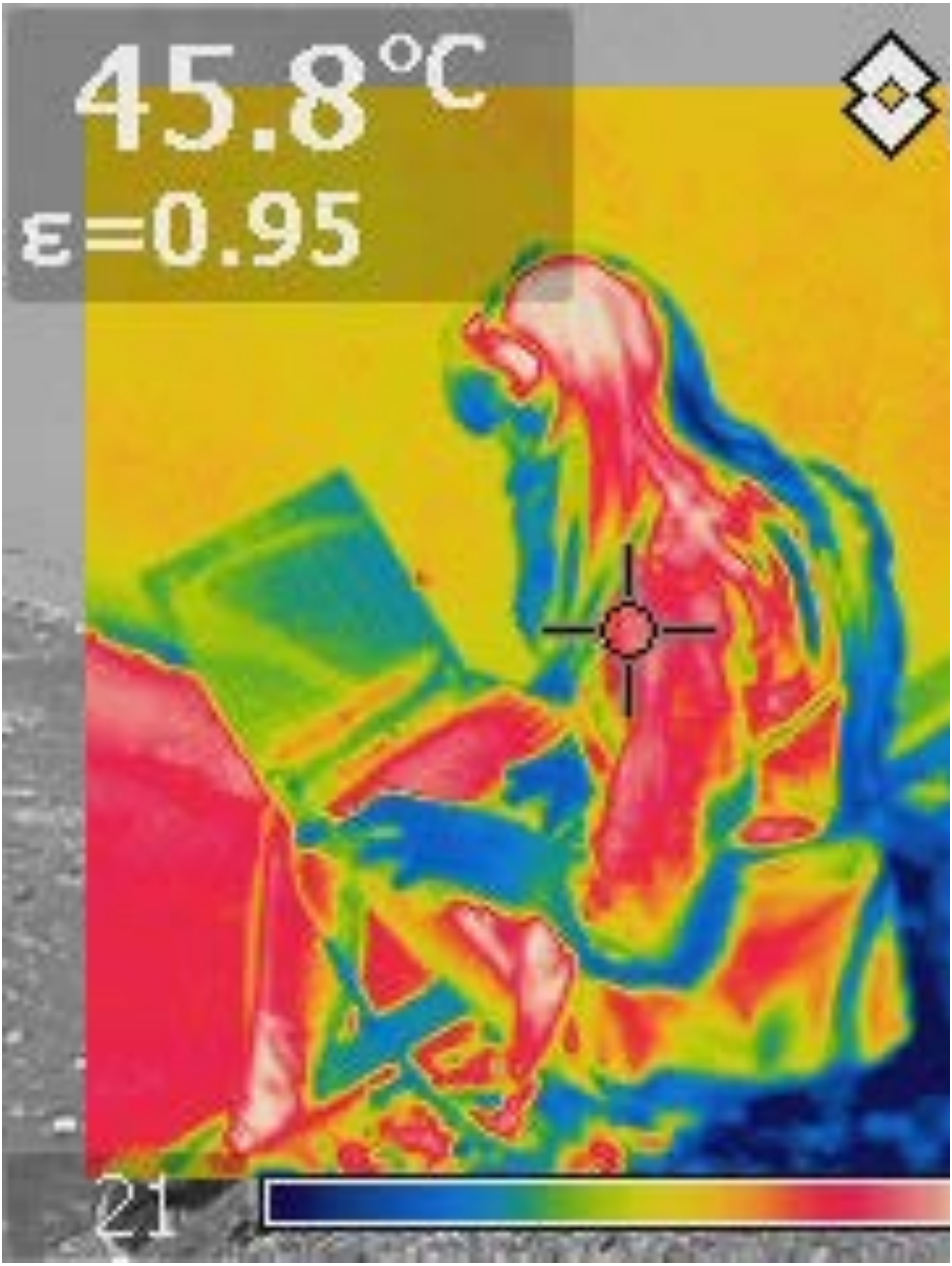

Thermal image of a student working (image by Wendy Walls, 2024).

