing sector to construction projects created a more comprehensive approach, covering both the strategic and operational dimensions of management.

Fabricio and Melhado (2001) proposed the use of concurrent engineering principles to improve the design process in order to consider all the issues involved in the life cycle of construction projects. The application of the concepts of concurrent engineering brought in multi-disciplinary collaboration as its main orientation, with early integration of knowledge of the execution of works into the design and selection of construction methods. Advancing further in anticipating the introduction of knowledge from other agents and stages, based on industrial practices, concurrent design was proposed by Fabricio and Melhado (2002). The framework, published some years later as a book chapter, is presented in **Figure 26.3**.

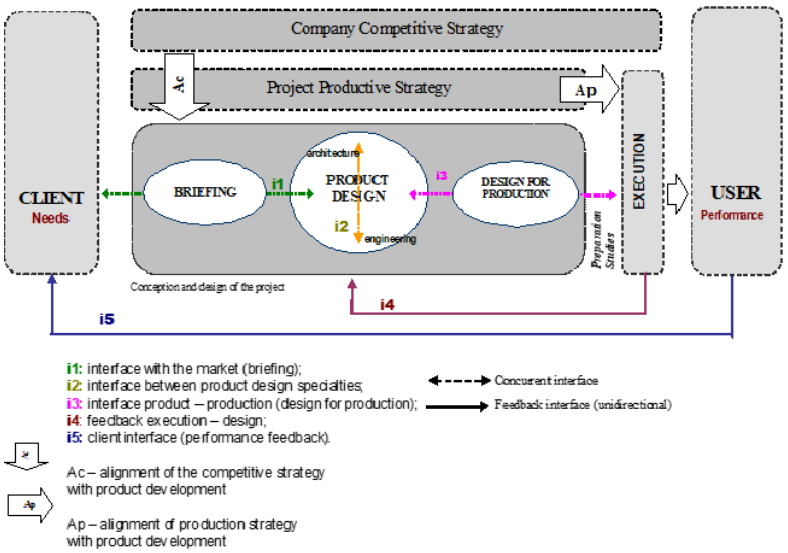


**Figure 26.3 – The concurrent design concept (Fabricio and Melhado, 2009)**

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Thus, inspired by the idea of great improvements in performance that were observed in manufacturing, construction researchers and practitioners started to introduce concepts such as constructability, concurrent design, and lean production to their applications in the Brazilian building industry. Those concepts are thus clearly related to decisions taken in design, even if they have sometimes been associated with its integration into the construction phase. One of the common points among the principles of concurrent design, constructability and lean construction is the anticipation of decisions, increasing the value of the most upstream stages of the design process. This principle contrasts with the dominant culture in the construction industry, in which decisions and changes to earlier decisions largely occur late, justified

by the prevalence of the client's position and the low investment in pre-construction stages. The situation tends to change when contractual modes move away from the traditional design-tender-construction approach, thus providing more favourable conditions for improving the design process, increasing team multi-disciplinarity, early collaboration and integration of the phases of the project cycle.

In practice, owing to a prevalence of clients' priorities, the principles of concurrent design and constructability although they are well-known, are not always taken into consideration. Wyse et al. (2013) developed a case study of a large real estate and construction company in Brazil, where they identified the lack of definition of responsibilities regarding decision-making on technical aspects, leading to missed compatibility guidelines in the interfaces between the disciplines of design, constructability and performance, thus compromising the meeting of the deadline for the detailing phase of the project, as well as the final quality of the building. The standards developed by the company itself were not used in the initial design phases. Consequently, in general, the projects reached the construction phase with unresolved clashes and inadequate technical solutions.

### 3.3 THE IMPACT OF ISO 9000 STANDARDS ON DESIGN MANAGEMENT

The wave of adoption of ISO 9000 standards in the Brazilian construction industry began in the early 1990s. In addition to certification initiatives for companies in the industry, in 1996, the state government established the Sao Paulo Housing Construction Quality Program – Qualihab, based on the guidelines defined by ISO 9000 standards, a pioneering programme in Brazil for civil construction, with application to housing construction (CDHU, 2024). Closer to the end of the decade, the federal government would also establish its quality management programme, quite similar to the one in São Paulo, covering public contracts and projects financed by public banks. Launched in 1998, the Brazilian Program on Quality and Productivity of the Habitat (PBQP-H) includes, among other actions, the gradual adoption of quality management systems and their third-party certification. Initially called SiQ (Qualification System for Construction Companies), it became the Conformity Assessment System for Construction Companies (SiAC) on March 2005 (Brasil, 2024). The compulsory nature of the requirements of both Qualihab and PBQP-H for certification of quality systems for contractors and suppliers had a great impact on these two groups of stakeholders, while design and consultancy firms were only partially influenced, with no significant changes in their management.

As a result of the "ISO 9000 wave", the majority of contractors, including even the smaller firms, found themselves compelled to implement and maintain certified quality management systems, which opened up the space for other management systems, mainly those covering occupational health and safety, and

environmental management and social responsibility. However, among architecture, engineering and consultancy firms, which are generally smaller than construction companies, and also have specific organisational structures and cultures, the level of the adoption of quality management systems has been much lower; it has particularly been restricted to large firms and those with an international origin.

