

## WE GAIN A LOT...BUT WHAT ARE WE LOSING?

*A Critical Exploration of the Implications of Digital Design Technologies on Sustainable Architecture*

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**Abstract.** In the field of architecture, new technologies are enabling us to promptly simulate, quantify, and compare multitudes of design alternatives and consider an ever more expanding list of environmental and economic parameters within the early design phases of projects. However, architecture today veers further towards non-neutral technologies, changing our culture, introducing new values, and (re)shaping our social ideals. The change of media, from the manual to the digital, has deeply transformed architecture and city design. There is undoubtedly progress, but what are we losing in this automation, virtualization and over-digitalization? Are architects—creators of space, human experience, and cultural capital—starting to occupy the role of technicians? Sustainable architecture is a field that is already experiencing tensions between the quantitative and the qualitative, the optimum and the ethical, and the parametric and haptic methods. Yet the rapidly evolving CAAD technologies overlook many of the non-quantifiable values of these binaries. Gains in speed and efficiency in the design process with the help of parametric design may be challenging the designer's *reflection-in-action* process required for critical architecture while ethical, cultural, and human dimensions can hardly be modelled algorithmically. Similarly, computational thinking and digitalization in architectural education, have yet to come to terms

with the loss of analogue ways of learning that favour a more diverse and inclusive classroom environment. Instead of keeping the analogue and the haptic practices away from the immaculate realm of CAAD, this paper argues for hybrid technologies that recognize these practices and their value in sustainable design and incorporate them. Film animation, as a branch of architecture's most expressive means, film, can serve as a paradigm of a feasible disruptive technology, but most importantly, as an indicator of the hybridity between the handmade and the digital and its effectiveness in expressing vital elements of sustainability that are otherwise dismissed.

**Keywords:** *Digital tools, handmade images, parametric design, environmental sustainability, architectural pedagogy, reflection in action, hybrid visualization techniques.*

**ملخص.** في مجال العمارة , قد تمكنا من خلال التكنولوجيا الرقمية الجديد من ان نحكي ونحسب الكميات ونقارن العديد من البدائل وكذلك اتخاذ القرار الفوري مع الأخذ في الاعتبار العديد من المحددات البيئية والإقتصادية وذلك من بدء المراحل الأولى للمشروع .ومن هنا نجد أن العمارة في الوقت الحالي تميل إلى التكنولوجيا غير المحيدة التي تغير من الموروثات وتقدم قيما جديدة وتساعد على تشكيل القيم الإجتماعية .فالتغيير في الميديا من التقليدية إلى الرقمية قد أثرت بشدة في تطوير العمارة والتصميم العمراني للمدن. من المؤكد أنه هناك تقدم هائل. ولكن ماذا نخسر من هذا التطور إلى الميكنة أو الأوتوماشن والإفتراضية والتوغل في الرقمية؟.. هل الإبداع المعماري والخبرات الحياتية والجذور الثقافية قد بدأت في أن تستبدل بالطرق التقنية؟ إن مجال العمارة بالفعل يتعرض إلى شد وجذب بين نظريات الكم والكيف وبين المثالية والأخلاقيات وبين المحدود والملموس. وما زال التسارع لتكنولوجيا CAAD تصطدم بالعديد من المحددات غير القابلة للقياس. إن المكتسبات الحادثة في الكفاءة والسرعة في عملية التصميم بمساعدة محددات التقييم قد تكون محفزة للمعماري لأن ينعكس ذلك علي التطور المطلوب في التصميم من أجل عماره متميزة بينما المثل والحضاره والأبعاد الإنسانية قد يكون من أصعب ما يكون وضعها في معادلات قياسية. وبالمثل التحول الى التصميم الرقمي عن طريق الحاسبات يأتي في الدراسة المعمارية علي حساب الطرق التناظرية للتعليم والتي تتطلب معرفة شاملة ومتنوعة من خلال الفصول الدراسية. فبدلا من أن تبقى الطرق التناظرية و الممارسات المحسوسة بعيدا عن عالم CAAD النقي نجد أن هذه الورقة البحثية تناقش إستحداث تكنولوجيا تجمع بين هذه التطبيقات التكنولوجية والطرق التقليدية وقيمتها في التصميم المستدام وتدمجهم معا. وأيضا يمكن تناول "الأنيماشن" أو العروض التخيلية كفرع من أقوى الوسائل للتعبير عن التصميم المعماري والتي يمكن أن تخدم كنموذج للتكنولوجيا التي يمكن أن يكون لها تأثير هادم ولكنها أهم شئى تعمل كمؤشر للدمج بين التصميم التقليدي والرقمي ومدى كفاءتهما في التعبير عن العناصر الحيوية للإستدامة والتي كان ممكن أن تتعرض فيما عدا ذلك للإستبعاد .

