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Article

The Modern Campus Fails as Pedestrian Space

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Abstract: The challenge of campus design, like other aspects of contemporary environmental design, reveals a serious problem in education and practice. The foundational design theories of a century ago have been exposed as an obsolete way of thinking about cities, human nature, biological nature, and even the nature of mathematical and physical structures. Yet in practice, these discredited models persist, obscured by new theoretical language and extravagant "neoplastic" forms, but embodying persistent though untested ideologies and driven by systems inertia. This paper considers the campus design typology (including business campuses, commercial districts, hospitals, and schools) as a design paradigm for pedestrian public space with implications for human flourishing and well-being. We propose a specific human-oriented design method to encourage the well-being of occupants and improve the outcomes for creative development, education, and health.

Keywords: pedestrian realm; campus design; public space; urban space; path-network; university layout; Christopher Alexander; Jane Jacobs; Visual Attention Software

1. Introduction

The contemporary design of the campus — including business campuses, commercial districts, hospitals, and schools — reveals a remarkable persistence of early 20th century theories of architecture and planning that have since been widely discredited. Yet their negative influence can be seen in many different campus designs today. Their organizing patterns work against the functioning of the pedestrian space that is the driver of activity in the complex. This paper will focus on the university campus in particular, although the results also apply to the other kinds of buildings grouped around one or more pedestrian spaces.

The specific topic here is campus design, yet we have a much broader aim. The present discussion uses campus design as an example of two fundamentally different order-creation regimes in the built environment. Those contrasting urban typologies are generated in response to the living qualities of the space adapting to pedestrian experience and movement. An adaptive typology, termed "biogenerative structure", contrasts with and negates the neoplastic structure that seems to be built all over the world today. Neoplastic structure includes contemporary fashionable designs, swoopy and wildly innovative, but also early stripped down and "pure" forms (which were new in the 1920s), all of them "new for the sake of newness". We will argue that those open spaces are profoundly unsatisfying from the human-centric point of view, and degrade the user experience of the pedestrian space.

The dual crucial concerns of the human-centric approach to campus design are: (*i*) the users' psychological perception of the urban space as it couples to its surrounding building façades; and (*ii*) a cognitive grasp of path-connectivity from the ground layout. Yet these cornerstones play no role in the standard design process. The "neoplastic type" campus arises from a conceptually limited approach to design and planning. Building massing is envisioned in miniature models that are judged on their visual attraction — from a distant perspective — as abstract sculptures. A design

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approach that focuses on the isolated building, however, tends to create fragmented, left-over open space. Planning strategy focuses on creating an abstract artistic composition of building footprints and built paths and plazas, whose visual appeal is judged strictly from an aerial view. Neither component of the neoplastic type of campus design (architectural or planning) involves human-centric considerations.

Even though this paper focuses on the structures that define a campus, its purpose is to argue for more human-oriented design of pedestrian spaces in general. The human health dimension comes from the connection established between anxiety and stress generated from the geometry of the environment [1–3]. While the topic of environmental contributions to stress-induced immune dysfunction is well-studied, most researchers either neglect the specific effects of the geometry itself or relegate those to a minor role. This is what we wish to focus on here, and we will do so from the architectural and urban design perspective rather than the medical one.

Fitting environmental structures to the human body's physical dimensions (ergonomics), while essential, is only one part of human-centric design. Even more important is satisfying connective and interpretative mechanisms coded in the human neural system, most of which go back to our pre-human ancestors. Those reactions — primarily unconscious — to environmental information shape the body's actions by triggering anxiety and stress versus positive emotions and impacts. Biophilia denotes the affinity humans have for animals, biological forms, and plants. Whenever a setting elicits positive responses, the environment contributes to human health and well-being. Adaptive design coupled to moral concerns minimizes harm to users and optimizes for long-term sustainability, since users enjoy the spaces in a visceral manner.

We postulate an analogy to other public health issues with implications for well-being and human flourishing. Major industries extract profits from society by promoting unhealthy habits and products through a narrative driven by public relations. The public consumes those products, and engages in those practices, because the mainstream media obscure data from health professionals (while, in the darkest instances, the profession itself contributes to the deception). Such is the case with the architecture-industrial complex, which has been highly successful in selling the "modern" style of campus criticized here. Widely-publicized images of futuristic design influence attitudes, values, and behaviors of individuals and whole societies. The result is the proliferation of pedestrian spaces that are not loved because they generate anxiety.

2. Content and ideas of this paper

2.1. Two contrasting philosophies for campus design

This study will focus on the morphology of the "quadrangle type" campus, a very old and successful pattern, versus what we are calling the "neoplastic type" — the imaginatively distorted and irregular permutations of earlier "modernist" models of planning and design. The quadrangle type of land use privileges open pedestrian spaces that are defined by being partially surrounded by building façades, where the buildings shape the urban space rather than standing alone. Furthermore, the gardens and pedestrian plazas are connected by a network of paths that are themselves well-defined longitudinal open spaces. Examples of this planning typology include the first hospitals, monasteries, and religious buildings of all denominations found throughout the world. Historically, when building complexes were assigned to learning institutions, the quadrangle type campus was a natural choice for housing the first universities.

Recalling the original design purpose of those early religious institutions, their layout and geometry were optimized to create a protected psychological state, in which the individual would be free from the stresses of the outside world. The campus was meant to provide an environment for contemplation, reflection, and thinking about higher questions. Its geometrical qualities were essential towards achieving this aim.

In our times, the commercial mall (either open or closed) uses similar motivations to promote commerce by creating an attractive pedestrian environment around which shops and restaurants

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cluster. Intrusive design elements that might create anxiety are not tolerated, as those would sabotage the welcoming psychological ambience meant to put the user in the proper state of mind.

The "living" nature of the most successful open space includes pavement, enclosed plants, street furniture, and surrounding walls as one coherent large-scale entity. The widely influential architectural theorist and critic Christopher Alexander called this geometric ensemble the "hull of public space", which envelopes people like the open hull of a boat [4]. Alexander described how the cognitive and psychological experience of a successful public space is the key to a successful city, whose "living" parts, moreover, consist of precisely such spaces. The living city derives from people's interaction and movement; hence it depends upon a particular urban structure that contains and catalyzes such activity [5,6]. By contrast, locations where the built components plus paths of movement fail to define a coherent place simply do not work to sustain the life of the user in a holistic manner.

Scales matter more in biogenerative architecture than in neoplastic architecture, where they are an afterthought, if they are addressed at all! A main feature of our analysis is to link all the distinct scales within a theoretical (fractal) framework, not only at the urban scale, but also in the building and even in details, etc. We are not talking about biomimicry (which has often been misused to create sculptural buildings that fragment their surrounding public space), but of mathematical design constraints derived in parallel with neuro-architecture. Importantly, the echo of neoplasms or cancers is not an accident, e.g., as discussed in Ramray Bhat's seminal paper [7].

Both Alexander and Jan Gehl approached urban structure from the perspective of prioritizing in-between and open spaces over individual buildings and roads [8,9]. There is a preferred sequence to design this correctly. First design the open pedestrian places, then their protected connections, then the buildings, and as a last step connect everything with roads without disturbing what is already in an optimal position and shape. Although this approach to the built environment has not yet entered mainstream urbanism, it is nevertheless responsible for a large number of prominent and successful commercial projects [10]. In a parallel thread, traditional architects and "new urbanists" promote urban design rules that had not been applied since before World War II, to design and revitalize urban places that are now much-loved by the public [11–14].

A complementary model to the quadrangle type of campus historically sets buildings sensitively in a large lawn, together with additional vegetation. While the traditional landscape campus is successful, and often blends with the quadrangle type, the 20th Century's abstract aesthetic altered the design basis. Three fundamental changes took place: (1) the landscape architecture became random so that the placement of paths and plants no longer has meaning *for someone navigating the grounds*; and (2) the positioning of different buildings on the campus site plan is not meant to create attractive in-between and open spaces; (3) the buildings' architecture abandoned organized complexity of the façades for either an empty minimalist aesthetic or a broken Deconstructivist one.

To prepare readers for the comparison between the neoplastic and quadrangle types of campuses, we summarize some contrasting features in the following table. These will be explained in the body of the paper.

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Table 1. What differentiates the neoplastic type of campus from the quadrangle type. Practical elements or geometric structures to be considered when designing open spaces in a new campus.

Geometric structures	Neoplastic type campus	Quadrangle type campus
Planning strategy and design sequence	Create an abstract artistic composition of building footprints, built paths, and plazas (judged from an aerial view). Shape everything — footpaths, gardens, plazas, street furniture, etc. — around each isolated building to showcase it.	Apply adaptive design considerations, involving cognitive and psychological experience and emotional feedback from the user. First design the open pedestrian places, then their protected connections, and then situate the buildings.
Building massing and positioning	Buildings judged as abstract sculptures with their visual appeal emphasized from aerial and distant views. From up close, one sees isolated buildings as gigantic sculptures floating within an amorphous sea of public space.	Building façades partially surround open pedestrian spaces, with the building edge inviting people to approach, sit upon, walk alongside, etc. Emphasize visual appeal and complexity at key pedestrian spots.
Geometrical ordering of open spaces	Large formal built structures on a campus create fragmented, left-over open space that is amorphous and fragmented. Self-centered buildings offer a convex outer edge that encroaches upon external space. The building shape does the opposite of "embracing" the adjacent open space.	Create human-scale open and green places, going up in scale to a monumental space. Have many small spaces, a middle number of middle-sized ones, and a few very large ones. Pedestrian space couples psychologically to its surrounding building façades and defines a convex outdoor realm.
Scaling in architecture and planning	Formal images impose abstract large scales, erasing most intermediate and smaller scales. Non-fractal structures are either minimalistic, random, or embody monotonous repetition.	Urban and building scales and even the details all cooperate through alignment and symmetries. Fractal (scaling) symmetries cooperate with other nested symmetries that emphasize the vertical axis.
Building façades	Misaligned windows negate symmetry and verticality, designs lack organized complexity, and use a generic techno-modernist style, with large amounts of glass and shiny metal walls. These do not register unconsciously, and can even be menacing and uninviting to pedestrians.	Morphological features embody organized complexity, including placement of windows into cognitively pleasing relationships. Attractive because they beckon to the pedestrian unconsciously. Design for the specific site, with adaptive materials to focus vision and touch.
Pedestrian psychology	Expects a person to cross a wide-open (exposed) space through its middle. Paths are decided in the architect's office, ignoring human psychology on experiencing open spaces. Random landscape design full of pointless obstructions frustrates a person attracted to walk towards a spot but cannot get to it directly.	People will choose to walk under arcades and create their own paths in more meaningful, protected settings. Strong pairings that add functions to campus space include low walls running along one side of a path; paths running alongside lawn edges or pools; paths along the landing of wide stairs.
Entryway approach and transition	Entrance is either invisible (indistinguishable from a glass curtain-wall) or menacing (a dark slit beneath a giant cantilever). The entrance	Entrance is easily visible from all points of approach and is designed in a psychologically inviting manner. Arches, columns, framing, ornament,

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	transition is either abrupt (an opening cut into a concrete wall with no frame or space for the body to adjust) or ambiguous and inconclusive (passing through a glass curtain-wall).	and symmetries help to achieve this aim. An entryway accommodates social activity, with the process of entrance transition shaping the engineering structure.

In spite of new and better models of urban structure based on neurological user feedback that discredits design abstractions, the way of planning a university campus as isolated buildings floating within an amorphous expanse of public space is still widely adopted. Partly this is the result of persistent institutional incentives, partly of the power of imagery and still-profitable image-making, and partly the lack of curiosity about what creates a built environment adaptive to human biology and psychology. That knowledge has been steadily discovered over the past several decades, including the re-discovery of design tools that were sidelined and forgotten during the rush to become "modern" [15–18]. Institutions today need a new understanding of viable alternative design models and practical indications on how to implement them.

The core misunderstanding of how interior and exterior space is really felt and used by human beings comes from a persistent fallacy about the modern relevance of ancient evolutionary patterns of human space and place [19,20]. Design that is based on untested assumptions and ideology and anchored on wishful thinking has replaced genuine knowledge, without the mainstream profession investing resources in checking the validity of its practice. It is time to call out this anti-scientific fallacy once and for all. Failure to understand this is leading the world to build ever more inhuman cities, which deplete natural ecosystems as they burn up fossil fuels in drifting towards global catastrophe. This issue of sustainable development has been extensively addressed, and guidelines set for cities that will benefit society and the environment [21–23]. We and other researchers emphasize human-scale, low-tech solutions over extravagant techno-fixes that perpetuate gargantuan glass-and-steel building typologies. The current paper sets out emotionally-attractive pedestrian space in campuses as a motivation for maintaining the ensemble over time.