Thus, throughout this process of adopting and adapting ISO 9000 by the construction industry, design and consultancy companies were pressured by this wave of quality systems certification, but, given that certification was not mandatory for them, in practice, this wave had two main consequences for them: (1) the understanding of design as a process; and (2) the implementation of ISO 9000 systems in a few design firms, especially the biggest ones, a move that has been quite partial and limited. Salgado (2000) discussed the impact of ISO 9000 standards on design quality, mainly considering quality control and procurement as required management actions. Manso and Mitidieri (2007) found that the certification of quality management systems according to ISO 9000 standards contributed to the valorisation of the design process in Brazil, as it highlighted the fact that this process plays a key role in the final quality of the building and the satisfaction of its users, focusing mainly on collaboration and interface management.

From the point of view of the design professionals, it is necessary to consider that the building design process is associated, by its very nature, with temporary groups of people and organisations, which becomes challenging for each participant, even more so considering that they will participate simultaneously in different design teams (Emmitt, 2014). Universally, the literature has stressed the reduced importance given to design management: “Much research time and effort has been dedicated to improving performance during the construction phase, both in terms of management and construction techniques. This is in marked contrast to the work aimed at improving performance during the design phase. It is necessary to also consider the nature of the work in most of the design firms, where the low remuneration contrasts with the high engagement required” (Austin et al., 1994, p. 445).

Multi-disciplinary design planning has always been a challenging task, mainly because of the inter-dependence among the many design disciplines involved. Since the 1990’s, some authors have proposed innovative methods of improving the efficiency of the design process through the application of advanced planning techniques. Austin et al. (1994) developed an approach using data flow diagrams (DFDs), a type of graphical representation of design activities, based on analysis techniques employed in software system specification. The DFDs are converted into a matrix form and applied to reorder design tasks and minimise iterations by grouping inter-dependent tasks together. Manzione and Melhado (2007) proposed a method

for design planning based on the same principle, aiming to improve time effectiveness and avoid clashes between design disciplines.

In addition to methodological weaknesses being at the origin of the problems discussed so far, it is necessary to note that outsourcing and low-paid employment are remarkable in the building design field, partially explaining the difficulties concerning design quality management. Matthewson (2015) refers to a sense of disillusionment and insecurity in the architectural profession, and the cultural resistance against management, as it is commonly perceived as the enemy of creativity, also identifying heavy and time-demanding workloads associated with project teams which are sometimes severely under-staffed, all along being characterised by lack of management processes, informal work practices and favouritism.

Considering the particularities of the building design culture, Cambiaghi and Melhado (2006) developed a standard framework for quality management systems to be implemented in the Brazilian design offices, with the aim of adapting quality management processes to the characteristics of this type of organisation, as well as making it more affordable to small firms, which do not have many resources. **Figure 26.4** shows the structure of a quality management system created for design and consultancy firms, based on a gradual implementation, which recognises the reality of micro and small firms, and for this reason contains very few elements, aiming to simplify and reduce the costs associated with the system (Cambiaghi; Melhado, 2006). The proposed system has a preparatory phase (Phase 0) that is intended to document existing management processes and establish a strategic plan for the next two phases. Once the preparatory phase has been completed, the design firm moves to Phase 1, in which essential processes, such as the management of information provided by the client, communication, and design documents are the focus. In Phase 2, management processes involving team management, design process management and clients' satisfaction assessment are implemented, ensuring continuous improvement throughout the process.

