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# Digital transformation in Portuguese architecture studios: Insights from the field

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**Abstract.** The integration of digital tools in architecture is revolutionizing the field, affecting design processes, construction precision, and project management. This study explores the digital transformation of Portuguese architecture studios, focusing on the adoption and impact of digital tools such as Building Information Modeling (BIM) and digital fabrication. Through qualitative analysis of interviews with nine architectural practices, the research identifies key motivations, strategies, and outcomes associated with digital integration. The findings highlight significant benefits, including enhanced project coordination, precision, and efficiency, alongside persistent challenges like high costs, resistance to change, and regulatory barriers. The study underscores the strategic importance of digital tools in advancing architectural practice and calls for supportive policies, educational reforms, and industry collaboration to overcome adoption hurdles. By addressing these challenges, Portuguese studios can fully leverage digital technologies to foster innovation, improve project outcomes, and contribute to the evolution of architectural practices.

**Keywords:** Digital Tools, BIM, Digital Fabrication, Architectural Practice, Portugal

# 1 Introduction

The architecture industry is undergoing a significant transformation with the increasing integration of digital tools and technologies. This shift is reshaping traditional design processes, enhancing construction precision, and improving project management efficiency. The digital transformation in architecture is driven by the advent of advanced software applications, Building Information Modeling (BIM), and digital fabrication technologies, which collectively contribute to more efficient and innovative architectural practices (Carpo, 2023; Burry, 2020).

In the context of Portuguese architecture studios, the adoption of digital tools has been gradual yet impactful. Historically, the architectural landscape in Portugal has been characterized by traditional methodologies, with a focus on manual drafting and physical model-making. However, the global trend towards digitalization has compelled Portuguese architects to embrace new technologies to stay competitive and meet the evolving demands of clients and the industry. This transition is not without its challenges, including high implementation costs, the need for specialized training, and resistance to change within the architecture work processes.

Digital tools in architecture offer numerous advantages that enhance the overall quality and efficiency of projects. BIM, for instance, facilitates the creation of detailed and accurate 3D models that integrate various aspects of a project, including architecture, engineering, and construction. This integration allows for better coordination among different stakeholders, reducing errors and ensuring that all components of a project are aligned. Digital fabrication, on the other hand, enables the precise creation of complex structures and components, which would be difficult or impossible to achieve using traditional methods. These technologies not only streamline the design and construction processes but also open up new possibilities for architectural innovation and creativity (Oxman & Oxman, 2014).

Despite the clear benefits, the adoption of digital tools in Portuguese architecture studios faces several barriers. High initial costs for software and equipment, ongoing maintenance expenses, and the need for continuous training are significant financial obstacles. Additionally, there is often resistance to change among architects and other stakeholders who are accustomed to traditional methods. This resistance can originate from a lack of familiarity with digital tools, concerns about the learning curve, and uncertainty about the return on investment. Moreover, local policies and regulations can also pose challenges, as they may not be fully aligned with the capabilities and requirements of digital technologies.

To understand the current state of digital transition in Portuguese architecture, this study focuses on a qualitative analysis through interviews with architects from nine different practices. These interviews provide insights into the motivations behind adopting digital tools, the strategies employed to integrate these technologies, and the outcomes achieved. By examining the

experiences of these studios, the research aims to identify both the benefits and challenges associated with digital transformation in architectural practice.

The main objective of this research is to clarify the process-oriented and organizational changes brought by digital technologies. It seeks to provide valuable insights for architects, educators, and policymakers to develop strategies that can leverage the full potential of digital technologies within the Portuguese architectural context. By highlighting case studies and identifying common challenges, the study aims to contribute to the advancement of architectural discourse and practice in Portugal.

Ultimately, this research highlights the strategic importance of digital tools in shaping the future of architecture. It argues for the necessity of supportive policies, educational reforms, and industry-wide collaboration to overcome existing barriers and fully realize the transformative potential of digital technologies. By addressing these challenges, Portuguese architecture studios can enhance their practices, foster innovation, and improve the sustainability and efficiency of the built environment (Menges & Ahlquist, 2011; Brozovsky et al., 2024; RIBA Journal, 2024).