The present study extends our previous suggestions for human-centric campus planning [24,25]. The rubric in planning university campuses is more manageable than the entire city since it sets limits of function and region [26,27]. It is the paradigmatic example of a pedestrian environment, except when the institution is situated in a city center. A campus has a much lower level of complexity linked to urban functions, while the mechanisms impacting different human activities can be better controlled. For this reason, campus planning provides an excellent case for applying design tools that generate living spaces.

The perceptive observer can recognize a fundamental difference between older campuses and their buildings, and the campuses and buildings of the later 20th century up to the present day. It is not just that the former buildings had traditional forms and patterns, with perhaps charming aesthetic characteristics (which some prejudiced observers would classify as "dated"). It is that the deeper geometrical structures of the two place types are fundamentally different [28]. That difference exposes a dangerous lack of design knowledge in both the profession and among the decision-makers who continue to commission architects ignorant of the basic principles of adaptive campus design.

2.2. Organization of this paper

This paper is necessarily long and encyclopedic in its coverage because there are so many things wrong with current design practice. We are trying to fill in the knowledge gap for a profession that willfully jettisoned its accumulated tools for adaptive design. The powerful transformation of cities and the world towards ugly industrial images has come from a change in human consciousness.

The theories of Christopher Alexander (Section 3) and Jane Jacobs (Section 4) about the organization of city structure privilege pedestrian flows and the human scale of public space. Alexander's essay "A City is Not a Tree" and Jacobs' book *Death and Life of Great American Cities* set the stage for questioning modernist planning orthodoxy by considering adaptation and complexity. More recent research uses mathematics and science to verify those earlier insights. Utilized — and

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well-loved — spaces turn out to be fractal, combining different scales in a coherent manner (Section 5). This is the conceptual antithesis of empty, homogeneous, and monotonous plans, and is exemplified by historical campuses and urban fabric.

An excursion into neuroscience and psychology brings us to Alexander's "design patterns", an older design tool that, while very popular among the public, never influenced dominant architectural culture (Section 6). Medical measurements distinguish between healing geometries and those that generate anxiety and stress; results now being documented. It turns out that Alexander and his colleagues anticipated this program by collecting socio-geometric configurations responsible for user well-being into *A Pattern Language*, and we list some patterns relevant to campus planning. We supplement Alexander's original patterns with more recent patterns that we developed.

Section 7 discusses the qualities that we claim lead to user well-being on a campus. Most of these qualities are missing from campuses built during the past several decades. The remainder of the paper builds up arguments to support this conclusion, and tries to answer the question of why it happened.

The scientific core of this paper is a comparative analysis using 3M company's Visual Attention Scans to evaluate two campuses in China: a traditional one in Huize (a former temple complex) versus a contemporary university in Guangzhou (Section 8). Eye-tracking simulation software shows overwhelmingly more engagement with the traditional campus, in every comparison. Introducing design tools to create such engaging environments today, the "feeling map" combines with "walkabout design" to help plan a human-centric campus (Section 9). This method was used by Alexander to design and build the highly attractive *Eishin School* in Japan in 1985.

Section 10 discusses several related topics underlying school design today with which we disagree. Minimalism destroys living structure by being anti-fractal (Section 10.1); campus design has moved in a direction opposite to human-centric planning, but which is unnoticed by society (Section 10.2); patterned pavements offer a neglected method of achieving an emotional connection to the ground (Section 10.3); entryways need to be visible and attractively designed to both promote coherence of the open space, and to facilitate the entry transition (Section 10.4); attractive promises of techno-modernist design are deceptive and have never delivered (Section 10.5); campus design follows the superheated real-estate model of glass skyscrapers in city centers as the worst precedent for a pedestrian environment (Section 10.6); the distribution of windows on a building façade influences the engagement of someone with the lawn or plaza in front (Section 10.7); the biophilic effect requires that built structures reinforce the vertical symmetry axis, otherwise users experience anxiety (Section 10.8); despite massive documentation of how color affects learning and well-being, new campus buildings tend to avoid color harmony (Section 10.9); architects have for several decades confused formal with monumental planning, with drastic consequences for new campus layouts (Section 10.10).

Section 11 digs deeper into the underlying philosophy behind the design approach known as the myth of "architecture of our time". This idea has become a central part of the collective narrative, so that it is nearly impossible to criticize it. And yet accumulating scientific evidence shows how the product fails its users. Project decisions are not made based on science but according to an established narrative fed by vast commercial profits, exploitation, and special interests. Our conclusion, Section 12, expresses the hope that humankind can see new, living campuses generated by applying human-centric design tools such as those described here.

3. Christopher Alexander's insights

The story is best illustrated with a landmark critique from the 1960s. We will review here the trenchant insights of Christopher Alexander and Jane Jacobs, widely talked about but still not implemented by mainstream construction and planning.

In 1965, the architect Christopher Alexander published a widely-cited paper on the essential structure of lively human spaces [29]. "A city is not a tree" made the simple but powerful observation that urban spatial relationships, and those of settlements in general, did not form neat tree-like hierarchical structures (where the system is driven by a top-down branching hierarchy). Instead, they had overlapping connections — what we would recognize today as web-networks (sometimes known as "peer-to-peer" or level systems) [30]. These distributed networks are the essential connective structures of the Internet, of ecological systems, of biological systems, of many other systems in the natural world — and even of the human brain [31]. By contrast, tree-like systems characterize totalitarian political systems, and also fragile artificial systems that are incapable of self-repair [32].

What Alexander pointed out, however, was that the human mind is in the habit of neatly segregating mental objects into tree-like categories, stripped of their overlapping complexity and linkage of scales. This simplification makes cognition easier, even as it loses essential information. The most obvious example is the way buildings are planned as singular objects, swimming in a sea of undifferentiated public space. This model was one of the foundational organizing concepts of early 20th century modernist practice — and Alexander's remarkable contribution was to show, through a mathematical analysis, that it is woefully inadequate.

Alexander's "A city is not a tree" had a considerable impact in its day. Robert Campbell, the Pulitzer Prizewinning architecture critic for the Boston Globe, later said that Alexander's work "had an enormous, critical influence on my life and work, and I think that's true of a whole generation of people." He went on to describe how the 1965 paper "really blew away what were the foundational principles of the education at Harvard in those days."

That educational system had been established by Walter Gropius and his colleagues, leaders of a movement whose modernist ideas were based on the simplistic rationalization of the city — a more orderly and sanitary place, promising to be able to better promote human health and well-being [33,34]. But the "architectural cleansing" they proposed had its dark side, as is now obvious. Visual clarity comes because myriads of necessary network connections are cut; it is those that make a city human, but which appear as "messy" to architects ignorant of living processes [35,36]. As many critics have pointed out, the concept of neatly segregating the human environment into zones and functions has left us a world of dysfunctional and unsustainable settlements [37,38]. We now rush to slap on solar panels and chia walls, but somehow, the defects of the underlying structures persist, and even grow worse.

Alexander concluded his paper on network connectivity with a warning:

"For the human mind, the tree is the easiest vehicle for complex thoughts. But the city is not, cannot and must not be a tree. The city is a receptacle for life. If the receptacle severs the overlap of the strands of life within it, because it is a tree, it will be like a bowl full of razor blades on edge, ready to cut up whatever is entrusted to it. In such a receptacle life will be cut to pieces. If we make cities which are trees, they will cut our life within to pieces."

As in many similar historical instances, a contemporary Cassandra warning of dire consequences was ignored, as the building, construction, and planning professions had other priorities. Since the related industries were making enormous profits applying the wrong ideas, why bother to change a successful business model? And, those societal entities that were supposed to represent the interests of the user simply relinquished their role and supported the global machine generating quick, easy profits (and serious long-term problems for humanity). Criticism of the defects of the geometry as far as human experience was concerned was ignored, while a steady stream of public relations sponsored by the profession kept the public ignorant.

4. Jane Jacobs and "organized complexity"

Around the same time, another perceptive critic made a landmark contribution to the modernist critique. *The Death and Life of Great American Cities*, by the architectural journalist Jane Jacobs, had, if anything, an even greater impact on the understanding of the deficiencies of the orthodox planning and design of the day [39]. But it was in her last chapter that Jacobs made an incisive analysis of the structural deficiencies, not unlike Alexander's. Planners were mistaking cities as problems of two-variable systems, or of statistical systems, with many variables operating at random. Instead, Jacobs said, cities were problems of "organized complexity" — many variables interacting within a web-network of relationships, working at many scales.

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We could apply that critique to a campus plan. In the old way of thinking, a building might be one variable, and its public space setting might be the other. Then a solution might be to put them into some kind of rational relationship on the plan, with a tree-like configuration of buildings connected to public spaces. But within the public spaces, one could treat the elements (people, trees, etc.) as random statistical populations. The buildings could "swim around" in the public spaces, with no consequences for how well the campus actually functioned.

Yet that is not the way space is cognitively organized or utilized. Jacobs uncovered a basic misunderstanding in spatial planning: designing a plan on paper (that was then; it's done on a computer screen nowadays) can never capture the actual use of the result after it is built. Paradoxically, neat geometrical ordering of buildings on a campus very often represents a random and illogical complexity as far as the path-connectivity for pedestrian users. What does organize the spatial complexity is the network and shape of open urban spaces, which is a design task that most campus planners are unable to achieve. Simply put, professional training prepares designers with the wrong tools for their job.

5. The fractal structure of space

As Alexander and Jacobs pointed out, simplistic geometrical ordering is not how great places actually work. (This refers to aligning buildings on a plan like children's blocks along a line, curved or straight, and the footprints of the buildings themselves being unnecessarily boxy.) Rather, living places have a very distinct structure of public, private, and semi-public and semi-private spaces. This structure has the characteristics of a mathematical "fractal" — that is, a pattern or structure that repeats at large scales, small scales, and many scales in between. In the case of human-scale spaces, this "fractal" is the essential structure of a room — a structure that separates (with walls) but also connects human spaces (with doors, windows, etc.). Interpreting architecture and planning in terms of fractals is now a robust research discipline (with references below).

In the case of a room, we recognize that it is important for the people using it to control their degree of connectivity, as one node in a comfortable network of spaces. So they can open doors, close windows, draw blinds — or even lock the doors if they wish. Sometimes, the room-type structures don't need strong enclosures — they can be defined more loosely, with columns or other elements.

As we have observed in a research program on the importance of symmetry for human well-being [40,41], cities are made up of exactly these kinds of structures — not only at the scale of a room, but at the larger scales of room-like spaces outdoors (porches, galleries, balconies, yards, streets, squares, parks…). These structures extend to smaller spaces that represent the decreasing scales of fractal structure (small rooms, alcoves, bay windows, cabinets, drawers…). "Living" spaces need the range of connected, embedded scales best illustrated in plants: e.g., trunk, branches, clusters of leaves, leaves, veins on a leaf, etc. to accommodate the wide range of human activities and spatial psychological needs [42–48]. Fractal properties are required of building façades, surrounding boundary walls, and the articulation of the space itself. A fractal — whether it is natural or one generated mathematically through recursion — ties all its different scales together into a coherent whole.

Importantly, these connected spaces afford control of how public or private they are, partly through their permanent structure, and partly through the ways the users can change them. A back room of a house with a lockable door affords the most privacy. A front yard affords very little privacy — and yet it is not a public space. (Often, useful enclosure is defined with a hedge, fence, or other semi-permeable structure.)

Neuroscience experiments support mathematical results showing that pleasurable urban experience is contingent on seeing natural-like fractal structure [49]. The recruitment of what is called the Default Mode Network of the brain (a functional network mostly related to "internal" thought processes, as opposed to task execution) during the visual perception of fractals [50,51] can be considered as an indicator of their privileged state in terms of perceptual fluency (which is the ease by which information is processed in the brain).

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If one looks at the great urban structures of the world, this fractal structure is quickly evident. Below is a famous 1748 drawing of Rome by the architect and surveyor Giambattista Nolli. It shows the figure-ground relationship of the city's buildings, and their readily apparent fractal structure. There are many different and interconnected enclosures of public or open space (the white "ground") defined by the private or built space (the shaded "figure"). There are many small ones, a few very large ones, and a middle number of middle-sized ones. Sometimes the definitions of the spaces come from walls or buildings, sometimes by columns. Sometimes the spaces are within buildings, sometimes outside — and sometimes, they are complex networks formed of both kinds. The entire structure forms a complex tapestry, and indeed, one of the world's great cities.