**الكلمات المفتاحية:** الأدوات الرقمية، الصور المصنعة يدويا، التصميم البارامتري، الإستدامة البيئية، التعليم المعماري، الانعكاس التصميمي، أدوات الإظهار المختلطة.

## 1. Introduction

### 1.1. DIGITALIZATION IN ARCHITECTURE

The digital age has brought tremendous changes to our world. In architecture, digital tools have revolutionized the way drawings are produced, as well as how buildings are visualized, optimized, assessed, and constructed. However, the recent developments in computing abilities are confronting design and architecture with new technologies that are increasingly substantive. Today, architectural design is increasingly relying on digital technologies, changing our culture, introducing new values, and (re)shaping our social ideals. The change of media, from the manual to the digital, has deeply transformed architecture and city design.

In this environment of technological dominance, the architect is asked to take up new responsibilities. Sustainability is a case in point.

### 2.1. A CONTEMPORARY VIEW OF SUSTAINABILITY

Over the last decades, we transitioned our collective understanding of sustainability from a product-focused one (i.e. green design) to one of system innovations (i.e. design for sustainable transitions) (Ceschin & Gaziulusoy, 2016). While many of us still associate, ground and define sustainability in architecture through eco-efficiency (i.e. the optimization of environmental performance metrics), this measurement-driven definition contradicts the multitude of meanings, and non-technical layers that can contribute to the sustainability of a *place* (Cucuzzella & Goubran, 2020). It also disregards the formal definition of sustainability as an intersection of domains; the social, economic and environmental, in its most basic sense, with the addition of the cultural (McMinn & Polo, 2005), ethical (Ehrenfeld, 2009), or spiritual (Walker, 2006, 2015) in its more elaborate forms.

In a series of articles published in the early 2000s, Guy and Farmer (Farmer & Guy, 2004, 2005; Guy & Farmer, 2000, 2001) have established a seminal vision to comprehending and applying the concept of sustainability meaningfully – in what they defined as "pluralistically". This is well-aligned with the view that a stable, or bounded definition of sustainability in architecture, will reduce the process of design (i.e. sustainable design) to a series of managerial decisions around energy, water and feasibility (Cucuzzella & Goubran, 2020; Pyla, 2008; Vandevyvere & Heynen, 2014).

In the ever-changing realities, we are certain that the architect's role has to transition from that of the technical advisor to one of "a more sociological engineer or entrepreneur" (Mooi, 2014). While technologies, and information and communication technologies (ICTs) in specific, have become defining

features to our sustainability approach, it is essential not to confuse the designer's role with that of the technology integrator. In that sense, we have to consider that sustainability can only be attained by balancing between the high- and low-tech (Beder, 1994), between the smart and the human, between the digital/artificial and the natural, and the imagined and the real.

## 2. Critical Perspectives

### 2.1. BUILDING DESIGN AND PROCESS

New digital tools have influenced the whole field of architectural design over the past decades, leading to *parametricism* (Schumacher & Leach, 2009). This practice, which is the direct result of digital tools in architecture, not only affects the design process but also has significant impacts on the architectural forms. To assess the effects of digitalization in their entirety, we will examine the role of parametric tools in the following two aspects: 1) the design process, and 2) the final results on the architectural process, namely, the architectural forms (Fig. 1).