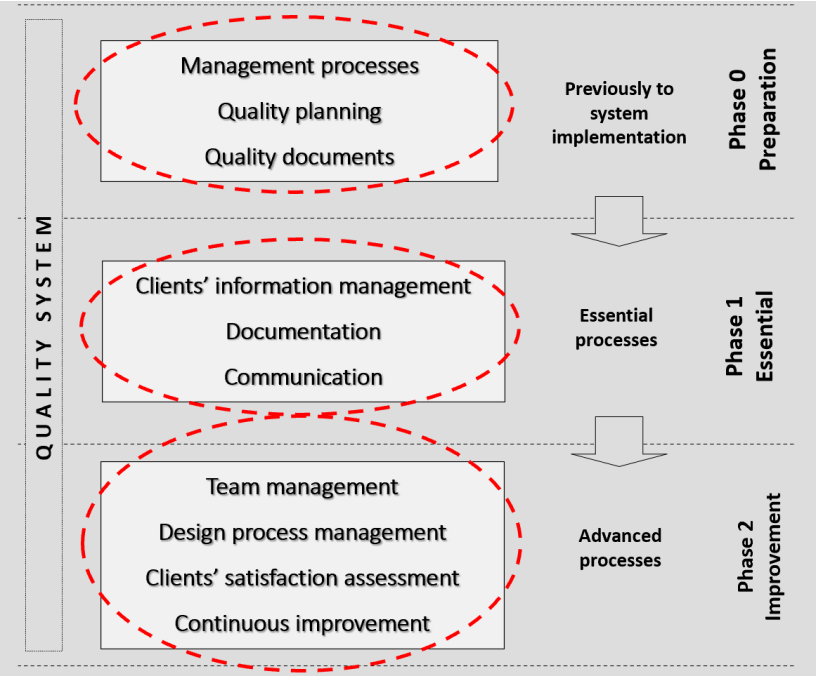


**Figure 26.4 – Quality management system for design and consultancy offices (Cambiaghi and Melhado, 2006)**

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Several research groups in Brazilian universities carried out studies with design firms on the implementation of management systems, both those which were certified and those which were not. Particularly, at the University of São Paulo, there has been around 20 years of research, resulting in contributions that ranged from the proposal of management systems specifically designed for design and consultancy firms in architecture or engineering, to the creation of improvement groups of management practices based on co-operation between researchers and professionals, involving around 40 firms. (Oliveira, 2005; Souza, 2009; De Paula et al., 2013).

Gradually decreasing in importance among design firms, as well as among academic researchers, the "ISO 9000 wave" lost most of its appeal when other significant approaches were launched. As a residual impact, among design and construction actors, the notion of process management remained, despite the lack of references to universally accepted standards that can be successfully applied to the management of design and design firms.

## 3.4 PERFORMANCE STANDARDS AND MANAGEMENT GUIDES

In Europe, Building Performance assumed relevance from the 1950s and, mainly in the 1960s, with the industrialisation of construction to undertake the reconstruction of buildings after the Second World War. In Brazil, the performance of buildings has been discussed since the 1980s and standardisation initiatives date back to the 2000s (Oliveira et al., 2023).

In the 2000s, mixed groups of researchers and practitioners undertook important initiatives for the modernisation of design practices in Brazil, giving rise to a set of national technical standards that establish performance requirements for residential buildings (Okamoto, 2015); and also, professional institutions led the publication of a set of manuals on architectural and engineering design and design management practices, focusing on the design process of real estate projects (Melhado et al., 2006), which were later amended to consider the requirements of the performance standards (Melhado et al., 2015). However, it was only in 2013 that the National Housing Performance Standard (ABNT NBR 15.575) was published, and since then, it has had a huge impact on design methods. Performance standards, being compulsory and constituting a requirement in order for projects to be granted legal approval, have changed design practices in Brazil, since most performance requirements have been required to be verified early in the design stage of housing and residential building projects (Okamoto, 2015).

In the same direction, Osoegawa and Mitidieri (2020) observed the difficulty professionals had in meeting performance standards and aiming to comply with ABNT NBR 15575:2013, and concluded that, after the publication of these standards, systematic design analysis became essential. Guidance for this task is considered necessary to support the design process. Specifically, the design and design management manuals for real estate projects, although they have been very well received in academic and professional circles, have had less widespread and universal adoption, as they are not mandatory, as is the case with performance standards. Being less frequently used as they are not legal in nature, these useful manuals have a structure of phases and activities that strongly assist the implementation of the design process of the various architectural and engineering disciplines, along with the design co-ordination process (Melhado et al., 2006).

Instead, and in parallel, several construction professionals began to show interest in applying methods derived from a project management concept originated by the management guide of the Project Management Institute (PMI). Even if it became popular, the application of the PMBoK Guide needs to consider the special particularities of construction projects (Faraji et al., 2022). Particularly, in Brazil, this project management approach had an initial big impact on design management, which is explained, in

part, by a curious issue of vocabulary, since “project” and “design” are expressed by a single word in Portuguese. Despite the misunderstanding, Ballard; Koskela (1998, p.3) argued that “project management concepts and techniques have proven incapable of solving the difficult problems of design management”. Whether as a response or by mere coincidence, other guides would emerge a few years later which were more appropriate to the context and practices of the sector: the so-called "design services scope guides", focusing on real estate projects. In total, there are 14 scope guides for various design disciplines, from architecture, landscaping, structure, air conditioning, building services, and so on, to design management (Melhado et al., 2006).

In summary, the improved requirements of standards and the availability of design and design management guides helped to transform the methods used for performing design management, thus highlighting the role of design co-ordinators, and introducing specialised consultancy to address such requirements, as well as creating better structured processes of building design.

## 3.5 SUSTAINABILITY AND DESIGN MANAGEMENT

The introduction of sustainability requirements in construction projects has evolved gradually in Brazil, after the diffusion of the principles established by the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, in 1992. Initially little discussed, the sustainability principles of the agenda created in 1992 became a priority topic at conferences on construction around the 2000s.

Based on the conclusions from the Latin American Conference on Sustainable Building, Gomes and Silva (2005) pointed out design guidelines and strategies by both the industry and academic institutions were among the most effective drivers to sustainability improvement. Since then, architectural offices have been particularly affected by the wave of sustainability in building design, and numerous professional guides were published, aiming to better structure the sustainable building design process. The real boost came with the emergence of environmental certification for buildings from 2007, such as Leadership in Energy and Environmental Design (LEED) (American); Haute Qualité Environnementale (HQE) (French); HQE was adapted to develop Brazilian standards AQUA-HQE Certification (AQUA standing for Alta Qualidade Ambiental); British Research Establishment Environmental Assessment Method (BREEAM) (British); and "Selo Casa Azul da Caixa" certifications. Since then, there has been a significant increase in the number of environmental certifications for buildings, rising from just 79 in 2011 to 1,130 projects certified in 2021. Of the total of 1130 environmental certifications issued to Brazilian buildings until July 2021, 62.5 percent were certified with LEED and 31.5 percent were certified with AQUA-HQE (Dias et al., 2023).