LANDSCAPE
REVIEW

Turning up the heat: reflecting on a decade of teaching landscape climate design

Jillian Walliss and Wendy Walls

When a landscape digital design practice emerged in the 2000s, it offered an unprecedented ability to engage with invisible atmospheric conditions. With big data and new software tools, dynamic systems could be integrated directly into design processes. Since 2015, the University of Melbourne landscape programme has explored these new design potentials in studio and electives focused on heat. The same decade has seen deeper acceptance of the climate crisis, more accessible and extensive data sets and more advanced software, yet student outcomes are no more sophisticated or innovative. Reflecting education and research practice, and drawing on student work and critical theory, this paper discusses conceptual difficulties in engaging with non-linear digital design processes. Interest in atmospheric theoretical framings and technological applications has been replaced by passive solutionism and linear design thinking, or 'problem-solving'. Centrally, conceptions of simulation as offering an understanding of atmospheric behaviours have shifted to a belief in control; an attitude mirrored in practice with problematic results. As the artificial intelligence era begins, the implications for landscape architecture practice are critical. The increasing reliance on technology to accurately model 'reality' allows complex algorithms to decide the future of cities, diminishing, if not erasing, the role of creativity and design.

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Atmosphere and the digital turn (2015–2020)

In the early 1990s, architecture theorist Mario Carpo (2013) described architecture's first digital turn and the potentials of digital technology to shift ways of designing. Key to this was the emergence of parametric modelling, which foregrounded relational decision-making and the potentials of computationally supported complexity in design processes.

Although it happened substantially later, landscape architecture also experienced a digital turn focused on design practice. This turn has been documented in a suite of publications in the mid-2010s, such as *Landscape Architecture and Digital Technologies* (Walliss and Rahmann, 2016b), *Responsive Landscapes* (Cantrell and Holzman, 2016), *Codify: Parametric and Computational Design in Landscape Architecture* (Cantrell and Mekies, 2018) and *Dynamic Patterns* (M'Closkey and VanDerSys, 2017).

For landscape architecture, the digital turn offered possibilities of new computational design investigations that escaped the constraints of static representational techniques such as mapping, diagramming and the plan. Whereas static techniques offer 'a visual representation of information and position the designer to respond to what is already known or what can be visually discerned', working with data and simulation facilitated:

> time-based investigations in which change is implicit through the active composition of behaviours and relationships. In this new context, the designer adopts an experimental process, establishing interdependencies and relationships between information, phenomena and systems across micro and macro scales. Rather than prescribe solutions, these research-driven design methodologies present 'a controlled discovery,' offering productive techniques for engaging with the unpredictability of climate change. (Walliss and Rahmann, 2016a, pp 41–42)

KEY WORDS
design pedagogy, landscape architecture, digital, AI, climate design

Citation: Walliss, J.; Walls, W. (**2025**) Turning up the heat: reflecting on a decade of teaching landscape climate design. *Landscape Review*, 21(2), pp 46–57.
Received: 23 May 2025
Published: 29 October 2025

Importantly, the emerging non-linear digital design processes were supported by design theorists such as Lally (2014) and Rahm (2014), who described ways of understanding and designing through intensities, gradients and change. Also influenced by earlier design theory incorporating systems such as the work of ecologist Gregory Bateson, these critical understandings of variance are described by Keith VanDerSys (2014) of PEG studio as uncovering 'a difference that makes a difference', identifying conditions, behaviours and forces of the greatest degree of change in which to intervene.

This period was therefore not about modelling reality, but instead about accessing enough information to identify what computer scientist Chris Leckie defines as a 'high value' problem. He comments that our unprecedented access to data demands a level of critical thinking, requiring us to move from a vast amount of data to 'pick out the interesting or unusual events that are worth exploring and then filter them down' (Leckie, 2013).

For landscape architects engaging with questions of atmosphere and thermal conditions, the distinctions of identifying difference and high-value problems, as opposed to absolute or controlled outcomes, are critical to engaging with the generative design opportunities of data and digital tools. These framings also demand rigour in the critical thinking of the designer as to how they interrogate and apply data-driven information to the design process.

A landscape architecture master's thesis project (Toh, 2015), which aimed to modify the extremely humid streetscape of Singapore's premier shopping street Orchard Road, offers a clear demonstration of how this critical thinking leads to a novel design response. Research sourced from scientific journals highlighted the negative effects of traditional linear street tree planting, in that the practice increased air temperature (due to the reduced wind speed), as well as having the potential to raise humidity levels through tree coverage.

Working parametrically with Grasshopper as a Rhino plug-in, with inputs of small and big data, it was possible first to optimise tree placement for maximum shade but uninterrupted airflow. In a second phase, this new street tree-planting scheme was reconsidered in conjunction with the different albedo effects of paving colour to further increase air circulation along the street. Central to the Grasshopper definition was a matrix of weightage that placed more value on certain effects than others in different locations. Lighter-coloured pavers were placed under trees to achieve the effect of drawing air away from the trees, while darker shades of pavers were placed nearer to the road to encourage air movement towards the centre, aiding in its dispersal.