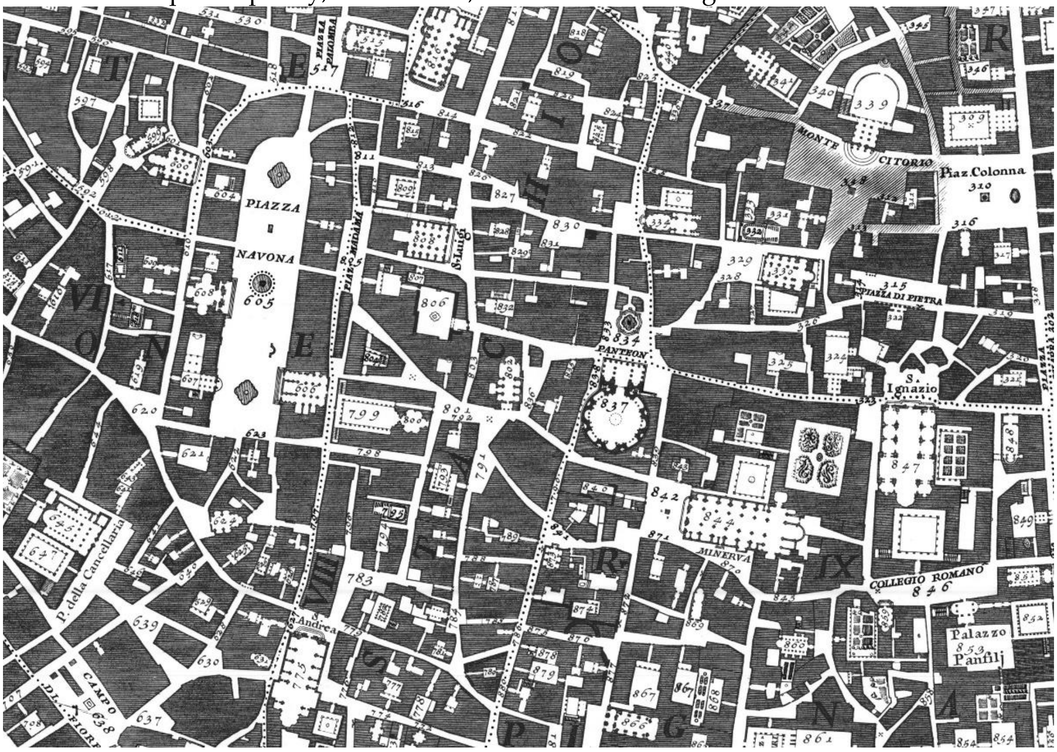

Figure 1. Plan of interior and exterior spaces of Rome, by Giambattista Nolli. Image in the public domain.

The same thing can be seen in the structure of university campuses. Below is an aerial photograph of the campus at the University of Cambridge. Once again, it is possible to observe a highly fractal structure. There are many interconnected spaces, a few large ones, many small ones, and a medium number of medium-size ones. If we were to observe the architectural plans, we would see the same fractal pattern extending right into the buildings themselves, just like in Nolli's plan of Rome. The whole structure is a rich tapestry of spaces. Most importantly, the web-network of connected interior plus interior spaces is what organizes the entire built complex so that it is experienced as a living environment.

Figure 2. Aerial view of Cambridge University, UK. Image in the public domain.

Interestingly, the dual fractal structure (building/space) can be seen extending down in scale in a way that connects intimately with human users. For the physical structures, the fractal goes down into the building details — the patterns of dormers, towers, dentils, and other features that also form the very appealing rhythm of the place. For the spaces, the non-homogeneity of the surrounding walls and borders provides a non-smooth boundary that defines smaller and smaller pieces of volume to be experienced by both tactile and visual senses. This fractal description rules out the 20th century obsession with surrounding all public spaces with smooth glass curtain-walls.

The latest findings recommend that a campus show fractal structure, both in its urban layout (horizontal ground), and in the architectural design of its building façades (vertical boundaries), down to the exposed materials, plantings, and street furniture. This is a scientific, not an architectural conclusion, because it is based on how human neurophysiology reacts positively to fractals but negatively to smooth, minimalist shapes and surfaces [52]. Fractals are only one obvious component of “living structure”, which combines physiological mechanisms such as biophilia to enhance the users’ health. We turn to those other factors next.

6. The link between biological aesthetics and psychological health: design patterns for campus spaces

The relationship to the aesthetics of these architectural details and their fractal structures is not a coincidence. We are now learning from a number of fields — cognitive psychology, environmental psychology, neuroscience, and other research disciplines — that the experiences we have of our environments are intimately related to our evolutionary history and our ability to discern environments that are conducive to our own well-being. Just as we perceive the appeal of a larger enclosure that affords us protection as well as views — so-called “prospect and refuge” — we perceive the appeal of smaller structures that form enclosures, boundaries, centers, groups, and other cognitively-pleasing relationships.

Planning a campus by prioritizing healing effects of its geometry and spaces will necessitate a complete change from current design practice. This paper explains what those changes are. Medical findings that underpin how built structures affect user health need to be incorporated as the basis of a new design paradigm [53,54], as we describe in the following. None of these techniques are currently taught in architecture schools, and a professional designer needs to pick those up from the medical literature (a task for which architecture graduates are not trained for).

To begin with, people navigate an open space under the unconscious influence of their neural system, which is continuously reacting to environmental information [55,56]. Just crossing a campus lawn or plaza is not the straightforward process that one usually imagines, but depends on time-changing feedback that generates emotions. For this reason, the standard method of designing campus footpaths abstractly in the architect's office is to be condemned because it can lead to the users' experiencing stress.

The "thigmotaxis" effect describes how animals choose to move close to a physical boundary or wall that provides psychological protection [57–59]. Crossing a wide-open (exposed) space through its middle is not a frequent occurrence, and it occurs most often where physical or visual indicators aid such a trajectory. The same behavior, unsurprisingly, is seen in human movement, where people will choose to walk under arcades — where those are available — because of the feeling of partial enclosure. Innumerable studies on the use of public space reveal how pedestrians ignore the carefully-planned concrete paths that cross unprotected open space, to instead create their own paths in more meaningful, protected settings [60,61]. This is a physiological explanation of decades of such "rebellious" behavior, where users refuse to conform to the architect's design imposition.

Much of the core of a campus should be pedestrian because of its special circumstances and needs (the exception being an institution in the city center). This allows the creation of courtyards and smaller outdoor spaces. Vehicular traffic flow is made tangential (i.e., touching the campus on its periphery) with through lanes for service vehicles placed underground, and using sensitive planning to protect the pedestrians. The main psychological effect is for a pedestrian to see — from a not-too-distant perspective — whether the pedestrian ground couples visually with the building façades. The building edge thus assumes a main role that has been ignored by mainstream design. Christopher Alexander called this *Pattern 160: Building Edge* [19]. He and his co-authors point out that an attractive building is oriented towards the outside: its edge is a *place* with discernable volume whose complex geometry invites people to approach, lounge around, sit, walk alongside, etc.

Normally, one might call such a building "beautiful" (or conventionally-trained architects might condemn it as "old-fashioned"), but this misses the essential mechanism at play. A positive effect is happening at the building/ground interface. The façade is felt to be beautiful because it beckons unconsciously to the pedestrian instead of not registering at all, or even being menacing to discourage approach. An inviting edge and front elevation encourage walking towards such a building. For this reason, surrounding buildings can catalyze people to use multiple cross-paths in an open space, and that space will then feel "alive". An adaptive geometry for the building edges energizes the lawn or pavement for which those buildings define a border.

Basic psychological responses lead to a common-sense design rule for the campus open space: e.g., do not place physical impediments to paths that cross the space, such as inaccessible lawn, low walls, changes of level, stairs, steep sloping ground, monumental sculptures, commemorative structures, pools of water, etc. [26,27,62]. The position of those elements may look attractive from the air, as an abstract composition, but will ruin the pedestrian experience of the plaza by fragmenting the potential flows. An open space ought to avoid changes of ground level, and use the built elements to helpfully reinforce a system of cross-paths instead of blocking their spontaneous generation.

In our previous analysis [26,27] we detailed how the landscape architecture of a campus should be designed to reinforce all the potential paths that connect the buildings and endow the open space with "life". Built elements on the ground running parallel to and next to each other should couple with and reinforce each other, whereas the same elements crossing each other impede any unrealized flows. Some examples of strong pairings that add functions to a campus space include low walls running along one side of a path; paths running alongside lawn edges or pools; paths along the landing of wide stairs, enabling the additional function of people being able to sit on the stairs, etc.

This kind of environmental aesthetics is not the same as the aesthetics created by artists. It is instead a matter of public health, as the wrong geometries force users to experience constant stress while they navigate the environment. A stressful architectural experience cannot be avoided if a person needs to accomplish a task there. As Jane Jacobs observed, we need art in cities, to enrich and illuminate the life around us. But the framework of our lives, our buildings and our cities, must not be an abstract work of art — because to do so would be to force people to live, in effect, within gigantic sculptures. This amounts to a massive confusion between art and life, as Jacobs also observed. The result, she stated in her characteristic withering prose, is neither art nor life, but taxidermy.

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Design patterns that combine biological aesthetics with psychological health and well-being have already been documented. A specific aspect of the built environment requires certain constraints that couple structure with function in a way that enhances positive feelings, otherwise it doesn't work well. For those who have not worked with design patterns, each one condenses an enormous amount of validated experience with human-centric practice (and does not represent someone's, or a particular group's, opinion). They recur throughout history and in different cultures and settings, hence, are largely universal. We list some of them here and urge the reader to read the full descriptions.

Some patterns relevant to a campus from Alexander's original patterns include *Pattern 114: Hierarchy of Open Space*, *Pattern 119: Arcades*, *Pattern 124: Activity Pockets*, *Pattern 125: Stair Seats*, *Pattern 126: Something Roughly in the Middle*, *Pattern 168: Connection to the Earth* [19]. More recent open-source design patterns are developed by the present authors, for example *New Pattern 2.4: Biophilic Urbanism*, *New Pattern 4.2: Pedestrian Sanctuary*, *New Pattern 6.1: Place Network*, *New Pattern 6.4: Capillary Pathway*, *New Pattern 10.3: Layered Zones*, *New Pattern 11.3: Fractal Pattern*, *New Pattern 1.4: Framing*, *New Pattern 12.3: Friendly Surfaces*, *New Pattern 15.2: Human-Scale Detail*, *New Pattern 15.3: Construction Ornament*, *New Pattern 15.4: Complex Materials* [20].

The sensitive designer will find these design tools (actually, design constraints and guidelines) useful in achieving "living" campus spaces. Planning that follows all the above patterns will most certainly generate the quadrangle type campus and diverge from the neoplastic type. This dichotomy drives a profession motivated by an overriding desire to implement neoplastic types of campuses to ignore design patterns altogether; and for architecture schools to avoid teaching them — see discussion in Section 10, below.

The rest of this study collects evidence for how the enjoyment of a pedestrian campus depends upon an unconscious, visceral connection with the information coming from both the ground and the surrounding structures. Well-designed campus grounds, using human-centric tools and feedback, raise the pleasure of experiencing the open space, whereas random landscape design full of pointless obstructions that frustrate a person attracted to walk towards a spot, but cannot, diminishes it. But this is not enough. The spatial emotional experience derives in large part from the organized complexity (and inherent biophilic effect) of the surrounding building façades and other structures. In Section 8 we are going to perform Visual Attention Scans to investigate this mechanism.

7. What are we making today?

7.1. Incoherent open space and narcissistic buildings do not make a living campus

And yet, in our time we are making buildings as gigantic sculptures, separated from and floating within an amorphous sea of public space. Self-centered buildings offer a convex outer edge, which cannot possibly define the convex outdoor realm as required by human psycho-physiology. The resulting open space is random, indifferent, and even hostile toward the comfort of its human users. It does not support human experience, movement, and interaction — contrary to how "neat" it may look on a plan. As Jacobs warned, this is a sign of a severe confusion in the way we go about making what should be good quality environments for human beings: a fundamental failure of professional responsibility to use art in support of human life in urban habitats; what we get instead is attention-getting works of abstract art replacing adaptive structures.

This confusion basically amounts to a kind of magical thinking: that if we focus primarily on making abstract works of (modernist) sculptural art, all else will be well. The method fails miserably. Looking at fashionable new buildings on many campuses around the world, featured in recent issues of prestigious architectural magazines, reveals several common features. We note the amorphous public space, the lack of any edge connecting the private with the public realm, and the monolithic nature of the (private) buildings. There is no life at the public space edges of each building; rather, the building is inserted into an incoherent public realm as a gigantic and unrelated sculptural form. These are recent examples of what is still regarded as best practice, in the world's most advanced countries. Yet from the point of view of human well-being and quality of habitat, this is evidence of a severe deficiency in the accepted professional methodologies, models, standards, and tools.