## 2 Methodology

This study applies a qualitative research methodology to explore the digital transformation of Portuguese architecture studios. The data collection method is semi-structured interviews with architects from nine different practices, each representing various stages of digital tool adoption. This approach allows for an in-depth understanding of the motivations, strategies, and outcomes associated with integrating digital technologies such as BIM, digital fabrication, and advanced software applications into architectural design and construction.

### 2.1 Participant Selection

The selection of participants was based on purposive sampling to ensure a diverse representation of architectural practices in Portugal. The studios selected vary in size, focus, and extent of digital tool adoption. This diversity enables a comprehensive analysis of how different types of studios are navigating the digital transformation. The participants include founders, partners, and senior architects who are directly involved in the decision-making processes regarding the adoption of digital tools.

### 2.2 Data Collection

Semi-structured interviews were conducted to gather insights from the participants. This format allows for flexibility in exploring deeper into specific areas of interest while maintaining a consistent structure across interviews.

The interview questions were organized to cover several key themes:

**Motivations for Adopting Digital Tools:** Exploring the initial catalysts and ongoing reasons for integrating digital technologies.

**Implementation Strategies:** Investigating the approaches and methods used by studios to incorporate digital tools into their workflows.

**Challenges and Barriers:** Identifying the obstacles faced during the adoption process, including financial, technical, and cultural barriers.

**Outcomes and Benefits:** Understanding the benefits realized from the use of digital tools.

**Future Perspectives:** Gaining insights into how studios foresee the evolution of digital technologies in their practice.

Interviews were conducted via Zoom and in person, recorded with consent, and transcribed for analysis. Each interview lasted between 60 to 90 minutes, allowing for comprehensive coverage of the topics.

### 2.3 Ethical Considerations

The research followed ethical guidelines, ensuring informed consent, confidentiality, and the right to withdraw from the study at any time. Participants were provided with detailed information about the study's purpose, and procedures before consenting to participate.

## 3 Results

The findings reveal a trend towards increased use of digital tools driven by the need for efficiency, precision, and innovation. Key benefits include enhanced collaboration, the ability to manage complex designs, and improved project management. However, significant barriers such as high technology costs, the need for ongoing training, and initial resistance to change persist.

### 3.1 Case Study Summaries

The following case studies collectively illustrate the diverse ways in which Portuguese architecture studios are embracing digital transition. The adoption of digital tools like BIM and digital fabrication is driving significant improvements in project coordination, precision, and efficiency, despite ongoing challenges. The experiences of these studios provide valuable insights into the potential of digital technologies to revolutionize architectural practice in Portugal.

**SUMMARY**, has integrated digital tools and modularity as core components of its practice. The studio initially focused on modular and prefabricated designs, using reinforced concrete panels and metal prefabrication. A recent transition to more advanced digital tools, particularly for working with metal structures, has intensified SUMMARY's digital adoption. This shift has

significantly improved project coordination and execution quality, enabling the studio to manage more complex designs with greater precision and efficiency.

**SPACEWORKERS** studio began incorporating digital tools in 2007 to explore new design possibilities and enhance project precision. BIM and 3D printing have been particularly crucial in managing complex projects, allowing for precise coordination among various disciplines. These technologies enable the studio to visualize and test ideas more concretely, ensuring that the final execution aligns closely with the original vision. Projects like a residential building with intricate forms highlight the importance of digital tools in achieving detailed and accurate project outcomes.

**KONCEPTNESS** adopted BIM to remain competitive, especially in international markets like Canada. The firm's focus on urban design and planning required a sophisticated approach to project management and coordination. BIM played a crucial role in the successful completion of several projects. The use of BIM allows for efficient coordination among various suppliers and disciplines, demonstrating the technology's efficiency and capability to manage complex projects in real-time, facilitating better integration and reducing errors.