Through simulation and parametric tools, it was possible to derive the most thermally comfortable path that emerges from the aggregates of these design strategies. After adopting this optimum path as the foundation for street design, further design interventions can be introduced to enhance pedestrian comfort along it (figure 1). These include the programmatic use of the space and the location of street furniture and gathering points.

Shifting away from the stable equatorial Singaporean climate, the second landscape thesis project centred on the climatic extremes of the Daxing District of southern Beijing (Yu, 2016). Focusing on the everyday residential environment, the project aimed to work across multiple scales to reduce resident exposure to pollution by leveraging the combined effects of site planning, open space design and materiality. Beginning with a Geographic Information System (GIS), the plug-in Airflow Analyst and data accessed from a Beijing monitoring station (made available by a visiting Chinese professor), the optimum configuration and heights for standard Chinese residential buildings were explored. Decisions were premised on encouraging favourable pollution-dispersing northern wind speeds to be maintained between 7 and 10 metres per second, minimising the problematic southern winds that funnel pollution into the site and maximising solar access for residential buildings (figure 2).

Importantly, the move into more detailed design investigations was not a linear progression. Once the configuration of the buildings was established, a different question drove the next set of design decisions, beginning by investigating which times of year and times of day result in the highest pollution exposure. This bringing together of two temporal scales – the yearly pollution fluctuations with the 24-hour cycle of Chinese life – revealed that while air pollution reaches its highest levels during winter nights (when people are largely inside), the daytime pollution levels are much lower in winter than in summer. Here we see how making decisions around maximums differs from understanding the relationship between fluctuating pollution levels and people's day-to-day behaviours.

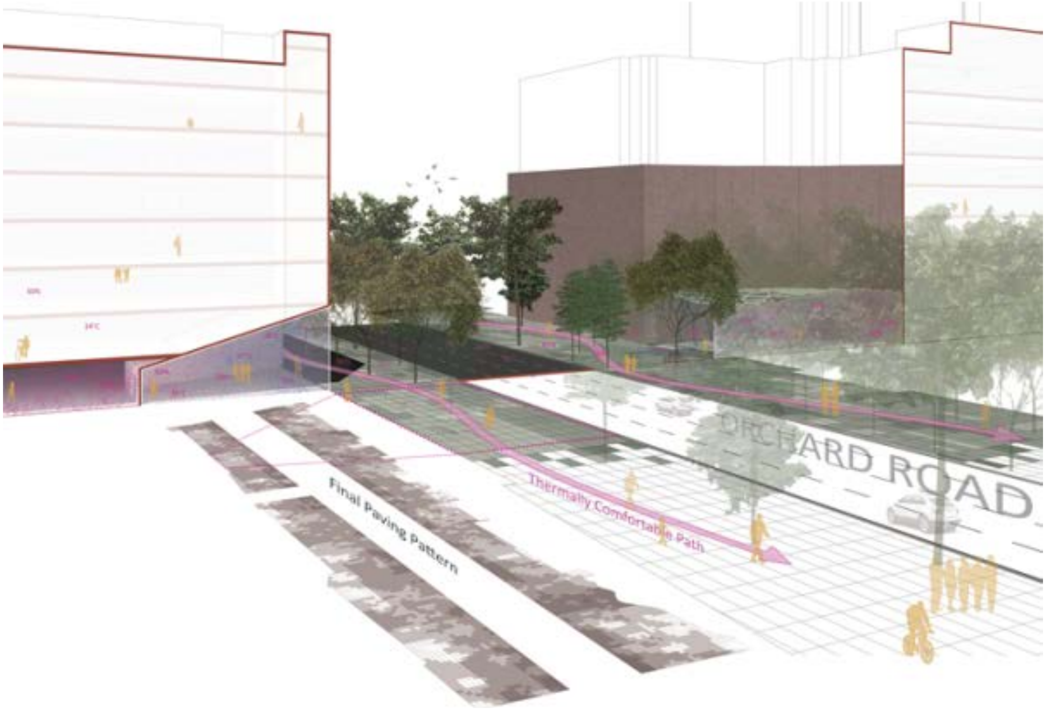
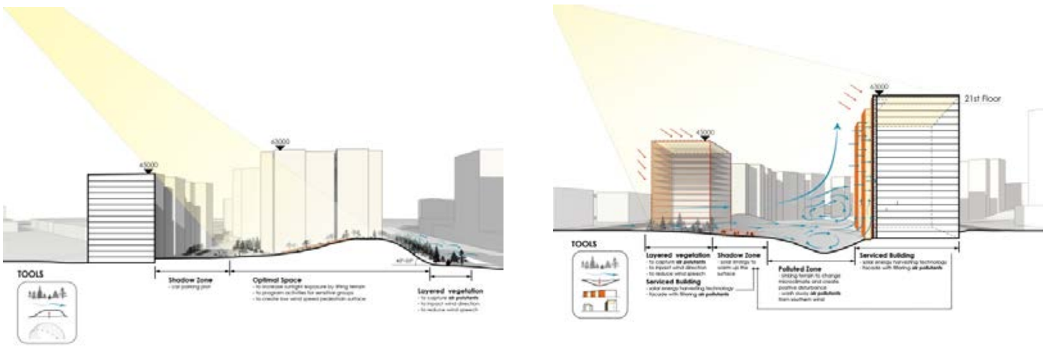