A major impact of environmental certification on the building design process was related to the introduction of requirements to be met by technical architectural and engineering solutions, in addition to other environmental requirements established by national standards or local construction regulations. Mainly due to the favourable perception of environmental certification, which is highly valued by clients and construction professionals in general, knowledge on sustainable design became a strategic factor for architects and engineers, and the design process has undergone some evolution, mainly concentrated in the design detailing stage (Gomes et al., 2008; Pegoraro et al., 2010).

Based on a survey carried out with 235 architectural, engineering and construction practitioners, De Paula et al. (2017) explored the link between management and sustainability, concluding that, although many construction players, when they face sustainability requirements, automatically think in terms of technical solutions, sustainability demands have changed processes and management, and most firms recognise that sustainability efforts are related to their strategic positioning. More than a set of requirements, as in Brazil and also abroad, sustainable design is understood as an opportunity to attain competitiveness and professional recognition.

One of the main consequences of the sustainability wave on design management was a clearer definition of the importance of requirements management throughout design development. The inclusion of consultancies specialised in environmental certification, energy efficiency and similar areas as part of the design team has also become quite common.

## 3.6 PREFABRICATED, MODULAR AND OFF-SITE CONSTRUCTION

The search for increasing productivity and reducing the duration of construction projects through industrialisation is far from new, and a direct application of industrial principles of standardised production on a large scale has proven inadequate since the first experiments conducted in post-war Europe. It is difficult to say exactly when the interest in production systems innovation using prefabricated, modular and off-site construction started in Brazil. However, in the 1960s, the approach gained intensity, regarding application in housing and residential construction. An article published by the world-famous architect Oscar Niemeyer in 1962 shows modular construction as an answer to the demand for housing construction, as can be seen in **Figure 26.5**.

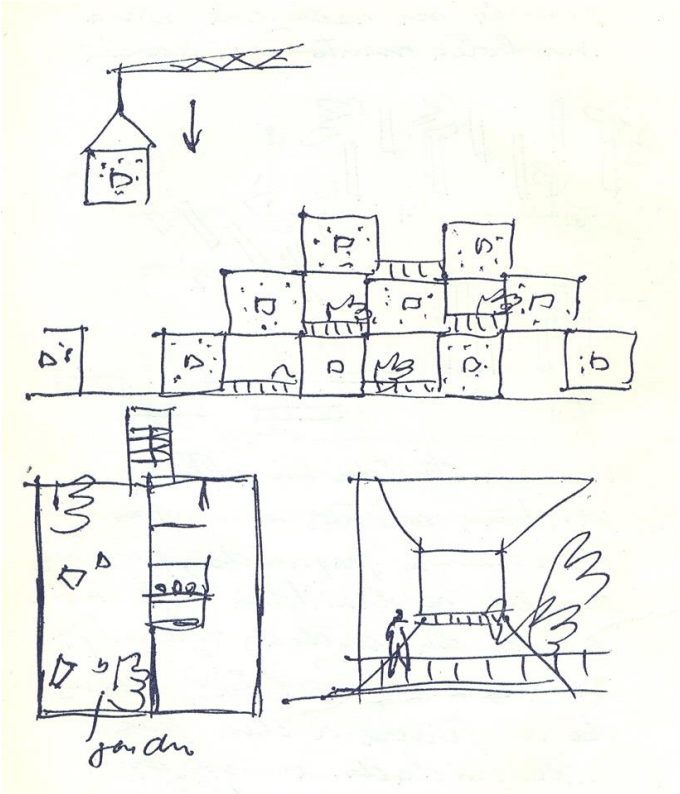

**Figure 26.5 – The concept of industrialised modular construction (Niemeyer, 1962)**

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Some unsuccessful innovative technologies led to a reduction in the number of systems offered, which helped the movement for the institution of national performance standards and the creation of a federal assessment requirement for innovative construction products and systems. An evolution in the field of performance assessment was necessary to prevent insecure and unhealthy housing, consolidating the national system named “National Technical Assessment System for Innovative Products and Conventional Systems” – SiNAT, a system that evaluates innovative products or processes used in construction on which there are no established technical standards (Oliveira et al., 2023).

The prefabrication systems originally proposed remained similar until recently, and the level of adoption was low compared to traditional construction. After some developments and innovative technologies such as 3D concrete printing and after prefabrication was relaunched with the use of digital tools, the topic of modular and off-site prefabrication has been on the agenda of academics and professionals in the construction. As the industry is more labour-intensive in developing countries, prefabricated solutions hold

a limited market share, which is related to industrial construction, fast-track and some other distinguished projects.