**REBELO DE ANDRADE** highlights the studio's long-standing use of digital tools. The office, which balances diverse interests and respects the landscape, has seen significant benefits from digital adoption. The Náutico project exemplifies how digital tools can enhance precision and efficiency. The project's success was marked by minimal variance in contractor bids, attributed to the detailed and accurate digital modeling. This precision facilitated better project management, ensuring clear communication and understanding among all stakeholders. The studio's history of using digital tools like Rhino and BIM emphasizes their commitment to innovative and efficient architectural practices.

**TEKSTUDIO** has integrated digital tools into their practice since the beginning. BIM has enabled TEKSTUDIO to push the boundaries of architectural design, allowing for the creation of detailed project coordination. The studio's adoption of digital tools has led to significant improvements mostly in project efficiency and execution quality.

**SARAIVA + ASSOCIADOS**, another prominent architectural firm, has leveraged digital tools to enhance its design and construction processes. The studio's use of BIM has facilitated better project coordination, enabling more efficient management of large-scale projects. S+A's commitment to digital adoption has resulted in improved precision and reduced errors, ensuring higher quality outcomes for their projects. The studio continues to explore new digital technologies to stay at the forefront of architectural innovation.

**CVDB ARQUITECTOS**, is in the process of integrating new digital tools into their practice. The studio's recent adoption of BIM has allowed for precise and efficient project execution. CVDB's focus on sustainable and efficient design solutions is supported by its interest in adoption of advanced digital tools, which facilitate better project coordination and management.

**ATELIER PENINSULAR**, led by a team of experienced architects, has embraced digital tools to enhance its architectural practice. The studio's focus on creating functional and aesthetically pleasing designs is supported by the use of BIM and digital fabrication. These tools have enabled Atelier Peninsular to improve project precision and efficiency, ensuring high-quality outcomes. The studio's ongoing commitment to digital adoption reflects its dedication to innovation and exploration in architecture.

**18_25 ARQUITECTOS**, a dynamic and forward-thinking architectural firm, has integrated digital tools extensively into its workflow. The studio's use of advanced software applications has facilitated better project coordination and results. 18_25 Arquitectos' focus on construction of architectural images is enhanced by its adoption of digital tools, which allow for precise and efficient project management. The studio's commitment to digital innovation ensures that it remains at the cutting edge of architectural practice.