Amorphous, "left-over" public spaces fail to define any inviting places to linger in. They transmit an unstated psychological message to a pedestrian — to move on. Typically, there is no psychologically comfortable connection between indoor and outdoor spaces. Some indoor spaces float up to one storey above the outdoor realm, suggesting, but at the same time forbidding, a welcome connection. University buildings on long, straight roads, following modernist planning, do away with living ground spaces altogether. Colonnades, which could define wonderful, inviting places, fail in their task because they are non-functional formal statements using the wrong scales, with little protection from sun and heat.

Why is this? Why have we not learned from the abundant examples of history, and the wonderful and successful places that are still successful and well-loved today? Evidently, the profession is stuck on crude typologies that it considers absolute and beyond questioning. But there is a deeper reason, representing the dark side of 20th Century design. That was the almost fanatical desire to ignore all evolved design and tectonic solutions, and to substitute them with novel but untested ideas (for example, the insistence on flat roofs in climates with heavy rainfall and snow). Such is the ideological fervor of this movement, supported by the intelligentsia and political power alike, that the massive failure of those ideas after implementation does not divert the quasi-religious drive to keep building them. Imposing a chosen and rigid set of design typologies was the profession's fixed goal for over one century, and nothing is allowed to question this program.

It is instructive to delve into the psychological motivation of a designer who focuses on an isolated building, and strongly resists adapting and connecting it to other buildings. Participating in a collective effort to form useful pedestrian space by coordinating design components is not on the agenda. Many designers refuse other elements (and other designers) sharing the "limelight" of their building. This attitude is encouraged by architectural education and by the media constantly praising egocentric "star" architects. The individual contemporary architect is uninterested in creating a living urban geometry, but only in showcasing his/her building as an abstract sculpture.

7.2. Available techniques being applied today

The authors of the present study (together with several collaborators) have developed a toolkit for the design of public spaces in general, and for a campus in particular [5,6,9,26,27,62]. Classic planning methods [10–14] and the complementary Alexandrian approach provide essential tools. In a city, a successful urban space draws people to use it from several surrounding blocks, which requires mixed-use urban fabric that has the capacity of supplying enough users above a certain threshold. Designing the path structure is facilitated by applying tested design patterns (see our listing at the end of the previous section). A range of optimal dimensions is also given by specific design patterns [19,20]. Finally, the architecture of the surrounding façades must embody biophilic and fractal qualities. As already emphasized, the emotional attraction of urban space depends, in large part, on the architectural coherence of the buildings bounding it. The reader is directed to those references for extensive details and guides to implementation.

Portable eye-tracking apparatus, and visual-attention software that simulates actual eye tracking, can easily diagnose whether a building façade is welcoming or not, and if a user can easily identify the entrance [63–71]. These are key features to the "humanity" of a campus, now verifiable using the latest technology (see Section 8, below). Separately, the emotional experience of space can be measured by portable, wearable indicators of body indices such as activation, mood, and stress levels [72–76]. These two types of measurement can be combined to diagnose a campus setting, either before (using virtual reality), or after it is built. Measurements so far confirm the detailed thesis of this paper.

The coherent network model considers a campus as almost entirely dependent on flows, with priority given to pedestrian flows necessary for the campus mission — which includes socialization through chance encounters. Complementary vehicular flows necessary for infrastructure and supply need to be designed as physically subordinate, so they do not cut or disturb the principal pedestrian flows.

A campus composed of “living” spaces establishes a larger-scale superstructure linking all of them together. Indoor spaces link with outdoor spaces — without grade change — via a psychologically comfortable interface. Large open outdoor spaces need to connect to adjacent spaces that are shaped by built structures. Emphasis is placed on effortless pedestrian navigation, not an abstract, visual impression. An indoor or outdoor space that is visible, but inaccessible, works against living structure. (A natural slope on open ground is fine.)

People experience the living campus through its open spaces: a web-network of linked pedestrian spaces connect to interior spaces inside the buildings, and it is this physical structure that must be done right. There is nothing here about individual building shape; hence the notion of an isolated “showcase” building works against campus attraction and cognitive coherence. Indeed, using buildings for their primary psychological purpose — which is to enclose and partially surround open spaces — pushes for design that deforms the buildings’ footprint so as to elongate them and even join them. This model is the topological opposite of isolated buildings sited in undefined (and psychologically-hostile) open space.

And so, we are proposing an almost complete reversal of the principles of modern campus design that were accepted as standard for close to a century. New buildings that draw attention to themselves may not contribute to, but could instead degrade the humanity of campus design; whereas the goal should henceforth shift to the coherence of interlinked pedestrian spaces. The difference resides in cognitive coherence and compositional balance of the façades, versus attention through the violation of stable geometries. Those concepts have been neglected for so long, however, that design tools for the attractive design of pedestrian open spaces were discarded, then lost and forgotten. There is therefore a dire need for campus architects to re-learn those techniques.

Campuses also have to deal with an unexpected paradigm shift in the education-delivery model [77]. Learning institutions face an existential threat following the COVID-19 pandemic when students learned to work remotely, and might not come back to a campus that feels viscerally hostile [78]. Ignoring the effects of an unfriendly built environment risks losing paying customers, exactly as in the case of commercial pedestrian malls.

8. Visual Attention Scans reveal coherence in the unconscious perceptual field

Images from two campuses (a traditional quadrangle campus in Huize, China and a neoplastic-form campus in Guangzhou, China from 2022) exemplify one of each of the two types of geometry described above. Representative views were scanned in pairs using Visual Attention Software by 3M Company (3M-VAS) [79], an artificial intelligence application trained on a large quantity of eye-tracking experimental data, which can be used to predict initial viewer reactions to images. Scans generate fixation-point probability maps (heatmaps) as well as fixation-point sequence estimations with a very high degree of accuracy (92%).

VAS simulates first-glance vision, which is informed by pre-attentive processing (that is, unconscious engagement with human cognition). The visual system is able to select relevant or salient information so as to guide appropriate responses that have been selected through evolution for their survival value. These visual features create an early “saliency map” [80]. This initial, pre-attentive processing of visual input lasts approximately 200–250 ms, and information extracted during this stage is then used to guide the early deployment of selective attention [81]. For this reason, early, unconscious processing influences subsequent decisions on where to move. Buildings that draw attention to themselves in a positive way at the same time offer processing fluency, which results in a more uniform blue glow in a VAS scan (as opposed to disjoint focusing on isolated red spots).

Our previous work on the perception of architecture has successfully employed the VAS tool [59,63,64,82], and it is also used on elements of landscape analysis [83,84], to which we refer the reader for more details. These studies discuss that beauty is recursive under scaling; therefore, analyzing zoomed-in parts of an image can give us more information than distant views, especially if the process is repeated for more than two zoom levels. Adaptive traditional building façades (vertical) and ground plans (flat) show several scales of subsymmetries. (Neoplastic buildings and ground layouts tend to have indistinct or very few scales.) With the exception of Figures 4 and 5 below, which serve as explanatory examples, we used one level only and did not repeat this zooming-in process here, as it has already been discussed in depth earlier.

To circumvent left-over-right bias, which seems to exist not only in people whose native languages is written in this direction, but also in infants [85] and even in other species [86], we varied the positions of the contemporary and the traditional campus images among different scan pairs. The conclusions are, however, consistent: the older campus is significantly more engaging.

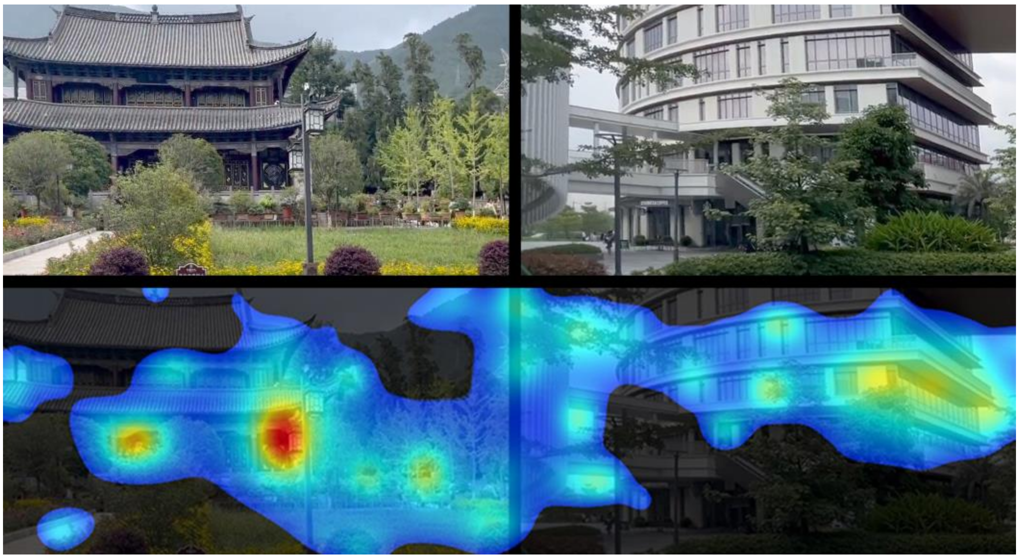

Figure 4. Paired VAS double scan of two homologous views in the two campuses. First gaze is attracted overwhelmingly towards the traditional one (Left), with the primary and secondary points on entrances to the building, and a wide distribution along the building/ground interface and other ground level areas. This attention is completely absent in the contemporary building (Right), where the main focal points are on some windows on higher floors, with the entrance and ground/building interface not even registering. Original images by M. Mehaffy, processed images by A. Lavdas.

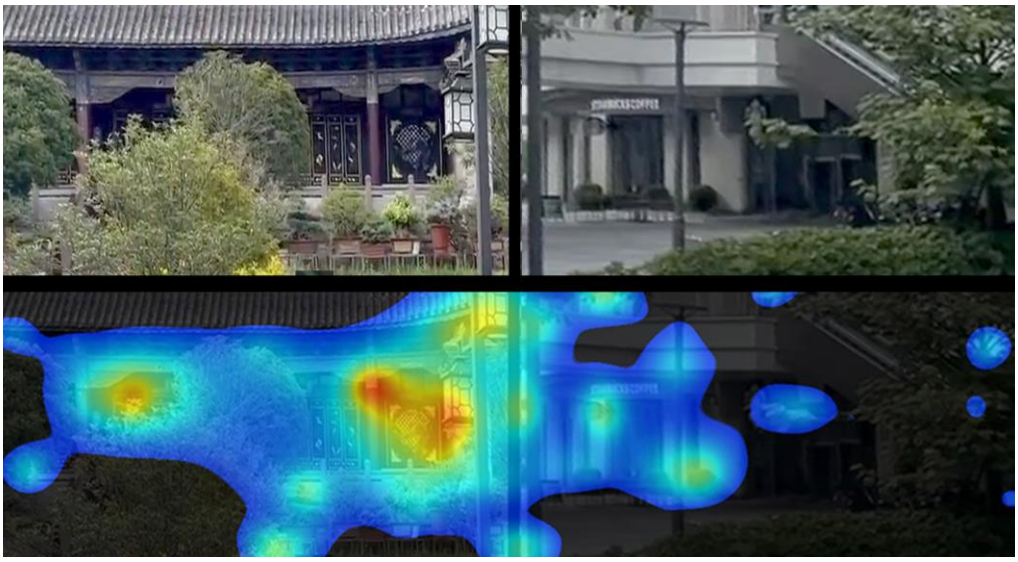

Figure 5. Zoomed-in version of the images in Figure 4. The findings remain essentially the same, with the entrance to the contemporary building now registering, but only just barely. Original images by M. Mehaffy, processed images by A. Lavdas.