Figure 1. Defining a thermally comfortable path for pedestrians along Orchard Road, Singapore (image by Jason Toh (2015)).



(a) **(b)**

Figure 2. **(a)** Open space design for *Polluted City: A Meteorological Driven Design Approach for Beijing*. **(b)** Explanation of design with wind flows. (Images by Junya Yu, (2016))

This observation, which can be considered 'the difference that makes a difference', formed the basis for establishing an open-space strategy based on 'warming' winter spaces primarily by inserting a large mound to maximise exposure to winter sun. This space was also designed to perform well in summer. Functional uses such as car parking were placed in less healthy areas of the site, while in the most polluted areas, spaces were designed for no habitation and acted as pollution traps incorporating smart pollution-diminishing materials in the façades.

These urban-scale projects demonstrate how both master's students used data to understand and reveal behaviours and relationships – not to find a singular solution. This same thinking guided design outcomes in smaller-scale design interventions delivered as part of the multidisciplinary elective Designing for Heat.

In this subject, students were tasked with analysing real-time data collected on-site using i-button temperature sensors. In one case, students discovered an anomaly in climatic behaviours, where the air temperature at certain locations would drop for a short period despite the overall trend of rising temperatures. The cause of this temperature drop was never fully established. However, the observation prompted further investigations into the potential for material effects to interrupt the building-up of heat, acting to 'reset the external spaces' (figure 3) and thereby preventing spaces from reaching maximum temperatures (Bessabava and Szumer, 2015).

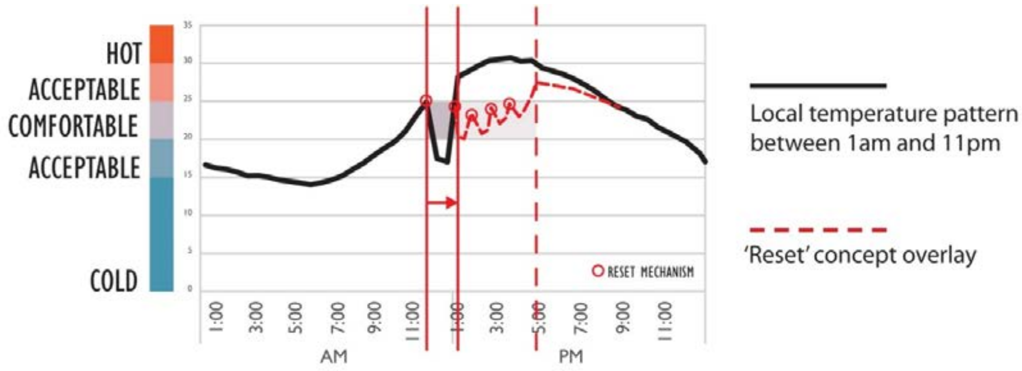
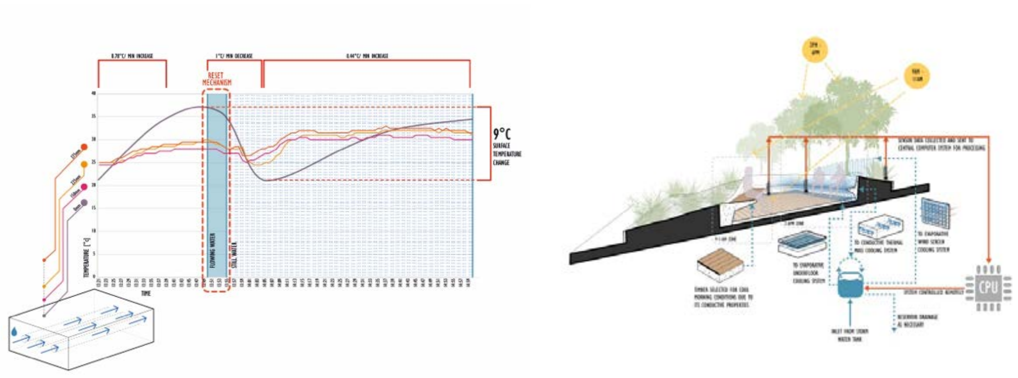


Figure 3. Diagramming the progressive build-up of heat over time and the anomaly effect of a sudden temperature decrease. This is shown against the proposed 'reset' concept of concurrent temperature drops (image by Bessabava and Szumer (2015)).