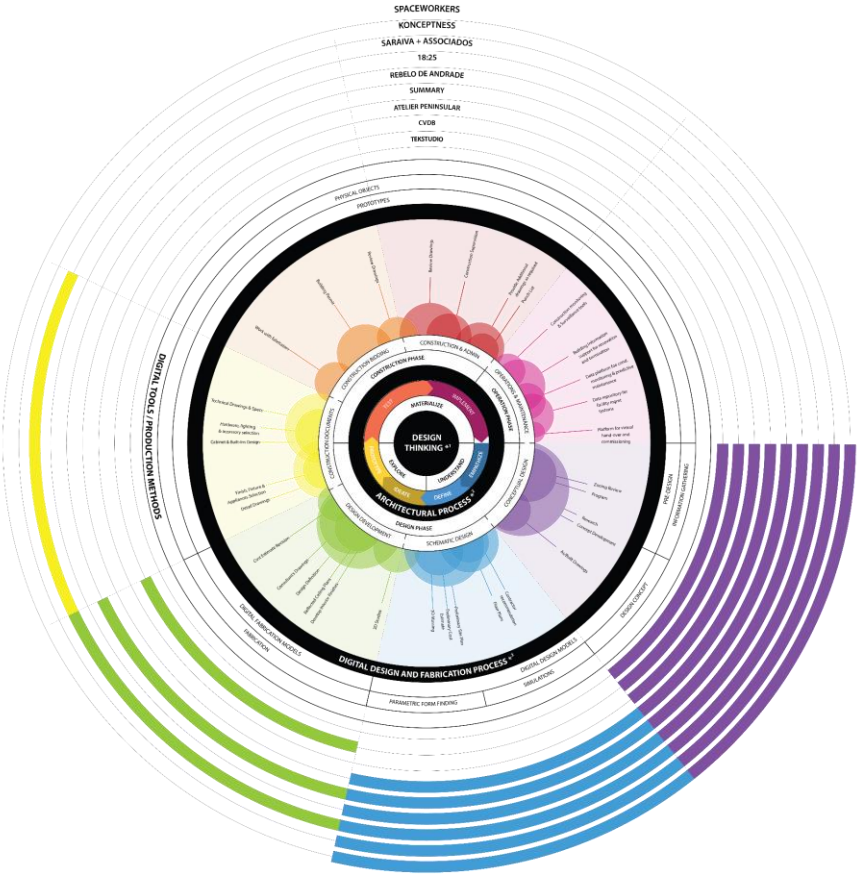


**Figure 1.** Taxonomy showing advantages and challenges faced by different architectural firms in Portugal when integrating digital tools into their practices**.**

Based on the framework previously developed in the research, composed of three levels: Multidisciplinary Methodology (Design Thinking Process proposed by the Nielsen Norman Group, consisting of 3 phases and 6 sub-phases (Gibbons, 2016)), Architectural Practice (Architectural Design Process Workflow, proposed by HMH Modern Architecture (hmh, 2022)), and Digital Tools (Digital Design and Fabrication Process, proposed by Perkins + Will (Hensel, 2016)).

The innermost circle represents "Design Thinking," which is at the core of the entire architectural and digital fabrication process, emphasizing iterative development, empathy with users, and a collaborative approach to problem-solving. Surrounding this, the architectural process is outlined, detailing key phases such as master planning, concept design, schematic design, design

development, construction documents, and construction and build. Each phase represents a crucial step in the traditional architectural workflow. Further out, the digital design and fabrication process is illustrated, showing specific tasks and considerations for each phase of the architectural process.

This structure allows us to position each studio according to the phase of the project in which digital tools are implemented, resulting in a diagram where we can perceive that the adoption of digital tools by the selected studios is more prominent in the early stages of project conception (Figure 1).

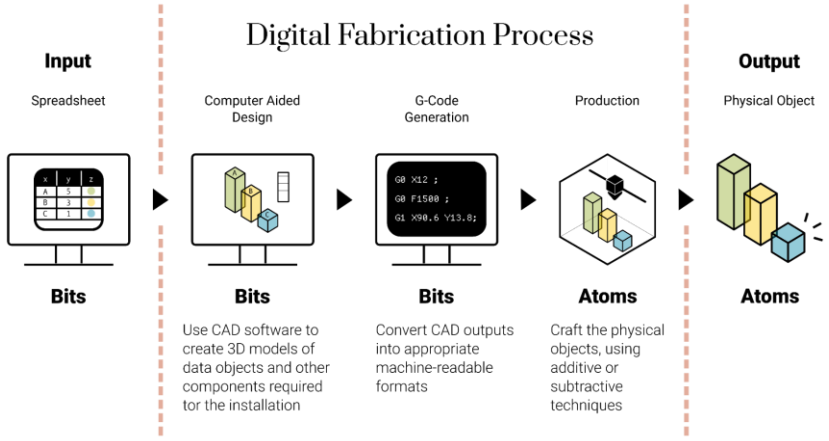


**Figure 2.** Exemplificatory abstraction of the main steps of a typical data driven BIM based digital fabrication process. Source: http://www.batjo.eu/digital-fabrication/, 2024**.**

The first component of a typical digital fabrication workflow is to transform sketches and drawings into a digital, mathematical, 3D model of all the components that need to be produced for the final output. This phase includes tasks such as binding data points and spreadsheets to visual elements like lines, curves, lengths, and widths of the physical object that will go into production.

Once the 3D modeling phase is complete, it needs to be converted into a file with machine-readable instructions, so that manufacturing machines can accurately and reliably craft the designed objects (G-Code generation). The G-Code file is then imported into the machines.