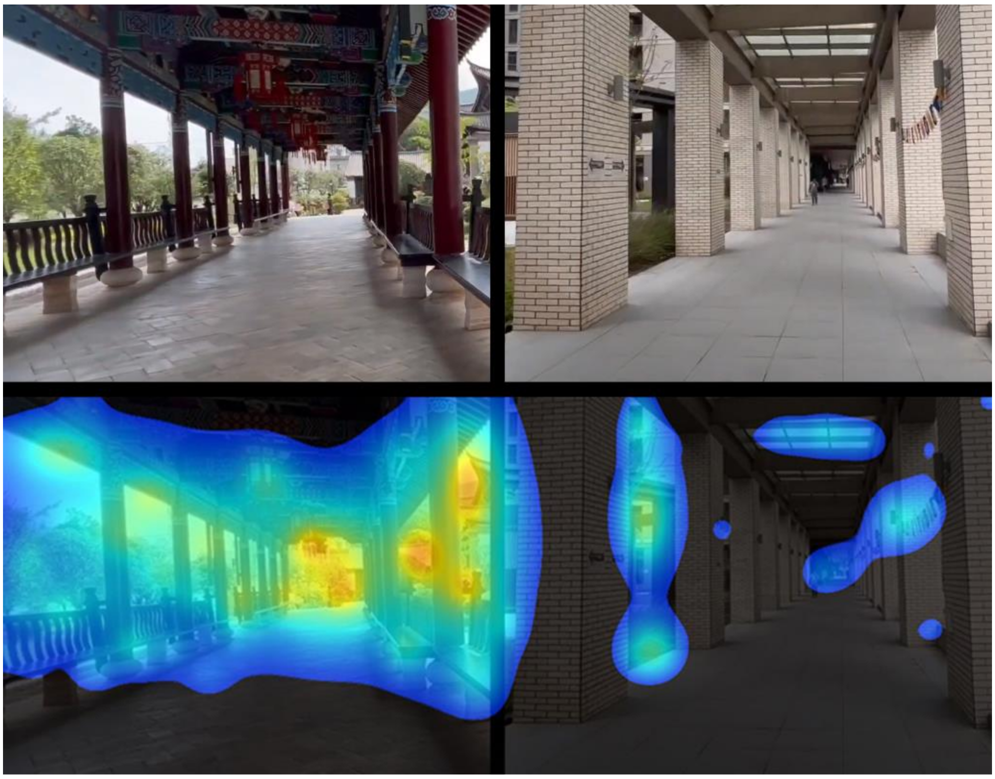

Figure 6. Contrasting views of two covered pathways in the two campuses. The first gaze heatmap is drawn almost exclusively to the traditional side (Left), with a homogeneous distribution along the wide openings of the sides and the end, and also on the roof, although no light is entering from it. On the contemporary side (Right), the little attraction there is comes from the small amount of light that is visible through the overly thick columns and the skylight. No part of the colonnade itself is covered by the heatmap (revealing no unconscious engagement), and the diagonal line of interest that leads along its length on the right is in fact created by the hanging banners. Original images by M. Mehaffy, processed images by A. Lavdas.

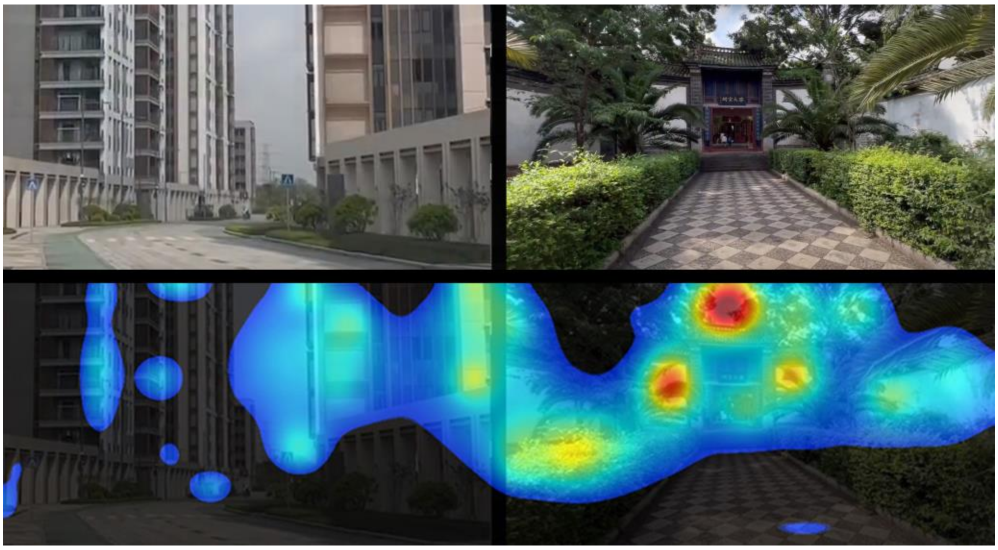

Figure 7. Different types of routes in the two campuses. Greenery framing the route is covered by an uninterrupted heatmap in the traditional campus (Right), whereas the monotonous repetitions of the colonnades in the contemporary campus do not attract attention (Left), even though the ones on the left-hand side are in the sun, while the unconscious gaze is mainly deflected to areas of the higher floors. Original images by M. Mehaffy, processed images by A. Lavdas.

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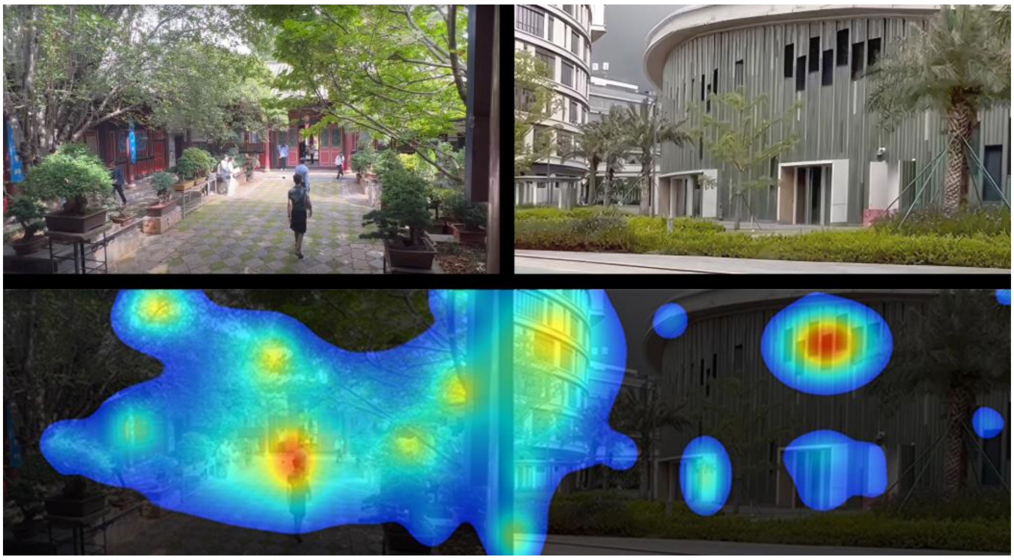

Figure 8. Despite the extensive greenery, the image from the contemporary campus on the right does not show coherence, the interface of the building with the ground is not noticed at all, and the entrances only minimally attract unconscious gaze, which is mostly deflected to the zig-zag row of windows on the upper floor. The traditional image on the left, by contrast, which shows a coherent coverage converging at the doorway. However, the presence of people, which are strong gaze attractors, can be a confounding factor, and we see that here. This artifact of the software is reconciled in Figure 9, below. Original images by M. Mehaffy, processed images by A. Lavdas.

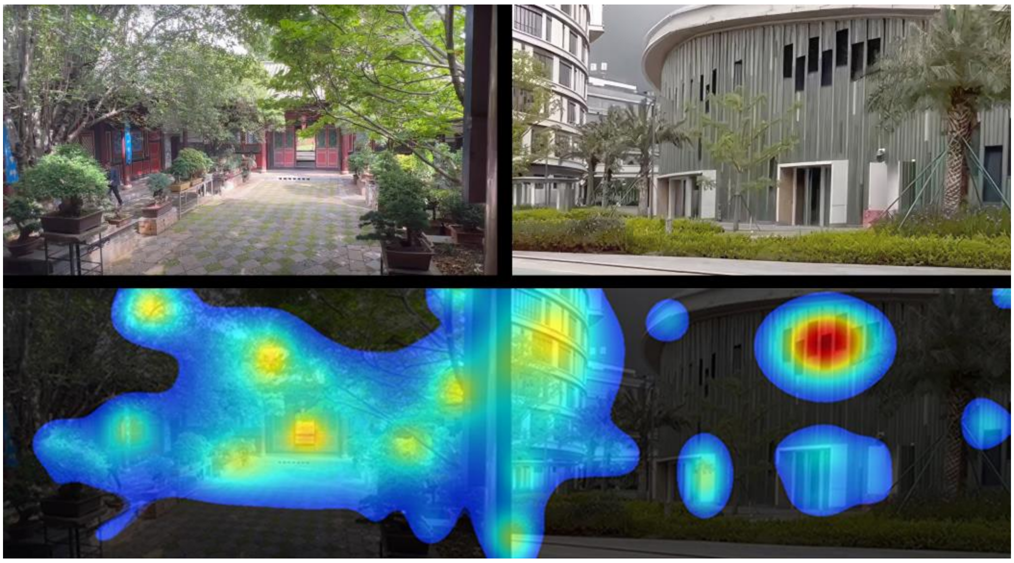

Figure 9. New double scan of the image of Figure 8 with people removed from the traditional campus (Left). The hotspot associated with the proximal human figure is now missing yet the results remain the same, reinforcing the original interpretation. Processing done using Adobe Photoshop 2023 Beta. Original images by M. Mehaffy, processed images by A. Lavdas.

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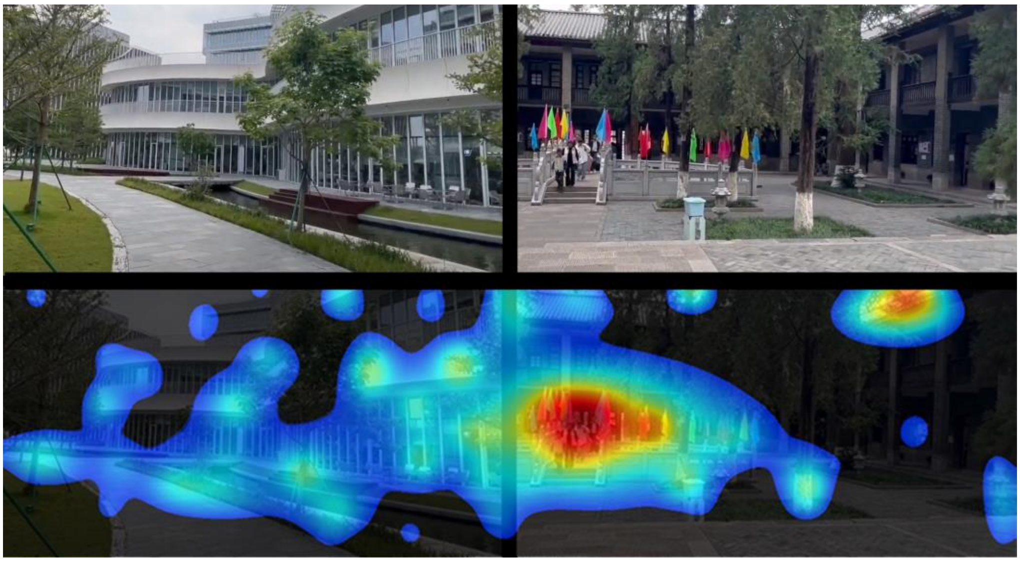

Figure 10. Two courtyards, both with greenery. Here, the use of plants enhances the contemporary building's (Left) connection to the ground, though no entrance points are spotted. On the traditional side (Right: a newer 1960's building in the old complex that nevertheless follows traditional sensibilities), the entrance point attracts the gaze, probably helped by the multi-colored banners. The presence of people, which are strong gaze attractors, may also play an important role here. To determine whether this was a crucial factor or not, the image was further tested in Figure 11, below. Original images by M. Mehaffy, processed images by A. Lavdas.