Technological innovations need to overcome, among other barriers to their dissemination, gaps in knowledge and technical standardisation. Ferreira (2023) highlighted the importance of developing specific additive manufacturing standards for civil construction, considering the particularities of 3D printing with cementitious materials, defining its mechanical properties, calculation and dimensioning methods, durability requirements, among other factors that limit its adoption.

With regard to the impacts on design management, the adoption of modular construction and off-site prefabrication depend on an innovation strategy in construction project planning, to be defined by clients at a very early design stage. Given that clients generally focus on business viability aspects in a conservative manner, the space for intensive use of industrial construction remains marginal in Brazil, while specific initiatives to increase constructability that depend solely on the action of contractors are more frequent.

## 3.7 THE RISE OF BIM AND DIGITAL TECHNOLOGIES IN CONSTRUCTION

The digital design process has changed since it was finally faced with new possibilities of information exchange and decision-making support provided by an evolution of digital tools from simply drawing support to the information-oriented representation of building components. Starting around the end of the 2000s in Brazil, the wave of adoption of Building Information Modelling (BIM) gave rise to multiple research groups and also to numerous public and private institutions dedicated to its implementation in Brazil. As understood by several authors, BIM can be defined as “a process focused on the development, use, and transfer of a digital information model of a building project to improve the design, construction, and operations of a project or portfolio of facilities” (Messner et al., 2020 p.8).

Strongly associated with BIM, the idea of “designing as building virtually” is not necessarily a product of the digital age in the construction industry. Originally conceived as “designing as building on a sheet of paper”, the concept has been widely disseminated for decades in the field of architecture, engineering and construction. Integration of 3D + 4D + 5D, and so on, becomes easier when applied with digital tools, but it still depends on professional experience and knowledge.

Academic research on BIM has grown exponentially in Brazil since the early 2010s, and BIM has been the subject of numerous publications and the theme of several scientific conferences. Manzione (2013), the first doctoral thesis on the implementation of BIM methodology in project development in Brazil, proposed

a conceptual framework for its use and discussed how to assess the level of information effectively inserted in building models. Souza et al. (2013), based on proceedings from focus groups, proposed a guide for design process management with the aim of defining and organising the responsibilities of the design co-ordinator in the context of design processes using BIM. In this guide, the tasks provided for are structured to plan, organise and control the flow of information resulting from design activities, considering the case of real estate and construction projects in Brazil. Product management, design process management, collaboration management, and information modelling support were the four main groups of design coordination activities proposed in this guide (see Souza (2016)). Fantin and Braida (2021) analysed a sample of 47 scientific articles published at conferences in Brazil, classifying them by themes ranging from "education" to "regulation", including the application of BIM in various design disciplines. They concluded that there is a notable relevance and connection of research involving BIM in the discussion of the quality of the built environment. Arrotéia (2022) qualitatively analysed a sample of 119 international papers from 2000 to 2020, considered the most cited ones among 1,378 articles found, and the analysis showed that 79 percent of the articles were on technology-focused issues; while 42 percent of the research was about process-focused issues; and only 11 percent were people-focused. In the study, 61 percent of the articles focused on 3D applications of BIM.

Similar to what happened abroad, government procurement policies concerning the use of BIM, at the federal and state levels, were released in Brazil, mainly in 2017. The so called “BIM BR Strategy”, meaning the Brazilian official strategy for BIM implementation requires progressive adoption of BIM in public projects, with 2028 as its completion date (Salgado et al., 2020).

As part of the foreseen results of BIM implementation, improvement in design quality and information flow along the building lifecycle stages, as well as more effective design co-ordination, are expected, but this is not at all guaranteed. Similar to what is possible to empirically observe in Brazil, Mehrbod et al. (2019) developed a case study in Canada observing design co-ordination meetings throughout design and construction stages, as a result of a two-year ethnographic field study of the design co-ordination process, and concluded that BIM modelling was often inaccurate, and practitioners preferred 2D over 3D representations the majority of the time. Despite the positive expectations, in Brazil as well as in several other countries, quite often, barriers to the full implementation of BIM have been identified and many of the desired results may depend on other elements. Poor definition of processes and scope, as well as inadequate contractual modalities can have a profound impact on cooperation, collaboration and integration between the actors involved. The heterogeneity in technological maturity and the

unavailability of information, with quality and at the right time, also restrict the potential for results. (Arrotéia et al., 2021; Jasiński, 2021; Godager et al., 2022; Zima and Mitera-Kielbasa, 2022).

A promising path towards the desired integration of the phases of a construction project, particularly favouring multi-disciplinary collaboration and integration between conception, design detailing and execution of works, is the adoption of innovative contracting models, such as Integrated Project Delivery (IPD). Caiado and Salgado (2006) analysed the influence of contracting methods on the quality of design and construction, showing how they can lead to non-collaborative relations. Okamoto et al. (2014) demonstrated that project performance and the strategic advantages potentially provided by design co-ordination can be compromised by the way design contracts are formulated and managed, and Abaurre (2014), trying to find an alternative path for that, was one of the first authors to research the potential of introducing IPD in Brazilian projects. However, since then, there has been no significant progress in the direction of implementing collaborative contracts. Without significant changes in hiring and remuneration practices for design services, combined with heterogeneous levels of technological maturity, digital innovation faces difficulties in achieving its potential for integration and collaboration. The individual evolution achieved by some stakeholders is not reflected in the desired organisational evolution for the construction project cycle throughout its phases, leaving significant gaps from the design of the asset to its management in operation.