The students used this performative trait as a lens to investigate thermal behaviours of different surface materials such as concrete, brick, steel, timber and vegetation. In a series of physical experiments, the students explored the potential for 'resetting' the material behaviour using passive cooling techniques in response to conduction, convection and radiation. The insights from the physical tests were further explored using computational fluid dynamics (CFD) simulation and parametric environmental modelling (figure 4) to enhance the potential comfort levels at a material scale at strategic locations within a site, without the need to cool down the entire outdoor space.



(a) **(b)**

Figure 4. **(a)** Diagram of data capture from material tests exploring the reset mechanism. **(b)** The design of 'Reset Pods' as thermally responsive systems. (Images by Bessabava and Szumer (2015))

These three student projects highlight how the use of data and simulation supported by scientific research leads them to constantly redefine the problem. In no way are the simulations offering the solution. Instead, the designers are curating the process, developing greater insights through each exploration and gaining more knowledge about where they can have agency and impact. This ability to define the point of intervention (spatially and temporally) is particularly important when engaging with dynamic atmospheric conditions such as heat and pollution. Given the complexity of climate change, it is impossible to directly affect the extremes of these phenomena, which are tied to broader global concerns like global emissions and deforestation. However, working as designers, it is possible to tactically interrupt, heighten or minimise different aspects of these conditions as they play out at the scale of a site, materials and human experience. Through abstraction of environmental processes, behaviours and relationships, computational tools offer a transition between the macro and the micro scales, transforming the notion of atmosphere as constraint to a perceivable material space.

It is important to note that in these cases, the students themselves scripted the project models and parametric tests. In doing so, they had to properly understand the parameters and behavioural rules they were dealing with. These earlier projects were delivered at a time when digital tools were novel in the landscape curriculum. While computer-aided design and 3D modelling were commonly used, plug-ins, real-time data and simulations were only beginning to emerge. In this context, these tools offered no easy processes or simple results so students who wanted to employ them were forced to be proactive. Thus, these examples offer insight into a generation of students who were curious about design, processes and technology and were prepared to push their thinking and technical skills beyond the limitations of the current tool set.

Since then, however, this critical and design-focused positioning of the role of data and digital tools has been changing in two ways. First, these data and tools have become easier to obtain and now permeate design decision-making and operations. The rapid arrival of integrated artificial intelligence (AI) technology has brought new workflow efficiencies that require less attention from the designer than in the earlier period, when, for example, designers were required to engage with scripting. The second change is that landscape architecture has increasingly aligned itself closer to science, manifesting as a problem-solving attitude. The ongoing concerns of climate change, urbanisation and resource depletion further encourage a solution-focused approach for disciplines like landscape, which includes taking up the epistemological position and 'repeatable' methodologies of science in design. The combined effect has been to disengage with parametric (relationships and behaviours) design and become more reliant on a linear cause-and-effect solutionism. Notably, these attitudes are encouraged by data and technology tools when the designer steps back from a critical position.

The seduction of accuracy (2020–2025)

Thinking about the developments of digital technology and architecture in the 2000s, Carpo (2017) identifies a second digital turn that reframes the digital as 'tools for thinking'. He writes:

> the unprecedented power of computation … favors a new kind of science where prediction can be based on sheer information retrieval, and form finding by simulation and optimization can replace deduction from mathematical formulas.

In contrast to using data to find 'the difference that makes a difference' or to identify high-value problems, exploring simulations through a reductionist process of cause and effect sets up very distinctive conditions for how we approach thinking in design.

For example, a paper discussing the work outlined in the previous section for a special edition of *Landscape and Urban Planning* was rejected due to the lack of scientific methodology. The paper argues for the value of the relative and tactical approaches to thermal sensation employed in the examples of design processes. Despite the paper explicitly setting up a theoretical position, qualitative methods and case study examples of designing with thermal performance in external sites, the reviewers looked instead for an explicit quantification of material performance. Reviewer 2 writes:

> The authors failed to explain exactly what microclimatic consequences each design alternative might bring about and what the underlying mechanisms are. The research was not able to answer to what extent timber regulates the surface heat gain and consequent thermal sensation in the morning sun as compared with concrete and other materials.