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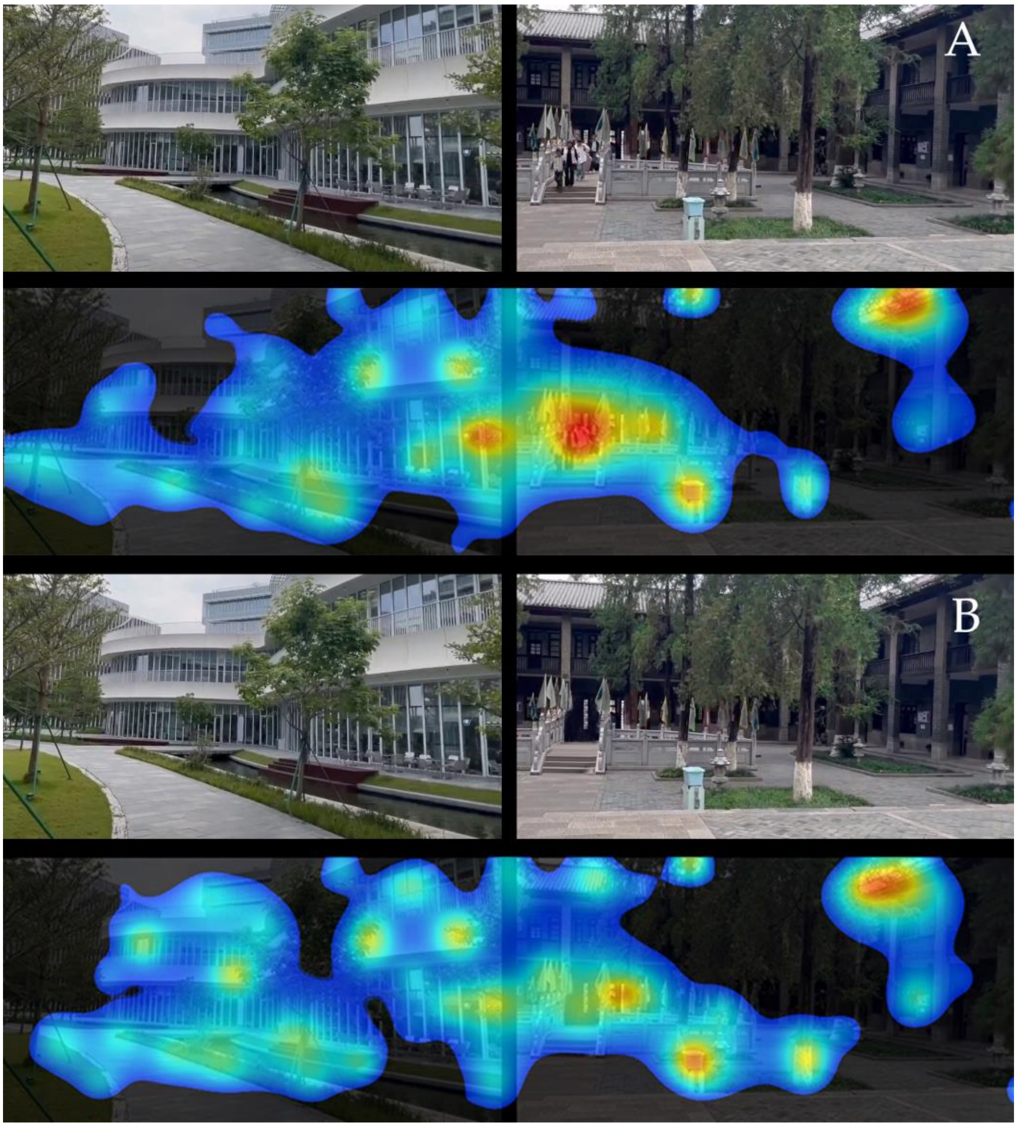

Figure 11. Two variations of the image in Figure 9, with the colors of the banners de-saturated from the images in Figure 10 (A), and then the people removed (B) (in the traditional campus, Right). The colors of the flags seem to have little influence, whereas the presence of people proves to be a much stronger modulator of the heatmap. However, even in case B, the entrance still attracts the gaze when human figures are removed, as predicted. Processing done using Adobe Photoshop 2023 Beta. Original images by M. Mehaffy, processed images by A. Lavdas.

We summarize the above results. One of us (M.W.M.) filmed two campuses on site in China in two short videos, from which screenshots were grabbed (by A.A.L.) of particular views thought to be most relevant. Eye tracking compared homologous views from the two campuses in paired VAS scans. In every case, the traditional campus proves to be far more engaging. As discussed in our previous publications, the VAS heatmaps allow an easy assessment that duplicates tracking actual unconscious eye movements to a 92% accuracy. Eye tracking could be used to zoom down into the scale of building and façade design, an analysis not pursued here. This paper focuses on a specific topic of campus design, using a specific case study to illustrate a broader set of ideas (biogenerative structure, its loss, the unsavory behavior of Western firms in China, etc.)

This study compared the "quadrangle type" campus versus the "neoplastic type" of land use *as viable models for planning a new campus today*. A new campus can indeed be made to feel like the traditional one, and, most important, create positive conditions of user well-being. Construction can use a mixture of traditional and industrial materials, but the design should resist the facile shortcut of copying traditional buildings or courtyards from somewhere else. New buildings must be designed for the specific site, adapted to existing elements and surrounding buildings. VAS pairwise scans comparing the new design alternatives to traditional designs help to check the positive effects of well-being on future users.

9.". Feeling maps" and "walkabout" design — how a technological revolution will help to answer age-old questions

This section reviews a topic that has recently taken on new life because of rapidly developing technology. Yodan Rofè introduced the concept of a "feeling map" to document the emotional state of a pedestrian as influenced by the physical setting. Changing visceral responses to the environment were registered as a person walked around and experienced changing visual stimulation. Then, one could try to establish a correlation between different feelings and different structures [87–90]. This type of experiment offers a direct measure of how an environment, and particular elements in that space, affect the experience of urban space.

The concept of a "feeling map" proves controversial, as architects and urban designers hold strong views that beauty and emotional responses are purely subjective, hence no correlation should be observed among different subjects experiencing the same setting. But that opinion proves to be wrong and is in fact coming from a deeply-held prejudice. This closed-mindedness is borne out of approaching architecture as an abstraction, which is not supposed to depend upon emotional feedback from the user. Experiments show that people of all backgrounds agree to a remarkable degree about the feelings triggered by views of environmental structures [91].

Today, the availability of technology that measures emotion directly makes those earlier arguments irrelevant [92]. Human bodies react in the same way. Among several useful new tools that can be applied towards such experiments, the "Emotional Heatmap" software from *iMotions* [93,94] works on images shown on a screen. By combining eye tracking with facial expression analysis, a heatmap is generated that shows a respondent's emotions when looking at different regions of an image. While we did not conduct such experiments for this paper, a new research project establishes important new tools for evaluating proposals for new campus buildings. At the same time, these tools prove invaluable for establishing new methods for diagnosing and upgrading existing campus open spaces.

"Walkabout design with human sensors" utilizes the concept of the feeling map, together with other results from the Alexandrian approach to human-centric design [26,27]. We choose a small group of people, then walk the grounds trying to imagine buildings standing there. Alexander suggests marking important spots where the group feels — visualized through visceral intuition and free imagination — that a path, an entrance, the side of a building, its corner, etc. are best situated [95]. Scrap materials are used for markers, such as string, bricks, poles, stakes in the ground, panels held up by someone, etc. Existing natural elements on the site (boulders, trees, sharp drop-offs, etc.) will thus be accommodated in the plan. At the conclusion of the design walkabout (which should be repeated for more accuracy once key points have been fixed), the discovered positions are measured and transferred to an accurate drawing.

The walkabout method of human-centric design provides an ideal diagnostic to evaluate the localized "life" of an existing campus. A diagnostic team walks about, noting which spots and views engage the user, versus ones that elicit no response, or create alarm and anxiety. An administration interested in improving the campus experience will wish to upgrade those places with the worst characteristics. The walkabout group envisions "the most wonderful replacement put up at this location"; the design office then prepares some proposal renderings and chooses from among the variants using both Visual Attention Scans and Emotional Heatmaps. Costs decide restructuring since some changes may be economically trivial whereas others are prohibitive — while having comparable positive effect.

10. When school buildings give the wrong message

This section criticizes contemporary campus buildings and layouts and argues how each undesirable aspect for user well-being judged according to scientific criteria arises from a failure to

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apply adaptive planning. We describe how campus architecture and planning are interdependent as far as their psycho-physiological impact on the user, so this is not a debate on styles but on health. It turns out that the design of new campus buildings has for decades assumed a dogmatic direction with no backtracking; yet society accepts and sponsors this unhealthy trend. Because our conclusions oppose the collective narrative (and are certainly controversial), separate arguments for distinct topics are presented in considerable detail below.

10.1. By erasing the smaller and intermediate scales, minimalism extinguishes living structure

The topic of school architecture calls for an exhaustive and separate study (not attempted here). Engaging façade designs help to construct the coherent experience of open pedestrian spaces in a campus, with consequences for creating a positive social atmosphere. What is surprising is that even those authors with whom we agree on how to design school buildings fail to mention the incorporation of complex, ordered symmetries into the built fabric [96–99]. By this we mean visible symmetries on façades and from the pedestrian perspective, but, aside from pavement tiling patterns, this does not refer to large-scale symmetries that are visible only from the air.

Coherent complex symmetries that the human (and animal) neural system has evolved to interpret are essential for organismic survival and well-being. Symmetries organize information that would otherwise be too much to process comfortably, thus using up valuable attention and mental energy [35,36,40,41,100]. Living forms exhibit a high degree of organized information — which is the basis for the health-giving biophilic effect [35,36,52,56,101–103]. Arguments against design minimalism include the neural system's requirement of (a) informational richness that communicates the potential of a place to affect a user's well-being; and (b) compactifying that information so that it can be assessed rapidly — known as "processing fluency".

This understanding immediately provokes a contradiction with the architecture, art, and design worlds, in which beauty is assumed to be subjective, and whose practitioners declare that the absence or presence of complex symmetries in the environment is a matter of individual taste. The illogical basis for this dogma is exposed by the practice of coercing everyone else into discarding nested symmetries. We argue instead that people need to experience visual symmetries in a variety of modalities — including the now-forbidden ornament — to maintain homeostatic equilibrium.

The current fashion in educational buildings eschews symmetries in both exteriors and interiors, as evidenced from their uniform appearance. (This claim may surprise readers who see dissimilar new buildings on different campuses, but we explain their common mathematical qualities below.) School indoor fittings and surfaces have for decades been stripped of any ornamentation and made "industrial" in a minimalist sense; for example, every handle is a steel ball and every balustrade a metal tube. Walls are visually empty, intentionally bereft of articulations that might define symmetric patterns on any scale.

School architecture today employs global tectonic materials of choice with very specific, and very limited, informational characteristics. Cast concrete defines a surface free from any ordered information on it; or an unattractive rough impression from the mold, which is not psychologically satisfying. Smooth metal and plate glass fail to do even that, because the eye cannot focus on either reflective or transparent surfaces. Shunning rich informational content, much of what is built today utilizes empty or visually ephemeral elements. Even clearly repeating patterns are characterized by empty, monotonous repetition, intentionally avoiding organized complexity.

10.2. Patterned pavements

Used for millennia to enhance and enrich pedestrian environments, patterned pavements in campus courtyards and paths contribute significantly to visceral anchoring and attraction to the ground. This dimension of a nourishing emotional experience from paved paths and plazas has been lost, despite the wonderful historical precedents from around the world. Patterned pavements provide a setting for "living" spaces by utilizing color, fractal scaling, and nested symmetries. Unfortunately, commercial paving products influenced by minimalism look dreary, hardly better than plain concrete; or they are implemented perversely to avoid nested symmetries. Applying

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today's technology imaginatively, one can create the most wonderful outdoor spaces using flooring patterns now missing from new campuses (see Chapter 7 of [33] for the link between human cognition and visual patterns).

10.3. The psychological importance of an entrance transition

The "doorway effect" refers to how people often forget their most recent train of thinking after crossing a doorway. This phenomenon can be explained in terms of how the hippocampus of the brain, which functions in both memory formation and spatial navigation, "resets" to create a new cognitive/spatial map [104–108]. What is known as "liminal space" or transitional space can feel unsettling until environmental information assures the user by establishing homeostasis, through an intense but unconscious process. We mention this effect to emphasize how the body is fully involved neurologically as it negotiates the act of transitioning between outside and inside.

Two distinct cognitive-emotional processes play a role during spatial navigation prompted when perceiving an entryway. One is the line-of-sight attraction from a distance (navigational affordance) [109–112], which contributes to the cognitive coherence of the space in front of an entrance. The other is the experience of crossing the entrance itself — an act of cognitive and emotional transition.

Canonical techno-modernist design ignores these physiological effects, and perversely, imbues the approach to an entrance and the physical process of transition with even more anxiety. The worst case occurs when the entrance can be located but is situated under a menacing cantilevered façade or giant extrusion, and a person outside is forced (against basic instincts) to approach a dark hole or slit on ground level. Somewhat less distressing, a glass curtain-wall that does not differentiate the door from the other adjacent glass panels succeeds in triggering anxiety through ambiguity, as the user cannot easily find the entrance [55,56,59,70,71]. In the latter case, the transition itself is ambiguous and inconclusive.