## 4. SOME LESSONS FOR THE DEVELOPING COUNTRIES IN GENERAL

In the late 1990s, Melhado (1998) stated that the quality of building design in Brazil was a component of competitiveness in building construction that needed to be better understood and explored. Among the actions to improve quality, the following stood out at the time: qualification of designers, development of design methodology, design coordination, post-delivery feedback on design results, and implementation of design for production – the latter requiring the standardisation of service execution and control procedures. After the introduction of BIM, in practice, several principles proposed to be adopted in design management became obscured by the wave of implementation of digital modelling technologies, leading professional practices to a “memoryless” transition, and academic researchers to focus mainly on the study of the application of software and systems associated with information modelling. It is increasingly clear that digital technologies, despite their potential to foster collaboration and integration, cannot have the mission of transforming business strategies and professional cultures that have persisted in the construction industry for many decades.

Summing up, the arrival of BIM technology and concepts associated with its implementation, although much celebrated, contributed to some setbacks in the ways in which construction projects are developed and managed. While the integration of information throughout the life cycle is highlighted with the implementation of BIM, there has been little discussion of the socio-technical aspects involved in the processes of clients, designers, project managers, and contractors. The underutilisation of available technological resources is evident, and several authors have researched the barriers that are restricting the potential positive results of the new digital technologies. "BIM wash" situations are often mentioned as a symptom of a mismatch between expectations and reality.

It is quite common that international experience coming from lead countries arise as reference to the local and less evolved architectural, engineering and construction industries. However, experiences from overseas are never directly transposable, and some factors distinguish the developing countries from the developed ones, thus affecting how strategically planning action programmes, either at firm level or institutional level, can create more effective policies. Melhado et al. (2011) presented a comparative analysis between the Brazilian and the European contexts, adopting as main influencing factors to be considered:

- Building regulations and standards;
- Design handbooks and guides as a reference for design management;
- Attributions and obligations of designers (architects, engineers and others);
- Integration of design and construction;
- Labour costs and workers' education; and
- Continuous education and training for designers and managers.

These authors concluded that the more recent standardisation, reduced education and training, and weak professional bodies, associated with cheap human labour as well as the impact of local culture, laws and regulations, limit the potential for innovation in design and design management processes. Moreover, the consolidation of learned lessons, an essential principle of management is also an important weak point in developing countries. Medeiros (2013) researched about knowledge management in Brazilian construction companies, concluding that knowledge management systems can be a source of feedback to avoid repeating errors, minimising problems such as inefficient processes, incompatibility between design disciplines or lack of design information, late design reviews and modifications, design deficiencies that generate rework and waste in the execution of works, as well as poor building quality; however, case studies carried out by this author identified several problems and deficiencies in the design process,

common to the companies studied, which could be minimized with an efficient knowledge management system.

## 5. PROPOSAL OF A RESEARCH AGENDA

### 5.1 GENERAL PRINCIPLES

The waves that have impacted the architectural, engineering and construction industries, inspired by the manufacturing industry, have progressively led to the implementation of concepts and methods that promise to increase quality and productivity, while, at the same time, reducing all kinds of waste. Sustainability and performance standards added requirements to be assessed all along the construction life cycle. Ultimately, the adoption of BIM seems to connect all these waves within a digital environment. However, in developing countries, conditioned by practices involving low labour costs and less rigid standards, would that connection be more formal than really effective? Perhaps there are some missing connections to reach a higher level of digital maturity.

Bringing out here the definition from Kane et al. (2019), digital maturity can be defined as the alignment of an organisation's people, culture, structure and activities to compete effectively by leveraging the opportunities enabled by technology, both inside and outside the organisation. Hence, a research agenda which can help move the design management field forward cannot be based only on technological innovation. As discussed in the previous sections, the implementation of technology, by itself, is not capable of promoting remarkable changes, being equally dependent on the evolution of processes evolution. Moreover, processes are still dependent on competencies and engagement of people. Above all, the contractual models matter, and management functions must be better defined and performed. **Figure 26.6** shows the four approaches adopted to develop priority themes of research, in the building design management field.

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Insert Figure 26.6 here

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Construction is different from the manufacturing industry in terms of production scale, product life cycle, and other factors. As they relate to a fragmented sector, architectural, engineering and construction projects do not encourage integrated solutions in principle, but changes in contracts and business models – with the evolution of client management processes, new division of responsibilities, and increased

collaboration, especially in the case of public contractors – can have significant impacts and favour innovation.