Considering the main phases of the digital fabrication process, and based on the insights of the interviews, we can position the studios within these stages (Figure 2). From the nine studios interviewed, only three currently use digital tools for the production of physical models, meaning they incorporate digital fabrication tools in the project design process. The remaining six studios adopt

digital tools solely for the production of virtual models, specifically using BIM tools.

## 4 Discussion

The integration of digital tools in Portuguese architecture studios represents a significant shift in the design and construction paradigms. This study, through interviews with nine diverse practices, highlights the transformative potential of digital technologies like BIM and digital fabrication. The findings indicate both the immense benefits and persistent challenges associated with this digital transition.

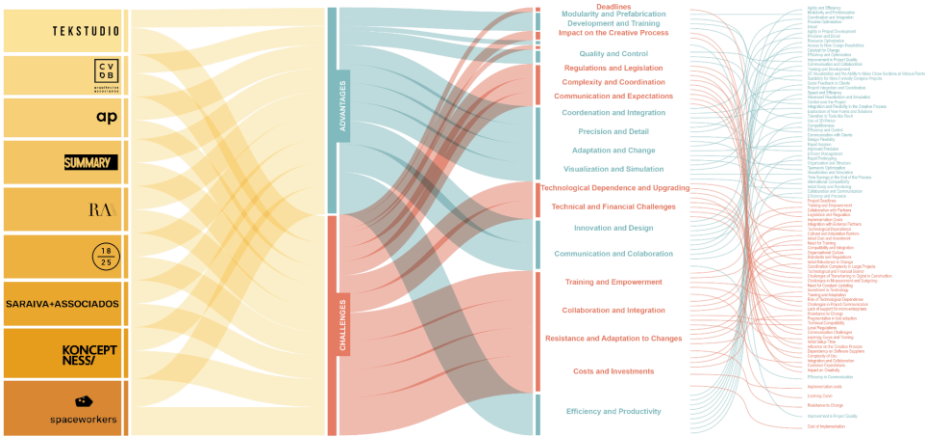


**Figure 3.** Taxonomy showing advantages and challenges faced by different architectural firms in Portugal when integrating digital tools into their practices**.**

Based on the conducted interviews with nine Portuguese architectural studios, we have produced a diagram that provides a visual representation of the data collected regarding the challenges and advantages they experienced with the adoption of digital tools (Figure 3).

The left column lists the participating architectural firms, the second section is divided into two main categories: advantages (represented by blue paths) and challenges (represented by red paths). The right column enumerates specific factors associated with each category, detailing particular issues or benefits. For example, advantages include improved project quality, precision in detail, enhanced coordination, and better visualization and simulation, while challenges include high costs, training needs, regulatory barriers, and complexity in coordination.

The colored paths illustrate the connections from the companies to the specific categories and factors. Blue paths denote the advantages identified by

each firm, while red paths denote the challenges identified by each firm. This diagram effectively highlights the distribution of advantages and challenges encountered by different architectural firms in integrating digital tools into their practices.

The interviews reveal a significant trend towards digital adoption, driven by the need for efficiency, innovation, and competitiveness. However, we face significant challenges that are essential to overcome in order to fully leverage the potential of digital technologies in architecture.

### 4.1 Benefits of Digital Adoption

The primary benefits of adopting digital tools in architectural practice are evident across all interviewed studios. Enhanced precision and efficiency stand out as major advantages. Digital tools allow for the creation of highly detailed and accurate 3D models, which integrate various project aspects such as architecture, engineering, and construction. This integration facilitates better coordination among stakeholders, reducing errors and ensuring alignment across all project components.

For example, the precise coordination in the Náutico project by Rebelo de Andrade was made possible through advanced digital modeling, which ensured minimal variance in contractor bids. Similarly, the use of BIM in several projects by Konceptness enabled efficient management and real-time collaboration among international teams, demonstrating the technology's capability to handle complex, multidisciplinary projects.