Similarly, reviewer 3 rejects the paper because:

> The paper does not elaborate on any of the author's own quantitative research work, but mainly discusses some problems and others' practices.

This example highlights the underlying assumptions in data-driven work that solutions, as designed outcomes, can be gained directly from quantitative research. Despite the extreme dynamism of external environments and the near impossibility of reducing a complex open system like the shifting thermal conditions of a landscape site, it is still assumed that with enough data and simulation power, it is possible to quantitatively derive a clean solution.

This acceptance of solutionism, and its reliance on simulation and data are closely tied to a desire for absolute accuracy and control. These attitudes are best exemplified by the increasing popularity of digital twins. These kinds of models are premised on flows of detailed data aimed at replicating real-world conditions under the assumption that it is possible to capture data on all aspects of a site. Such models are built on claims that information itself is neutral or objective and can be cleanly synthesised into a precise version of the real thing. This creates a kind of paradox in data-driven modelling because even highly detailed models struggle to reproduce the social, cultural and messy unplanned characteristics of real space (Cureton and Dunn, 2021; Gram-Hansen, 2017).

While often driven by a moral position of addressing the urgent questions of climate change and urbanisation, the reliance on reduction reveals a diminishing of critical thinking on how we are establishing the question in the first place (see, for example, Holmes, 2020; Lickwar and Oles, 2015). These shifts in thinking and attitudes are increasingly evident in student work, which demonstrates that they are no longer critical in their design processes and struggle to work with incomplete data. It is an outlook most often revealed in their passive acceptance of what the computer, data or AI tool offers as an answer.

Is this because the generation of digital natives has not known a non-digital design process? Does the easy access to data produce a submissiveness to it? Students seem increasingly reluctant to move beyond the accessible archive of quickly googled site facts and satellite images. Rather than expanding investigations, data richness has constrained the process of site 'discovery', which is central to landscape architecture. More so, these attitudes have extended into design exploration, where students continue to look for the easiest and quickest outcome, rather than engage with the difficulties, complexities and long journey of design.

For example, environmental simulation software is still challenging for design students. While these tools are far more accessible and applicable in design work than they were 10 years ago, many of these programs still require considerable time and effort to run. Among these are CFD simulations, which are mathematically complex and require greater computational power than more common design software. Running simulations requires careful attention to the model parameters, geometry or mesh creation and scale of the intended results. Even then, simulations may not offer the detail or resolution that students would like. Although the results of exploratory testing can still offer useful feedback into a design process, students will often spend time trying to perfect a simulation to make it 'more accurate' in order to find an answer, rather than engage with the ongoing process of defining parameters and adjusting the model as part of a design exploration.

This fixation with accuracy (along with the notion that the computer has the answer) has permeated through students' learning attitudes and into practice. Within the Designing for Heat intensive subject, which runs over four weeks, students are required to work fast and rapidly test ideas for influencing atmospheric performance through design.

Despite extensive design theory and discussion about the role and limitations of the tools, students are increasingly obsessed with the software working ‘properly’ under the assumption the answer lies in this result – rather than looking for behaviours or understanding how the results might inform a design exploration.

The emergence of this attitude can be tied to multiple factors. In contrast to the earlier workflows, which required students to actively script (including understanding the limitations of modelling), the arrival of more user-friendly tools can encourage a more passive assumption that tools will offer the answer. In addition, it is well documented internationally that the COVID-19 interruptions had a huge impact on higher education, including by shifting the role that university plays in students’ lives, which led to a drop in learning engagement (Burki, 2020; Guppy et al, 2022; Sharma and Alvi, 2021; Yang et al, 2024). Reduced engagement can also manifest in looking for the easy answer. From our own observations of teaching across this period, we estimate that our students are producing 30 per cent less work than pre-COVID cohorts.

For example, a quick design exercise asked students to consider a bridge structure on campus, specifically thinking about conditions of heat and the resulting atmosphere around, above and below. When one group’s attention was drawn to the shade occurring under the bridge, their response (figure 5) was to build another bridge above the initial bridge to ‘shade the hot area’. Even with the environmental simulations highlighting the relative diversity of thermal conditions across the landscape scale of the site, the students were only able to identify the hottest part (on top of the bridge) and propose to ‘fix’ that. When questioned about the recursive nature of the problem, meaning that it would not be resolved no matter how many layers of new bridges they added, the students continued to attempt to fix the heat with a shade shelter, rather than engage with the existing and deeper shade found under the bridge.