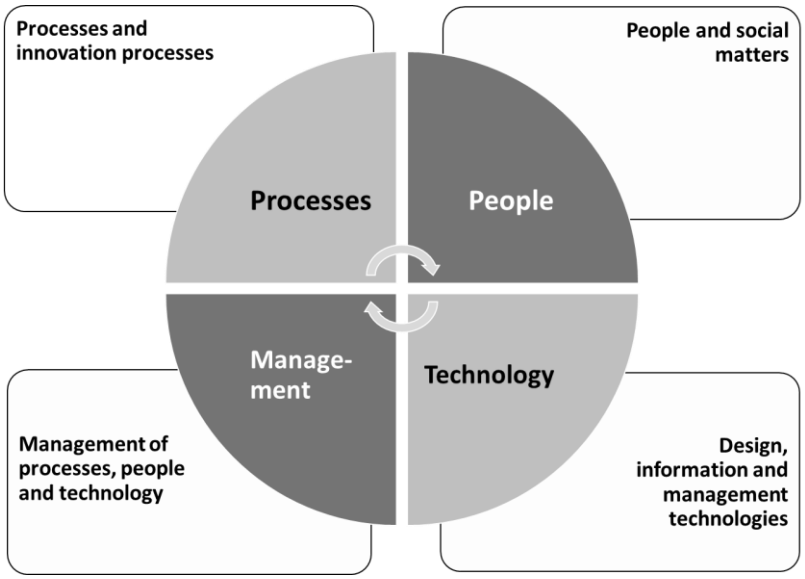


**Figure 26.6 – The four approaches in design management: people, processes, management, and technology**

According to ISO 56.000, "the innovation capabilities of an organization include the ability to understand and respond to changing conditions of its context, to pursue new opportunities and to leverage the knowledge and creativity of people within the organization in collaboration with external interested parties" (ISO, 2020). In innovation processes, the strategies adopted must consider a socio-technical approach based on the real starting context. Ethnographic approaches, as presented by Oswald and Dainty (2020) can be helpful in the quest to identify in depth, the most important aspects of ineffective management practices. The contrast between global and local is also a affecting parameter that should encourage the development and application of more customised management, instead of using generic frameworks.

## 5.2 A TENTATIVE RESEARCH AGENDA

This section presents themes which can be priorities for research and development in developing countries. Research on building design management is divided into these complementary approaches: people, processes, management and technology, as previously presented. The research themes are mainly related to sectoral demands and joint initiatives of academia, industry and government, seeking to

promote structural change and evolution. It goes without saying that combinations between approaches and themes should be considered, and can be quite effective, depending on the context of each country.

### 5.2.1 Research themes related to People

People are the most essential part of the needed improvement of design management practices. In developing countries, there are weaknesses involving the profiles of design managers and co-ordinators, whose qualifications and experience, recognition and valorisation should be improved in order to create conditions for significant improvements in the performance of design teams, as well as in the appropriate implementation of the necessary software and systems.

In all cases, in accordance with local issues and context, make stronger professional bodies would be also helpful to support the further education of design managers and co-ordinators, and also ensure their relevance in the situations of decision-making along all the stages of building projects.

Alongside standard references and with support from professional bodies, the continuous education effort can accelerate the evolution of practices. A comprehensive and universal education programme, resulting from official initiatives, would be preferable to punctuated and heterogeneous short courses, and the academic support can make the difference. It is important to note that the best education components would be more effective if the real demands of professional practice are considered, helping to make learning closer to application.

Moreover, a real evolution of managerial skills, no matter the sector being considered, needs gender equitable access to job positions and opportunities, in contrast with the “male management prevailing tradition” of most construction industries in developing countries.

### 5.2.2 Research themes related to Processes

In building projects, the involvement of multiple stakeholders means that multiple processes also come onto the scene. It is not possible to achieve process integration without common references. In this sense, regulation, standards and guides for building design management can play a relevant and powerful role to assure more productive management.

The reasoning above applies also to design planning techniques, a traditional weak point in building design management, where old and inadequate planning methods are generally used. An evolution regarding this topic can clearly be associated with innovative contracting models (see the discussion of these above).

Knowledge is often lost, and lessons learned are not shared, showing a great opportunity of developing processes for improving the understanding of the topic in order to accelerate evolution of practices. In this sense, a recommended strategy is national-level action, in preference to company-level initiatives.

Concerning the conceptual “waves” presented in this chapter, an integration of innovation management, lean construction, concurrent design and BIM would constitute a highly important research subject. Even if the concepts are the same at their origins, owing to the natural dependence of their successful application on the application context, each country can potentially find its own model.

### 5.2.3 Research themes related to Management

Management is limited by the environment of scope, responsibility and remuneration of specialised works that are, in general, fragmented and undertaken under multiple contracts. That is why innovative contracting models, focusing on collaborative and integrated teamwork, can improve project results, giving place to the best practices of integrated, multi-disciplinary teamwork.

The consolidation of building design management justifies the creation of its own “body of knowledge”, but a local “accent” is crucial to achieve success in the real conditions of application. This kind of guidance must be built in accordance with building culture, regulations, and standards, thus, it would be potentially different from one country to another, avoiding the adoption of internationally accepted but non-effective patterns.

As has been highlighted by researchers and professionals for many decades, it is during early design stages that better decisions can be made. An improved framework of management focusing on the most upstream design decisions is still a challenging but highly important subject.