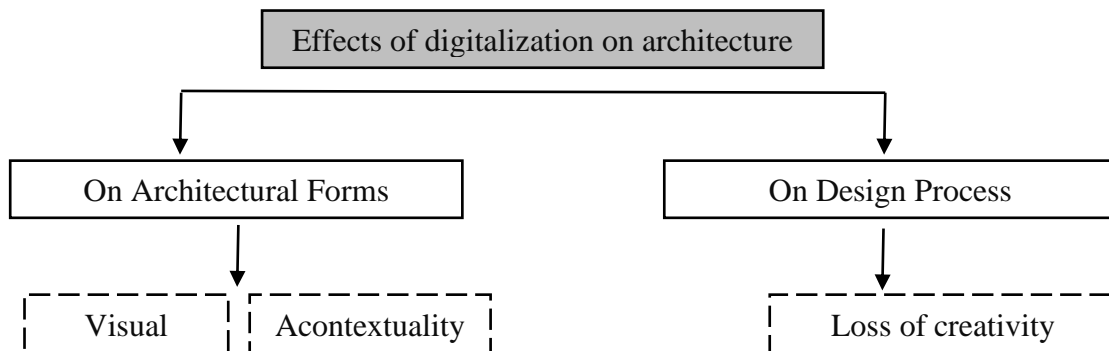


Figure 1. Assessing the effects of digitalization on both architectural forms and design process.

#### 2.1.1. Digitalization and its effects on architectural design processes.

Unlike past design processes, which were based on improving the quality of design step by step, today, architects quantify parameters to generate and control different architectural variations while designers can explore multiple viable solutions and concepts without being limited by their own drawing and modelling skills (Lawson, 2002). They also can change and modify their own rule-based representations in any stage of the design process (Schumacher, 2008). This availability and means that are offered by digital tools lead to

innumerable design alternatives that can be generated in parallel, which in turn allow for new modes of thinking and contribute to the explorative process (Barrios Hernandez, 2006; Holland, 2012; Karle & Kelly, 2011).

Such changes in the design process and methods have extended the boundaries of design knowledge (Gero, 1996; Liu & Lim, 2006). With them, however, come some shortcomings with regard to creativity. Traditionally, designers spent a lot of time on the design process, whereas today only one mouse click can provide thousands of alternatives. Although sketches (conventional design practices) are a time-consuming process, have few details, tend to suggest and explore rather than confirm by retaining a level of ambiguity (Poole & Shvartzberg, 2015), they allow the designer to spend more time on the artefact and engage in an exploratory search, discovering alternatives that were not conceived at all in the preliminary design phase. Schon (1987) names these emerging ideas a *reflection in action*. In other words, whereas in parametric design, all design alternatives are restricted to the initially defined code and parameters and cannot go beyond them, in traditional methods of design, the ambiguity of sketches has the potential to trigger new ideas outside a defined “box”.

One might say that in the parametric way of design, designers can change and modify their own rule-based models at any stage of the design process so that it can be kept open and flexible (Oxman & Gu, 2015). Yet in reality, their possible changes are limited to the rules that they themselves have set for the design problem in the first place. Recoding the whole process, would be more time-consuming than any traditional design method with the additional risk of missing all the alternatives that were generated initially as they would not be compatible with any new design code. This complexity of modifying or upgrading the code forces designers to narrow their alternatives within the current platform, since they are reluctant to recode the whole procedure (R. Woodbury, 2010). Consequently, a code-based design process would hinder creativity, since it would restrict designers to only one possible range of solutions.