Digital tools also support innovation and creativity in architectural design. Studios like Spaceworkers leverage these technologies to explore new design possibilities and create complex structures that would be challenging to achieve using traditional methods. The ability to visualize and test ideas more concretely through 3D printing and digital fabrication tools allows these studios to push the boundaries of architectural design.

### 4.2 Challenges and Barriers

Despite the clear benefits, several challenges interfere with the full adoption of digital tools in Portuguese architecture. High initial costs for software, hardware, and training are significant financial barriers. The continuous need for updates and maintenance adds to these expenses, making it difficult for smaller studios to invest in such technologies. For instance, Konceptness faced substantial costs when implementing BIM, including new servers, computers, and software renewals.

Resistance to change is another major barrier. This resistance is often rooted in a lack of familiarity with digital tools and concerns about the learning curve associated with new technologies. Several studios reported initial hesitation from team members accustomed to traditional methods. The

transition requires a cultural shift within organizations, which can be slow and challenging to achieve.

Local policies and regulatory frameworks also pose challenges. Many Portuguese municipalities and licensing authorities are not fully equipped to handle digital submissions, often requiring conversions of BIM projects to traditional 2D formats for approval. This redundancy not only increases the workload but also diminishes the efficiency gains promised by digital tools.

### 4.3 Strategies for Overcoming Challenges

To address these challenges, several strategies can be employed. Financial barriers can be mitigated through phased implementation and prioritizing investments in the most impactful digital tools. Studios can also seek partnerships and collaborations to share resources and expertise. For example, engaging with academic institutions for training and leveraging government subsidies or grants for technology adoption can ease financial burdens.

Educational initiatives are crucial in overcoming resistance to change. Continuous training and professional development programs can help architects and other stakeholders become proficient in digital tools. Sharing success stories and demonstrating the specific benefits of digital adoption can also foster a more positive attitude towards these technologies.

Policy reforms are essential to streamline the integration of digital tools in architectural practice. Government and regulatory bodies need to update their processes and requirements to accommodate digital submissions and encourage the adoption of advanced technologies. Creating a supportive policy environment can significantly accelerate the digital transformation of the architecture industry in Portugal.

The digital transformation of architectural practices in Portugal is underway, with significant benefits in terms of precision, efficiency, and innovation. However, challenges such as high costs, resistance to change, and regulatory barriers persist. By addressing these challenges through strategic investments, continuous education, and supportive policies, Portuguese architecture studios can fully leverage the potential of digital tools. This will not only enhance their practices but also contribute to the advancement of architectural discourse and practice, fostering a more innovative and sustainable built environment.

## References

Brozovsky, J., Labonnote, N., & Vigren, O. (2024). Digital technologies in architecture, engineering, and construction. Automation in Construction, 158, 105212.

Burry, J. (Ed.). (2020). Fabricate 2020: Making Resilient Architecture. UCL Press.

Carpo, M. (2023). Beyond Digital: Design and Automation at the End of Modernity. The MIT Press.

Garber, R. (Ed.). (2014). BIM Design: Realising the Creative Potential of Building Information Modelling. Wiley.

Gibbons, S. (2016, July 31). Design thinking 101. Retrieved October 16, 2022, from https://www.nngroup.com/articles/design-thinking/

Hensel, M., & Nilsson, F. (2016). The Changing Shape of Practice: Integrating Research and Design in Architecture. Routledge.

HMH Architecture + Interiors. (2014, December 18). Design phases. Retrieved October 16, 2022, from https://hmhai.com/faq-items/design-phases/

Menges, A., & Ahlquist, S. (2011). Computational Design Thinking. John Wiley & Sons.

Oxman, R., & Oxman, R. (Eds.). (2014). Theories of the Digital in Architecture. Routledge.

RIBA Journal. (2024). BIM, augmented reality and virtual reality: Transforming practice management. Retrieved from https://www.ribaj.com/intelligence/bim-augmented-reality-virtual-reality-practice-management-software

batjo - Bits, atoms and journalism. (2024). Digital fabrication, a primer. http://www.batjo.eu/digital-fabrication/