Figure 5. Student design work on heat showing interventions with a shade shelter on top of a bridge structure (image from Designing for Heat intensive subject, 2023).

This attitude of using the simulation only to identify problems is mirrored in many student responses when working with environmental conditions. Often students emphasise solutions involving object placement, even when faced with fallacies of logic.

In a further example from the Designing for Heat intensive, a group re-drew the wind and solar simulation results as diagrams expressing how they would like the air and light to move (figure 6). In this case, the students were frustrated with the simulation results not ‘working properly’, meaning they could not get the CFD simulation to interact with their proposed geometries in the way they wanted and so they reverted to a diagram depicting something entirely different to the CFD results. These kinds of diagrams are not unique to students and are colloquially known in environmental design as ‘arrows of hope’.

In this example, warm air is shown moving down the proposed chimney structures while cool air moves upwards, which simply ignores the laws of physics. Here the approach to the simulation tool is based on desiring detailed results in a specific area. When these do not show what is expected, the students turn away from the simulation entirely. In doing so, they also fail to examine or interrogate the simulation for what it does show – where wind effects occur at a different scale, or how the design might respond to the emergent or surprising discoveries.

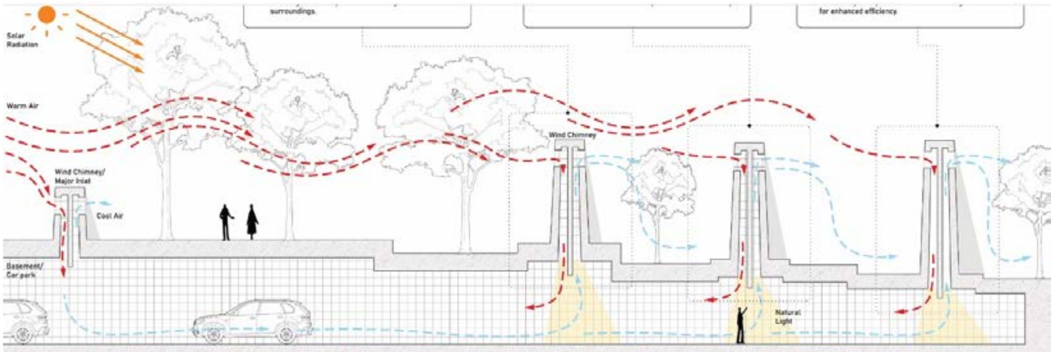


Figure 6. Student design showing air flow moving up and down proposed chimney structures (image from Designing for Heat intensive subject, 2023).

These student responses highlight some of the most worrying attitudes and thinking about data, tools and the role of design. While we also have recent examples of better work, the cases presented here clearly illustrate the trend in student attitudes and approach to learning. Perhaps most troubling within this trend of perceiving design as only problems and solutions, and the concurrent setting aside of common sense (bridges on bridges and cold air moving upwards), is the lack of curiosity about the relationships and behaviours that are at work in designing with thermal conditions. Wind simulations are imperfect and it is acknowledged that inaccuracies arise when working with digital CFD, particularly in the open system of an outdoor environment (Tominaga et al, 2023). Whereas trained environmental engineers can achieve precise and detailed results, accuracy is more limited for designers engaging with CFD tools. Despite this, CFD can still offer important insights into wind behaviours and interactions that are otherwise difficult to grasp. Such simulations, alongside other data and tools for solar intensities and energy effects, can reveal atmospheric effects as a tactile and rich material for design if understood as tools for discovery and exploration, not just simple answers.

These are not new ideas. Forty-six years ago, Lisa Heschong (1979) published *Thermal Delight in Architecture*, calling on designers to engage with thermal diversity and difference. Because of data and simulation tools, these effects of fluctuating thermal effects have never before been more tangible to designers. Yet we are seeing little interest in thermal delight or atmosphere as material from our students, particularly in comparison to an earlier generation.

In many ways, this experience accurately reflects Gartner's well-known hype cycle of technology (figure 7). That is, the initial expansion of data and simulation tools towards design represents a major 'peak of inflated expectations', only to be followed by a 'trough of disillusionment'.