### 2.1.2. *Digitalization and its effects on architectural forms*

In parametricism, architects rely solely on digital tools to design building forms through computer-aided design avoiding thus the nuanced reflection in action the hand enables. Although this transition from hand-drawn architecture to computerized architecture has brought possibilities to the table never imagined before, the drawbacks with regard to the architectural form can be easily recognized in some contemporary buildings of the last decade or so. In terms of formal features, incoherency can be considered an obvious predominant characteristic, both in the matching of the exterior to interior designs and their descriptive qualities. (Hazbei & Cucuzzella, 2021). Digital

tools increase computational control over design geometry (Dino, 2012) and are mostly used to create seductive and spectacular forms or even create an environmental envelope around the building overlooking basic architectural formal qualities such as the connection between site and building. In describing this technological advancement in architectural forms, Dalibor Vesely states that “complexity can be produced, but richness must be created” (Burry, 2013).

Digitalization facilitates form-finding processes and responds to site and climate requirements. However, these practices are increasingly depriving contemporary architecture of meaning (Grobman & Neuman, 2013). Parametric architecture, as it is practiced today, cannot convey contextual significance, since it considers merely climatic, topographic, and energy as regional factors (Mahgoub, 2007). In other words, parametric design focuses on digital forms and energy simulation techniques of buildings without addressing the cultural significance of local places (Lorenzo-Eiroa & Sprecher, 2013). Although this development in architectural digital tools can be considered as a way forward in environmental sustainability, it is a counteractive approach to cultural and social sustainability, producing acontextual architecture.

## 2.2. EDUCATION

Traditionally, the pedagogy of architecture design studios relied on hands-on and experiential learning techniques to equip students with the ability to critically reflect, brainstorm, and interact with their peers and surroundings while designing for time-intensive school projects (Schön, 1987). These peer-to-peer interactions, facilitated by the physical environment of the design studio, were beneficial to the growth of architecture students as they learned to exchange, debate and reflect on key concepts, values, and design principles that informed their tacit knowledge (Polanyi, 2009) and governed their future styles and workflows as licensed and practicing architects (Schön, 1987).

The application of digital design tools in projects for architecture schools has witnessed both positive and negative impacts on the nature of knowledge exchange between research and practice. While the swift adoption of digital technologies in the design process was imperative to the survival of architecture as a profession, the educational system continued to be skeptical of these advancements as they relied on the tangibility of creative outcomes through analogue resources such as hand-drawn project submissions, physical studio interactions, hands-on workshops, and field studies. Hence, most educational institutions persist in this tension between the digital and analogue dimensions of architecture pedagogy, and this results in a curriculum

that is ambiguous in its approach to sustainably train young professionals for the future.

This increasing polarity between the digital and analogue is also observed in the user interface of CAAD tools that are often neutral and rigid in the hopes of structuring and democratizing the design process. However, given that these tools are used by creative individuals with diverse social and cultural backgrounds, the neutrality of its elements flatten and undermine the complexity and inherent "messiness" of the design studio (Gross and Do, 1999). While students are encouraged to experiment and tinker with unfamiliar materials and concepts and come up with designs through trial and error, digital design technologies have added socio-cultural and psychological inhibitions to this process as they have promoted speed, efficiency and accuracy of seemingly "finished" solutions. Although CAAD tools have witnessed an exponential growth in the capacity of students and practitioners to produce and share larger quantities of work, they spur on a competitive environment that can result in an unhealthy bypassing of initial research, meditation, and reflection of design principles and values, resulting in an uneven distribution of the quality of the creative outcomes (Buchanan, 2012).

Furthermore, the participatory design paradigm of the architecture discipline in recent years has led to a shift in the power dynamics of a learning environment, where the instructors and students now need to share a level plane of discussion and symbiosis of knowledge and other resources. In the traditional format of a design studio critique, students typically present their work in front of a passive audience and receive critical feedback from instructors only at the end of their design processes (Graham, 2003). Today, the rise of "e-studios" has witnessed a shift in this communication as students can share their work outside the physical boundaries of the design studio right from the inception of the projects (Al-Qawasmi, 2005). Although digital studios prompt students to think "fluidly" and generate multiple design outputs over a very short span of time, instructors now struggle to devote their time and attention to giving quality feedback to individual work before final submissions. Additionally, students tend to overlook the socio-cultural contexts of their designs by adopting global principles that arise from the gentrification caused by digital applications. Therefore, the paradigm of digital media in the design learning process needs to move away from a narrow technical perspective that views them as "value-free neutral (tools) that produce objective realities" (Al-Qawasmi, 2005).