Traditional architecture solved these fundamental questions, now documented as design patterns. Firstly, a transition is clearly demarcated by *Pattern 110: Main Entrance* [19]. The building's entrance must be easily visible from all points of approach and be designed in a psychologically inviting manner (that is, nothing jutting out menacingly, nor unbalanced structures under which one must walk). Traditional building entrances on a campus use arches, columns, framing, ornament, and symmetries to achieve this aim. Human-centric design accommodates social activity, described in *Pattern 205: Structure Follows Social Spaces*, letting the process of entrance transition shape the engineering structure and not the other way around.

Secondly, *New Pattern 10.1: Indoor-Outdoor Ambiguity* [20] describes an equally desirable process. An intermediary space is created as a well-defined place (e.g., a courtyard or outdoor room) that has features of both indoor and outdoor space. The entry transition is extended from one possibly abrupt or ambiguous step to two distinct steps, where each step is now experienced as emotionally positive. This design solution is also documented in the original Alexandrian *Pattern 112: Entrance Transition*, which argues for the advantages of having a transition space between outside and inside.

10.4. Is there an overriding purpose to new campus design?

Society has moved inexorably towards a stylistic direction for campus design. Practices that contradict human-centric design are planned neither conspiratorially nor intelligently but are more a matter of fashion and opportunism. The syndrome of sleepwalking towards an unknown goal occurs when society collectively makes many small decisions, all leading towards disaster, yet nobody realizes which direction it's going — the most famous and most disastrous such example perhaps being the road to World War I [113]. Sociologists discuss this process as a failure of group decision-making due to factors such as "Confirmation Bias", "Group Think", and "Sunk Cost Fallacy" [114,115]. The "Tyranny of Small Decisions" [116] explains why campus design follows the glitz of architecture prizes, artistic innovation, celebrity architects, design fashion, visual excitement, etc.

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What we see implemented is the opposite of Alexander's connecting to the building details, entrances, materials, spaces, and surfaces at all distances, which make one feel to "belong" in that place [15–18,117]. By manipulating matter on all scales, from details up to the largest dimension in a determined manner, contemporary design achieves emotional isolation instead. Having previously documented the elements contributing to biologically-based objective beauty [82], it is evident that campus design tries to suppress it, although nobody will ever admit to doing this.

The VAS scans conducted in Section 8, above (plus in numerous other studies) reveal lowered unconscious engagement in a new campus built according to contemporary aesthetics. Tools such as *iMotions*' "Empathetic Gazes" software are set to uncover an even deeper isolation [93,94]. Two distinct techniques contribute to prevent engagement: expanses of glass and shiny metal walls prevent the eye from focusing on an external surface; while exaggerated cantilevers, overhangs, and displaced twisted floors looming overhead create alarm and draw attention away from a failure to engage at the human level on the ground.

A minimalist interface — an abrupt join — between building and pavement edge is useless for emotional connection. The overriding design aim is apparently to erase affordances: to create no human-scale spaces where the body fits in (corresponding to the scales of 1–2m); and to eliminate ornament and articulations on the exterior wall surfaces so that a student experiences unconsciously that the hand cannot grasp any "handle" for support (the scales of 1–10cm) [118]. These decisions based on architectural style disconnect students emotionally, thus keeping them viscerally separated from the physical structures and even the ground. The negative implications of this and related design decisions are profound for the users' health and well-being.

Alarmingly, we see contemporary campus design fixated upon erasing affordances, which is the opposite of what human neurophysiology demands. People perceive open spaces viscerally by unconsciously evaluating the affordance of different possible actions in them [54]. Places where users feel their body "fits in" comfortably — where they can linger, sit, socialize, study, walk, etc. in a psychologically-protected geometry — lower stress. The opposite, spaces that do not meet these expectations, generate high psychological stress and will be avoided. As we already noted, sophisticated recent technology that measures user emotions in navigating open spaces verifies our claims.

Emotional disengagement extends to façade design, where windows are deliberately misaligned and all possible symmetries — bilateral, nested, reflectional, translational, etc. — are avoided. Equally disengaging are diagonal structures that eliminate the gravitational reference and generate vertigo. The end-result is an alien, industrial machine. This type of "campus as a giant machine" *processes* students impersonally while preventing emotional attachment to its physical structure. A sensitive person's emotional impression could range from alien-neutral (in a glass curtain-wall minimalist campus) to alien-alarming (for buildings in the Deconstructivist style). Anxiety from buildings triggers a fight-or-flight response, so the body cannot focus on learning!

Using biophilic materials such as brick and wood, and introducing bushes, lawn, and trees moves campus design in the healthy direction of creating well-being through geometry — the opposite one from the basic techno-industrial trend. The irony is that these positive measures are now being applied only as biophilic "band-aids" or "greenwash" to mitigate up to 5% the alien effects of disengagement. The underlying design philosophy for a disconnecting campus geometry and structure and the determination to implement it remain unaffected, while the incentive structure in place forbids conventional practitioners from creating genuinely adaptive buildings and pedestrian spaces.

10.5. Two sets of architectural promises that either deceive or deliver

While individuals express widespread dislike for minimalist material typologies, society has accepted the techno-modernist "look" as part of an established narrative that promotes several positive qualities. These unquestioned convictions expect the fulfilment of fantastical promises from techno-modernist architecture, which may be listed as follows:

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PROMISE — { **cleanliness, efficiency, functionality, innovation, "modernity", progress, sophistication, transparency** }

Several publications demonstrate that there is no evidence to associate any of these desirable traits with the actual buildings [119,120]. Yet a deeply-rooted architectural myth couples techno-modernist images to an illogical, if fervently optimistic, goal. Belief in this objective influences architectural decisions, when review boards consequently select new buildings in a techno-modernist style with the expectations that those buildings will boost academic creativity, innovation, and learning. The promise is irresistible, especially since it is boosted by deceptive public relations. Unconscious stress generated by such structures, however, will tend to produce the opposite effect to the one desired.

A distinct set of qualities links to evolved, traditional typologies. Incorporating qualities of traditional, human-centric design in campus buildings can be shown to provide the following positive signals to users. These represent a separate set of impressions obtained from traditional architecture, this time achievable, as verified by centuries of cases:

DELIVER — { **belonging, comfort, engagement, familiarity, harmony, order, stability, warmth** }

Traditional designers working today are building individual campus buildings and entire campus precincts (e.g. [121–124]). This work exemplifies the above qualities (of the second set) but tends to be disdained by the architectural media, hence those buildings are not easy to find on the web. To illustrate the Alexandrian method in practice, the campus of the *Eishin School* was designed and built by Alexander and his team outside Tokyo in 1985 [95,125]. Noteworthy in Alexander's project is that he developed an architectural language adapted to the locality, and did not impose an idiosyncratic, imported one. On rare occasions, schools commission an established architectural office to produce a traditional design, but the product, while often attractive, achieves only mixed success since the firm's main work is industrial-modernist.

Universities striving to appear forward-thinking and prestigious pay little attention to the second set of positive qualities for their campus but focus exclusively on the first, elusive set. Institutions sincerely believe that eye-catching, unconventional buildings that project a desired image of "innovation" make for a better learning environment, even though science thoroughly disproves this obsession. The neurophysiology of human perception, however, can rarely get the first set of qualities from techno-modernist buildings. It is the media proselytizing socio-political ideology, not scientific data, that drive expectations for the promises from the first set of qualities [126]. An entrenched narrative ignores the generations of students that will have to study in campuses justified by this fanciful thinking.

Major architecture firms tend to be heavily set in the techno-modernist camp because they typically don't have the developed skills to design anything else. Using a now standard propaganda ploy, such offices divert attention away from an unattractive design by selling it to a university as certified according to one of the dubious checklists for energy efficiency [127]. Sustainability promised by techno-fixes thus subverts low-cost sustainability from when users love a place enough to maintain it. Entrenched bureaucracy (combined with vested interests) will prevent a school from turning to a smaller, lesser-known architect who does possess the design background to create living environments (see, for example [128–130]).

The problem only deepens when a built campus layout is evaluated, and its open space is found to be dysfunctional and even hostile [131,132]. Up until very recently, the standard method was to use post-occupancy evaluation surveys, which have the disadvantage of collecting arguably subjective user opinions. (Portable apparatus has changed that, but the new evaluation methods are not yet widely applied.) The architect of such a faulty project doesn't wish to hear any criticism and dismisses any negative opinions offhand. Even worse, the decision-makers do not wish to appear to have made a bad choice and wasted the university's building funds for something terrible. And so, nobody is held responsible for the disaster; the media pointedly do not talk about it, which encourages other institutions to repeat the same mistakes.

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Breaking the myth of expertise — where a group in a position of authority consistently makes wrong decisions that have detrimental consequences yet continues to maintain the public's trust — requires an engaged civil society that demands accountability and scientific credibility. It is essential for informed people to become aware of the negative health effects of bad design, especially in the face of systemic resistance to change. Those questioning established architectural authority will have to overcome cognitive dissonance formed by a lifetime of indoctrination [133,134]. Nevertheless, with today's open access to information, it is easier to circumvent the influence of irresponsible decision-making by those in power.

10.6. Campus design follows the superheated real-estate model

Economic progress is falsely tied to informationally-poor new buildings with a minimalist appearance, because wealthy cities have built impressive clusters of them. These projects contrast with informationally-rich, sometimes poorer, older regions. The public invariably comes to associate building activity and economic progress with a reduction of embedded information. Economically run-down urban regions of the world do contain old-fashioned buildings that show informational richness, and this image is misinterpreted as correlating with economic degradation. In fact, some of the dreariest, most inhuman urban regions are social housing projects built in the brutalist modernist style, the informational opposite of traditional urban fabric.

Despite public outcry, school design has not improved over the past few decades. Tom Wolfe, in his 1981 book *From Bauhaus to Our House*, described the problem as: "Every child goes to school in a building that looks like a duplicating-machine replacement-parts wholesale distribution warehouse." [135]. All the while, stress-inducing typologies have only intensified in school buildings. Wolfe's complaint was made long before all the massive medical evidence began to accumulate, so that today, ugly school design is not a matter of aesthetics but of public health [136].

Dominant architectural culture often tricks a wealthy individual into sponsoring an ugly building on campus because its design is praised by the mainstream media as being fashionable and "innovative". Yet examples of incoherent or informationally-poor exteriors from new public school or state university buildings come from all over the world and are taxpayer-funded, not the whims of private donors. This amounts to institutionalized malpractice. Some school building façades, through their absence of symmetry, give the impression of imbalance and even menace. The function of such constructions is vague, but the design intention may be interpreted as being willfully nihilistic. Architectural fashion chooses this sort of emotional aggression as appropriate for school campuses.

Human society the world over accepted a reduction in organized complexity without realizing what was happening. The consequence is that coherent symmetries that spurred the evolution of human intelligence have gradually been expunged from the environment. This is true for buildings, façades, floorings, street furniture, surfaces, and urban spaces. The clean "International Style" that took over following World War II is informationally-poor. (Welcome exceptions occurred where local culture added non-canonical information such as murals.) As a result, the symmetries eliminated from urban (and many suburban) environments by clearing away nature were never replaced by any near equivalent. Since buildings, roads, and parking lots have largely displaced nature, children and adults are getting significantly less exposure to natural symmetries than any previous generation of humans [78,96,137].

10.7. Window distribution affects feeling when one is situated in an urban space

Another concern with visual composition is how windows are arranged on the façades of school buildings. During the past several decades, windows were most often aligned in a monotonously repeating pattern, which gives boring and sometimes disorienting results because it can generate headaches [100,138]. Simplistic translational symmetry has now gone out of fashion. Symmetry negation replaced monotonous repetition. Windows are misaligned both horizontally and vertically, or are randomly distributed according to both their size and position. Why? Such designs, accepted

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as "cutting-edge", are expensive to build because of their lack of modularity and rejection of basic tectonics (the misaligned window frames can no longer support loads).

Many contemporary school buildings involve glass curtain walls. Sometimes a glass curtain wall is "ornamented" with randomly positioned thin vertical metal mullions stuck on. Their purpose is not structural, but totally ornamental, despite the fact that they do not create any emotionally-engaging ornament. The mullions are deliberately misaligned to avoid horizontal symmetries, and furthermore, do not align vertically between the two storeys. Following the above discussion, such unbalanced designs are psychologically disorienting and possibly menacing.

The visual impact of the campus geometry, especially window alignment and distribution, does indeed influence the pleasure of being in an open space. Several previous studies used Visual Attention Scans to evaluate how the eye notices different façade compositions unconsciously [63–71]. We conjectured that geometrical imbalance and incoherence generate anxiety in the viewer, and consequently, a person situated in a pedestrian space bounded by such façades will feel ill at ease. As a result, that open space will scarcely be used, with pedestrians crossing it only when they are forced to do so. And they are never going to enjoy the transit.