### 5.2.4 Research themes related to Technology

Thinking about innovative digital technologies from the perspective of design management, in developing countries, solutions drawn from developed countries face barriers to their effectiveness, such as high cost of software and systems licences, low adaptability to local practice and conditions, and a need for effort to learn them. An opportunity comes from this portrayal, which involves the development of more affordable and local-oriented software and systems for design development and management.

An emergent and fast-growing technology, artificial intelligence applications to improve design management constitute another field of research that deserves attention, especially in the context of the architectural, engineering and construction industries of developing countries, considering their complexity factors.

Summarising the four approaches, **Table 26.1** presents the research themes of the proposed agenda, together with a preliminary suggestion of research methods.

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**Table 26.1 – Research agenda on building design management**

| Research approach | Research theme | Aim and description | Possible research methods |
|---|---|---|---|
| **People** | *Design management and coordination reference profiles* | Define reference profiles according to local issues and practices, aiming to establish conceptual support for continuous education | Local survey involving professionals, case studies of best practices |
| | *Development of professional bodies* | Whatever is necessary, make stronger leadership of national bodies of architects and engineers, aiming to support innovation | International benchmarking, local focus groups |
| | *Continuous education systems* | Associated with a knowledge system, create or re-create a framework of shared and affordable education systems focused on innovation | Local survey involving professionals about career and education demands, international benchmarking |
| | *Gender equitable access to managerial positions* | Evaluate extent and effects of discrimination practices, aiming to propose measures to achieve gender equity | Local survey involving professionals, case studies, local focus groups |
| **Processes** | *Regulation, standards and guides for building design management* | Considering digital technologies, review or creation of a novel and coherent set of regulations, standards and guides | Local focus groups involving reference specialists and professional associations representatives |
| | *Design planning techniques* | Improvement of design planning techniques for concurrent, multidisciplinary collaborative design, considering all stakeholders needs | International case studies, local research-action involving innovative projects |
| | *Development of National knowledge and learning systems* | Create systems to improve the capability of organise and share knowledge, and give conditions to continuous learning, as a common value of the local AECO sector | International focus groups, local research-action involving official institutions and professional bodies |
| | *Integration innovation-lean-concurrent design-BIM* | Aiming to align those concepts and simulate its joint application in building projects, develop a management framework | International case studies, virtual simulation, local focus groups |

| | | | |
|---|---|---|---|
| **Management** | *Innovative contractual models* | Develop new models of project delivering, focusing on local issues and context, aiming to stimulate and recognise integrated collaborative teamwork | Global survey involving project and design managers, international focus groups, local research-action |
| | *Design management "body of knowledge"* | Create a guide of building design management specifically oriented to developing countries | International case studies, international focus groups, local diffusion and continuous adaptation |
| | *Improved management of early design stages* | Aiming to improve the potential of innovation and knowledge use since early design, create a reference method | International focus groups, local research-action projects |
| **Technology** | *Affordable and local-oriented software and systems* | The objective of the research is the improvement of affordability and adaptation of software and systems, considering the main local construction aspects | Local survey involving designers and design managers, virtual simulation, local focus groups |
| | *Artificial intelligence and design management* | The priority aim for research development involving A.I. is the creation of innovative organizational frameworks to improve decision-making, locally oriented | Virtual simulation, international focus groups, and local action-research projects |

## 6. CONCLUDING REMARKS

As affirmed by Emmitt (2010, p.33), and is still true, "the construction design managers wanted better recognition for, and understanding of, their role and there is a need for more educational and training programmes in construction design management". The context of the developing countries seems to confirm Emmitt's findings, as the relevance of "in office" roles are underestimated compared to "on construction site" ones. It is also necessary to consider that some architects and engineers resist being managed, retaining a reactive attitude when they encounter management systems.

Throughout the waves presented in this article, there was notable progress in Brazil with respect to the understanding of the positioning of design processes regarding the evolutions in certifications and standards, and the implementation of technologies, but without consolidation of design management being achieved. The gap between accumulated knowledge and its integration into professional practices is apparently more intense in developing countries than in developed ones. In Brazil, in professional

practice, even if the need for management in the design process is recognised, the design manager's role continued to be undefined and underestimated.

As recommended by several design management approaches and methods above mentioned, **early involvement** is crucial to achieving the best possible design results and is clearly more about procurement than technology issues. For this reason, the secondary importance given to design planning and the responsibility of clients should be questioned far more than that of design managers. When digital technologies are implemented, it seems evident that design process improvement should take priority. However, in reality, this is not the case. In developing countries such as Brazil, further research could put emphasis on downstream approaches to ensure a more realistic academic contribution, including design management guides and standards specifically conceived considering their culture and practices, thus respecting their naturally specific context.

Finally, it is important to highlight some limitations concerning this chapter. The analysis presented throughout the chapter considers only formal settlements and official standards; thus, it relates to about 50 percent of the construction activities in developing countries. It also contains a great deal of the present author's personal views embedded in the discussion of the issues considered, which could be different from what another specialist would present. Finally, the selection of Brazil as the case study is largely influenced by the author's 30 years of personal research experience. Nevertheless, although biased, a research agenda that goes beyond those proposed by others writing on developed countries is timely and necessary, and every initiative that favours a critical view of the directions to follow should be considered.

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