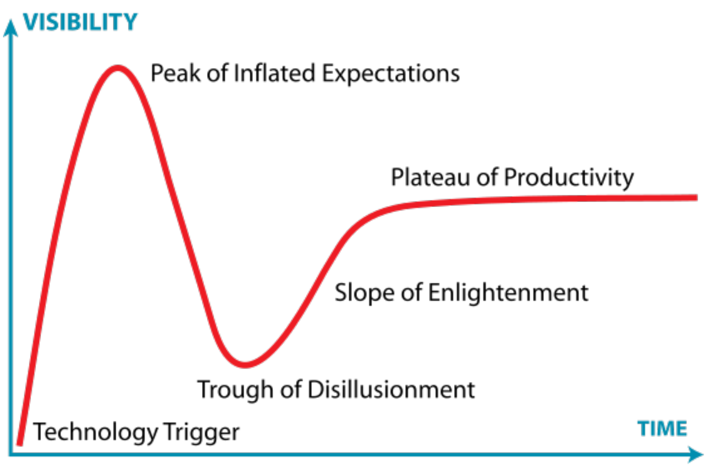


Figure 7. Gartner's hype cycle of technology diagram (image by Jeremykemp at English Wikipedia is licensed under CC BY-SA 3.0).

If the hype cycle continues in its usual course, technology users interrogate the tools more closely and rebuild them towards a 'plateau of productivity'. But are we on the upward slope of enlightenment? The constant move towards efficiencies, more data, AI shortcuts and 'hacks' suggests not. Instead, the rise of technology seems to be affecting a work ethic towards thinking less, not more. In explaining this phenomenon, Sun-Ha Hong (2020) suggests:

> The pursuit of machinic objectivity calls on human subjects to know more than they reasonably can, and in their failure to keep up, defer to new institutional arrangements of recessive and opaque technologies. (p 181)

These effects are becoming better documented in research on higher education and pedagogy, and on the major impact that AI is having on education. While some write on the opportunities of AI for advancing learning tools, scholars are also noting the negative effects on intellectual development over time (Asio and Gadia, 2024; Chan and Hu, 2023; Gimpel et al, 2023). A particular concern is for the development of holistic competencies, including creativity and critical thinking, when students presume they can bypass these independent cognitive skills with AI shortcuts. For example, in their systematic literature review on the effects of AI on students' cognitive abilities, Zhai, Wibowo and Li (2024) explain:

> students in research and education might depend too heavily on AI-generated content, neglecting the development of their ideas and original thought processes. This dependency can foster complacency, making students less inclined to engage deeply with the material or develop essential problem-solving skills. (p 31)

The damage that this attitude could have on design education is potentially vast, challenging the very premise that design is an exploratory and open-ended endeavour.

Conclusion

Landscape architecture is faced with a daunting future. External environments are at extreme risk under climate change effects of heat, drought, human demands and weather events. Designing into this uncertain future demands both rigour and curiosity. Simulation tools and data offer designers immensely valuable insight and information, but they cannot provide a straightforward answer to immeasurably complex questions. In other words, having more data will not in itself translate into a solution. As Cureton and Dunn (2021) explain:

> The abundance of 'real' data arguably is not a direct correlate for improved design, nor can it remove the unpredictable or 'black swan' events of near, middle, and far futures … Modelling closer to reality doesn't necessarily translate to making better spaces, and the designer's role is most critical here. (p 247)

Here lies the rub. The seduction of data accuracy lures designers and students into believing that the world can be replicated and controlled. But in that struggle for the perfect digital 'model' or accurate simulation, the understanding of the real world as incomplete, messy and unexpected is overlooked. As landscape architects, we should know this best, because the external world is in constant flux. Designing into dynamic landscape systems and environmental processes presents major conceptual and physical differences from the controllable indoor environments that heating, ventilation and air conditioning engineers and architects work with. Yet our more recent generation of students is failing to understand this difference.

Where does this leave design educators? First, it highlights the need for our design processes to work across the physical and digital worlds. Unlike the selective factors driving the digital model, the physical site is the ultimate 'proof of concept' bringing together the complex factors that underpin landscape. 'Digital twins' will only ever engage with a small fraction of the landscape condition. Second, in the rapidly unfolding era of AI it is becoming clear that critical thinking is the number one skill to encourage in our students. In terms of technology, this translates into developing understandings of what is 'in the black box', meaning what values, algorithms and parameters are driving the solution. And finally, this paper is a warning to not be enticed into chasing unattainable precision at the expense of design as a critical and creative practice. Rather, it is important to consider the value of these tools as a pursuit of possibilities. As Simone de Beauvoir wrote in 1948, science fails when it is consumed by the 'quest to attain and capture being', but it finds truth as 'free engagement of thought'.

About the authors

Associate Professor Jillian Walliss is interested in the relationship between theory, culture and contemporary design practice. She works across multiple platforms including digital media, exhibition and festival curation, guest editing of books and journals, along with writing for a wide range of academic and professional journals. Her research is characterised by strong links to design practice.

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