Although there has been a drastic increase in the efficiency of projects designed using digital and parametric design platforms, computational thinking renders a complex design problem into disconnected smaller parts and can discourage students from critically reflecting on the outcomes of these codified processes (Kavousi et al., 2019). Digital design and parametricism

can have dire implications for the creative skills of architecture students, as they are given the freedom to blame the “machines” for not producing the expected results, absolving them of responsibility as designers (Miessen, 2016)

Hence, the over-digitization of design techniques and processes bring the need for architectural pedagogy to shift toward an inclusive, socio-cultural and political restructuring of the discipline in order to embrace more hybrid mechanisms in conflictual environments of learning and practice. Rather than focusing on the extremities of the digital-analogue debate in architectural education, future curricula can encourage hybrid forms of teaching and learning architecture that embrace both analogue and digital tools in techniques for sustainable architecture.

### 2.3. VISUAL EXPRESSIONS

#### 2.3.1. *Film as Architecture Communicator (beyond photorealism)*

If digital technologies and parametricism obscure the role of architects and the degree of their responsibility vis-a-vis the design process, one has to recognize what that role is, namely, the creative role, the one being most at risk of being compromised. In a series of perceptive works, architect and architectural theorist Juhani Pallasmaa examines the entire creative process of the architect through the interaction between body and mind, between hand and eye. Without denouncing the conveniences of CAAD, he underlines the importance of conceiving architecture and even fabricating objects by engaging all of the senses, away from the computer screen. He argues that any tactile experience using a computer mouse is still an operation that takes place in an immaterial world and that “computer imaging tends to flatten our magnificent, multi-sensory, simultaneous and synchronic capacities of imagination by turning the design process into a passive visual manipulation, a retinal survey.” (2009, pp.96-97)

Hence, bodily ways of making are still crucial in the creative stages of architectural practice. This argument extends, naturally, into the realm of *communicating* architecture, in the classroom, the design studio but also in society at large. Maybe it is no coincidence that Juhani Pallasmaa is also a keen expert in film, which, according to him, is the medium *par excellence* in communicating architecture (2001, p.13), echoing thus a position held by numerous film scholars, going back to cinema pioneer and theorist Sergei Eisenstein himself (Eisenstein, Bois, & Glenny, 1989).

With this understanding of film’s capacity in expressing architecture, it is no surprise that the discourse around new moving image technologies and their potential to now act disruptively to the norms of photorealism is a very familiar one to architecture and film scholars alike. As CAAD technologies



are increasingly encroaching on the realm of animated representations of space, critiques on how CAAD has limited design creativity logically extend to the computer-generated moving image. Architect and essayist, Stan Allen, used low-tech animated films as a paradigm for an approach to CAAD that focuses on abstraction and significance rather than on precision (2009, pp.89-90). This viewpoint echoed a wave of writers on film and filmmakers who had already explored the materiality of the medium itself within its analogue past but also in ways of experiencing space in film that is not centred around vision (Marks, 2000; Bruno, 2014).