10.8. Biophilia privileges the vertical axis

Since the animal sensory system has evolved to cope with gravity and is set up to recognize biological forms with vertical symmetry, humans seek reassurance in a vertical axis. A symmetrical arch defines an implicit (virtual) vertical axis through its highest point. Skewed and tilted forms, on the other hand, generate alarm and physiological stress. Unless there is an explicit or implicit vertical axis of bilateral symmetry, a person feels psychological and physiological unease, with oftentimes-serious consequences such as nausea caused by the inner ear mechanism that is tuned to vertical orientation [100–102]. Any symmetry axis is fine when used to design a floor pavement, but an explicit or implicit vertical axis on a façade or entrance is essential for a physiological feeling of stability.

The need for a vertical symmetry axis comes from neurophysiology that evolved to deal with gravity as a directional anchor and reference for the body. A vertical symmetry axis also characterizes animal and human faces and their expressions. Because of the evolutionary life-and-death value of instantly evaluating such information, the brain is specifically tuned to recognize bilateral symmetries [17,59,139], and especially in relation to face-like patterns, processed in two brain areas (the fusiform face area and occipital face area) [140].

The presence of bilateral symmetry, therefore, satisfies the parameters of the human mechanism for interpreting faces, creating a more intimate connection with the form, which is lacking when this symmetry is absent. A façade or entrance that is vaguely face-like is emotionally reassuring. This ought to be an inviolate design principle, or would be in a society that prioritized the well-being of its citizens over satisfying the whims of those who promote architectural fashions.

10.9. Color in façades surrounding urban space

The absence of color and ornamentation from the façades of many 20th-century university buildings can be attributed to a radical change of ideology about design. The adoption of an austere colorless aesthetic was intended to convey intellectualism and seriousness in the function of educational institutions. But this conviction was an unscientific excuse for breaking from the past, driven purely by socio-political impulses. While there may not be a strict ban on color, its use has been suppressed in favor of drab minimalist design; otherwise, color is allowed only in garish primary hues. Most people do not know that the latter concession comes from a mystical religious cult to which some Bauhaus members belonged [141].

Substantial scientific evidence reveals that the appropriate use of color affects mood and well-being positively. Studies in environmental psychology have shown that color in a space can influence people's emotions and productivity. Experiments so far have evaluated the positive effects of color on student performance indoors [142–145]. These findings are easily ported over and extended to outdoor settings [146–150]. Color affects people's behavior in urban spaces, so this important information should be used as part of a campus design toolkit.

An enormous potential for universities to improve their open spaces with the help of color arises when designing or renovating campus buildings. Some contemporary architects are exploring ways to reintroduce color in their designs, but they lack a sense of color composition and harmony because of decades of defective education on this topic. So far, what we see as applications of color on a campus seem to be re-inventing the wheel, and do not draw upon stored knowledge on the psychology of color in the environment. In the authors' estimation, the best guide to the creation of harmonious color in architecture is Chapter 7 of Alexander's *The Luminous Ground* [151] (architecture schools indoctrinate students with cultish proclamations from the Bauhaus on color).

10.10. Formal campus layout and monumentality

Today's architects confuse formality with monumentality — not the same thing [13,152–154]. It is human-centric planning tools that adapt large-scale geometries to human sensibilities to create the monumental scale. This approach situates courtyards and lawns on a campus and shapes the spaces between buildings. But someone who is not conversant with human-centric planning misinterprets the result as being purely formal; and will in turn design formal landscaping that lacks perceived coherence as experienced on the ground. Furthermore, departures from monumentality arise from local adaptations: this is again misinterpreted as a random breaking of symmetry, encouraging designers to create indeterminate modernist space. There, the paths are arbitrary and not meaningful, and the natural elements are randomly assigned.

There is a value for campus landscape design and building siting plans where an ordering *is clearly visible to a pedestrian on the ground*, and is, moreover, comprehensible from many distinct perspectives. If the user cannot see this ordering, then it is useless. Inherent monumentality can play a positive role, but only if the user is able to connect to this large-scale structure though fractal scaling, i.e., by being able to relate effortlessly to multiple built and natural structures on the human scale that further connect to increasing scales, up to the largest one. Lacking the smaller and intermediate scales detaches the user from a large-scale structure, turning monumentality into oppression. Classic planning tools achieve the desired monumentality that attaches users to the human scale [8,10].

A formal structure in the campus plan can work both ways: either to enhance or to impede user health and satisfaction. In the first, positive instance, much older campuses had a monumental — one may say "sacred" — plan designed through the sensitive alignment and positioning of built structures. This ordering defines a perceivable character for the campus. But it is often the case that subsequent buildings have destroyed the original axes, hence diminished what was a desirable and functional monumentality. Frequently, those insensitive additions come from a failure by the administration and a new architect to understand the importance of the original layout for creating "living" spaces.

Or the architect's ego disrespects everything to draw attention to the new building imposed on the grounds. The latest method for erasing or preventing monumentality on a campus uses non-aligned storeys on new buildings. A floor is stacked irregularly and rotated by 15° or 90° from the one below it, a practice justified as "experimental creativity". Consequently, the broken façade does not define a unique axis, which may prevent the creation of a cognitive map [155,156]. This practice now in fashion triggers serious problems. Such an "elephant in the campus" creates anxiety and disorientation [157] even as it is praised by the administration that selected it (along with the press), hence nobody dares to criticize it.

The second, negative instance works exactly the other way around: older small places with a "living" character have been partially destroyed by a later structure that seeks formality. Sometimes, one can find "magical" natural or built spots on a campus that attract people to linger and sit because the surrounding information field approaches an ideal. But the university appears insensitive to such places, considers them "messy" hence expendable, and does not provide paths or seating facilities for users to enjoy them. Often, an adjoining newer structure has crudely cut off access, or blocked a piece of the original "living" space, for no reason other than to impose its own formal structure.

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The cumulative impression is of a profession that has lost its basic knowledge base. Even a trivial urban design problem like a paved plaza with small trees set in concrete planters seems to present unsurmountable obstacles. In most examples that the authors have seen, the shape of the planters is brusque and jarring (why insist on this callousness?) while their positioning on the pavement discourages rather than encouraging potential cross-paths. Somebody decided the planters' placement on a computer screen following an irrelevant formal plan. The designer lacked knowledge of even the basic rules for human-centric design. But then, these projects were approved and paid for by the university, and therefore the client shares the blame.

11. The myth of "architecture of our time"

This brings us to the final absurd barrier to design and planning reform. We have mentioned the problem of human cognition and its limits, but presumably we can learn from our past mistakes. We also mentioned the power of imagery, and its still-profitable uses in recycled futurism — a nostalgia for "yesterday's tomorrows". It is no accident that most new buildings erected on a contemporary campus look like they belong in the 1920s science-fiction films "Metropolis" and "The Cabinet of Dr. Caligari" [158,159]. Why are university administrators and architects so obsessed with design "innovation" based on a movie style that is one century old?

But perhaps the last great barrier is the belief, the unquestioned tenet of faith, that our time is different, and needs to have a certain "modern" look to it. That this "look" is an expression of modernity's exceptionalism, surpassing all the creations from previous eras of human activity. And that we must never even dare try to revive the past and its evolved patterns, as a living force for the environments of modernity. Dominant architectural culture allows practitioners to put quotation marks on those evolved patterns and typologies, use them as an architectural "joke", make them kitsch imitations, put them on the Strip in Las Vegas — that all seems okay. But to take them seriously as valid materials for a new architecture — this may be the last taboo.

For the first time in human history, the regime we have today for creating human environments (including campus environments) has been built not on a philosophical ideal of the good city, or the good place, but on a program of largely unquestioned accommodation to the global forces of industrialization and mechanization. It has been a kind of expertly run marketing campaign, with brilliant packaging, branding, theming, and sales pitches — so brilliant, in fact, that many people even today do not see through the veneer. But a veneer it is.

This regime certainly has brought a dark side to the world: resource depletion, environmental degradation, pollution and contamination, climate change, and less obvious, but no less dangerous, the erosion of cultural systems, in the face of a technology that is poorly adapted to human ends. To add insult to injury, those responsible for this mess are the ones who misuse public relations to sell their projects as most desirable because they are supposedly "sustainable".

It's increasingly clear that this regime is not sustainable. Its impacts are far-reaching, cumulative, and often devastating, to both urban and natural systems. This crisis in turn has produced a program of perpetual reinvention and novelty that skirts around the fundamental issues. To address the gluttonous consumption of resources, people add solar collectors and extra insulation. To address devastating impacts to natural ecologies, people add green roofs and rain gardens. To address society's cultural bankruptcy, people add ever more imaginatively extravagant neoplasms to our urban landscapes, bolstered by the branding of abstract art, and the validating theories of great universities.

But none of this addresses the core fallacy of the regime's philosophy, its historic program of capitulation to a mindless form of industrialism, and its corruption in that capitulation. Now we find ourselves like fish who swim in this ocean, yet hardly see it.

The problem is not only the mentality of architects, but the broader system of codes, incentives, models, rules, and standards that constitute a kind of "operating system for growth" that determines what can be built and where. Within this system, architects are provided with powerful incentives that reward the creation of gigantic sculptural objects. In so doing, they are performing a kind of marketing role for their clients, by "theming" their buildings, creating attention-getting spectacular forms of gigantic art. This commodification and marketing is an integral aspect of our current industrial and technological systems, which are almost exclusively focused on producing and marketing unrelated commodities, and not sufficiently focused on enhancing (and valuing) the deeper ecological connections between people and place. Without deeper reforms, the present system that shapes campuses will tend to revert back to this condition, regardless of people's better intentions. We need to reform the operating system for design, or it will continue doing what it does.

This is the dictate also known as "the architecture of our time". We are admonished by a dominant architectural culture that we must not "falsify history" but only create a new and valid architecture of our own era. But this is absurd on several levels. First, what is any more valid today about 1930s Germany and its sinister design affectations, than that of any other period of the past? Second, any careful study of architectural history shows that the idea of a neat linear sequence of architectures, with one and only one architecture valid at any point, is sheer nonsense. Instead, history is a fugue, a series of revivals, recapitulations, and additions, woven together into a complex tapestry. (Importantly, it includes many cultures; not just the Western European one championed as the "International Style" — with unpleasant colonialist overtones.)

But if this slogan is true — that we deserve and must have an "architecture of our time" — then on the evidence, we must deserve the dreadful architecture we have gotten! But surely we do not — our students do not — deserve that outcome. Since a campus is meant to anchor education within a welcoming space for students and teachers, and that in turn is a vital component of society, then reform is clearly mandated.

12. Conclusion

This essay reviewed the fundamental structure of campus geometries that are successful in creating a living environment, experienced as welcoming by faculty and students, and highly conducive to the educational function. Older historical campus buildings and layouts have this quality. The reason behind their success is not a mystery, but is due to specific design tools. Their proven benefits have been denied only as the result of fallacies, old habits of thought, and obsolete ideologies. After analyzing the mechanisms for how people interact with the geometry of the environment, we proposed an entirely different approach to designing a campus — more consistent, in fact, with the historical models and their benefits — that contrasts with what has since become standard.

In particular, the accepted typology of isolated buildings in an amorphous open space is to be replaced with a return to designing the urban spaces as the principal element anchoring the campus. Those spaces need to form a connected pedestrian network that is protected from vehicular traffic, and that extends into the buildings and their details — down to the smallest ones. A living campus is thus no longer conceived as a collection of stand-alone object-buildings, but as a network of welcoming (but also filtering) urban spaces, large and small.

The paper considered university campuses in particular, yet we believe the same issues apply to other kinds of campus designs: any building cluster anchored on pedestrian open space. We note that this represents an opportunity to explore these findings as they relate to other kinds of campus types, and indeed, other kinds of building groups and urban space assemblages.

If these reforms are ever going to be universally adopted, then the fallacies that lock in the current regime will have to be examined in the light of evidence, and then discarded once and for all. What is now mostly wasted open space — because it is psychologically unattractive to experience, hence to use — will be restructured to form the core of the campus identity. The topology of building footprints will have to change dramatically, from being isolated abstract sculptures deliberately standing apart from their public and semi-public spaces, to weaving together with other buildings and structures to help define a rich and dense network of semi-enclosed urban spaces. The result of this radical transformation will be reminiscent of historical and well-loved campuses, without copying those explicitly. This evolution will then proceed as all great forms of evolution do: building on (and not wantonly discarding) the collective successes of the past, adding to and transforming them, and growing ever richer.

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