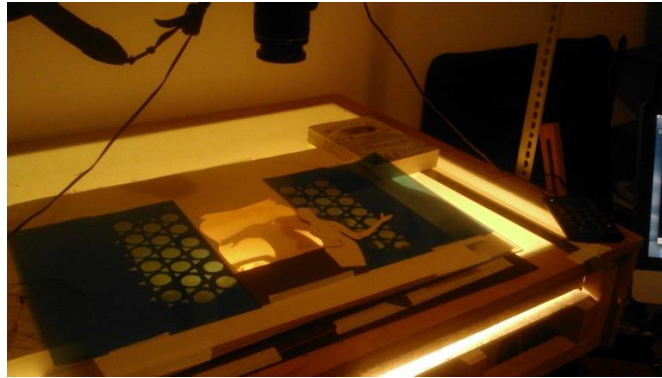
Ultimately, all of these arguments are directly linked to a more holistic understanding of architecture, one which corresponds better to the human lived experience. One can argue that the banishment of the body and the excessive reliance on photorealism, as encouraged in major CAAD software, is at the expense of meaningful architecture and, consequently, a sustainable one.

As a type of film that can largely involve the handmade, film animation is particularly well positioned to express architectural space in all its hapticity. Film animators study and manipulate each film frame individually. This arrest of time allows them for a greater involvement of their bodies onto each frame that can be a photograph of a hand drawing or of a hand-crafted set, as is the case with stop-motion techniques. Interestingly, digital technology, instead of replacing, has in fact encouraged such techniques (Parks, 2020), resulting to new, hybrid, more accessible ways of expressing architecture.

### 2.3.2. *Last Dance on the Main: A Case Study*

In his own work as film animator, Aristofanis Soulikias seeks to express the built environment beyond its Cartesian constraints of measurable space, in the realm of the lived and bodily experience, which is communicated through the handmade aspects of his filmmaking process, such as the non-digital nature of the materials he uses and the physical environment in which he captures the individual photographic stills. *Last Dance on the Main*, his 2014 animated documentary about the demolition of a row of historic buildings in Montreal's former Red-Light District and the successful resistance put up by local artists and activists to preserve their venue is a characteristic example. All the scenes and movements in the film were manually fabricated, captured by a digital camera, and assembled into a film with a special stop-motion software. The handmade component of the film was the cutting of paper silhouettes and other translucent surfaces as well as the use of ready-made objects and printed material, all placed on a light table as to be mostly backlit. The incremental changes in position were done by hand, often by trial and error and many repeated attempts. The digital component consisted of the capture of photographic stills with a mounted DSLR camera facing the horizontal light

table surface and connected to a computer to which the images were instantly sent (Fig.2).



*Figure 2. Production Still*

Despite being a digital end-product, digital tools did not dictate the overall aesthetic or animation of the film but rather facilitated the registration, selection, and processing of the images, allowing for the artist to better concentrate on animating the paper silhouettes and the other objects he used for the film. Within this hybrid form of film animation, enough of the multilayered work made by hand became perceivable, as to become itself a metaphor for the layers of significance of the endangered buildings and the communities that supported them. Furthermore, a film that was made with relatively modest means and resources reached 65 festivals worldwide and won several awards, posing the question of what sustainability can mean for both architecture and the means of communicating it.

### **3. Conclusion**

CAAD technology, as powerful as it has evolved, has had difficulty in encompassing a broader notion of sustainability as that is understood in the 21<sup>st</sup> century. The ultimate achievements of computational ways of thinking, speed, accuracy and efficiency, useful as they are, have yet to address successfully the idiosyncrasies of place and culture. Similarly, digital tools cannot necessarily replace the creative environments needed in architectural education or the architectural office. To address sustainability in architecture in its fullest sense, one needs to examine closely what is being lost and how that can be incorporated in today's architectural practices. This is not to imply that digital technologies cannot achieve some of the subversions and dissent from the tyranny of precision and speed (Hosea, 2019). However, hybrid ways of designing, making, and seeing, which involve both the digital and the

analogue, the ideated image and the physical space, the mind and the body, point to that optimum where there is enough of that precious room for creativity, spontaneity, and, in general, a more accurate and direct response to the lived human reality, both on the ground where architecture materializes and in the minds of citizens where it is imagined. Sustainability is less about the limits of performance reached by computers and more about the fine equilibrium between powerful tools and that which directly addresses our sense of place and humanity.

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