Transcript(ion) of nature into architectural substance and culture

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ABSTRACT: The authors of this article discuss the mutual relationship and influence of nature and culture represented by the built environment as the basic objective of the education strategy through the transcription of natural laws. They highlight various points of view on the importance of information, energy and thermodynamics in global sustainability and sustainable architecture and town planning, in particular. Besides terms, such as ecological algorithm and ekistics, the authors point out the emerging artificial intelligence that affects human activities, including education. In addition, they list the various advantages and disadvantages, threats and unknown consequences associated with AI or geoengineering. The authors conclude that in the era of misinformation and hoaxes, relevant information or correct interpretation of scientific facts and findings plays a key role. Literally, academic ground represents a battlefield in this sense and should act as a guarantee of correctness, reliability and moral/ethical principles.

Keywords: Nature, culture, energy, entropy, architectural education, artificial intelligence

INTRODUCTION

The mutual relation and intertwining between nature and mankind represented by material and spiritual culture are thousands of years old. From an ontological point of view and according to the second law of thermodynamics, cosmic/natural and juvenile cultural evolution are the only two ways of creating new systems and structures on the Earth. Since nature is ruled by ubiquitous laws and driven by relatively well-defined forces, humans usually follow, imitate, interpret and use them for their purposes and benefits. As a result of nature, the anthropoid literally exchanges resources and information between nature and culture. He/she design/generate inanimate objects whose (im)perfections are articulated, for example, through constructions, buildings, cities, agglomerations, their infrastructure, organisation of spaces, inventions, machines, devices, tools or a variety of processes associated with our daily life.

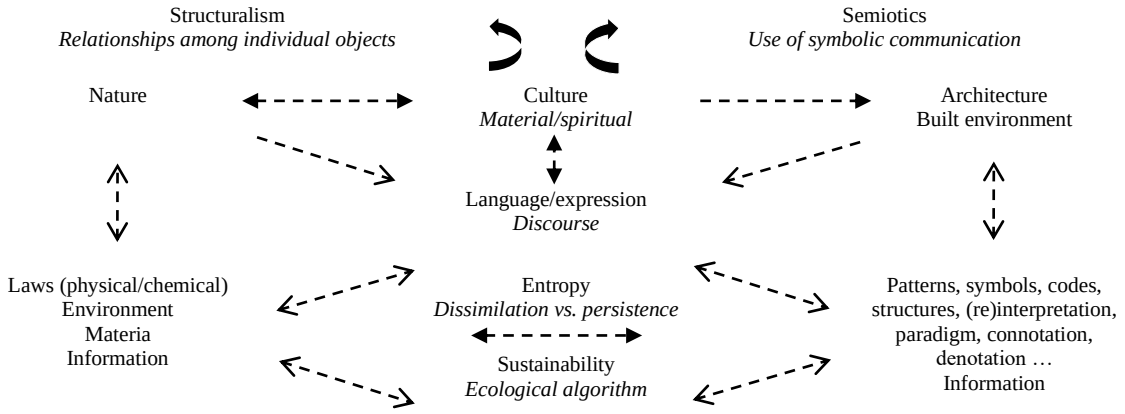


Figure 1: Interrelation between the language/expression of nature and culture.

All these human-made outcomes are part of the civilisation, technosphere, noosphere or spiritual culture - culture itself - that, in the geochemical terms of the Anthropocene, future geologists will be able to recognise at the top crust of the Earth. In this context, the built environment can be discerned as a constant process of translating natural laws, aesthetics, structures and *language*, high-dimensional forms evolved through innovations and repetitions over millennia into the substances of culture represented by architecture and its expressive means, among others. Architecture is

a language, Mies van der Rohe allegedly said. Therefore, in addition to the commonly known *omnis cultura ex cultura* - all culture comes from culture, the collocation *cultura formatur natura* - culture is moulded by nature, could be added. Such relations are within the scope of structuralism, semiotics, and other fields of study and research (Figure 1).

Beyond the cave as a proto base, it has undoubtedly been the force of gravity that has given rise to the architrave as the fundamental structural element of the dwelling, which has started to protect man from the vagaries of the weather and has laid the foundations of architecture thousands of years ago. Today, one can only surmise whether it was just a coincidence in the initial stage or deliberate action of the first man. However, nature is a great source of information. Nevertheless, in this regard, Oscar Wilde said:

> *If nature had been comfortable, mankind would never have invented architecture* [1].

Such statements may sound poetic at first glance; however, the force of nature has shown its power, e.g. through increasing the volume and, subsequently, the capacity of the human brain to use fire, which allowed for a higher nutritional intake from food or a higher amount of available energy, also known as *exergy*. Humans have diverted energy from the biceps to neurons [2]. Thus, along with the omnipresent natural information, its subordinate sociocultural information emerged. Both have been reflected in the structure of the human's DNA helix, knowledge, habits and traditions. The latter type of information initiated the intellectual and inventive process of cultural evolution - an open non-linear system with inner information - through its transmission to future generations, civilisations and their variety of cultures (Figure 2). Concurrently with natural information, they came under the constant influence of *entropy* as a major component of thermodynamic concepts, including information transfer, which will, in fact, affect the survival of humans in the future, too.

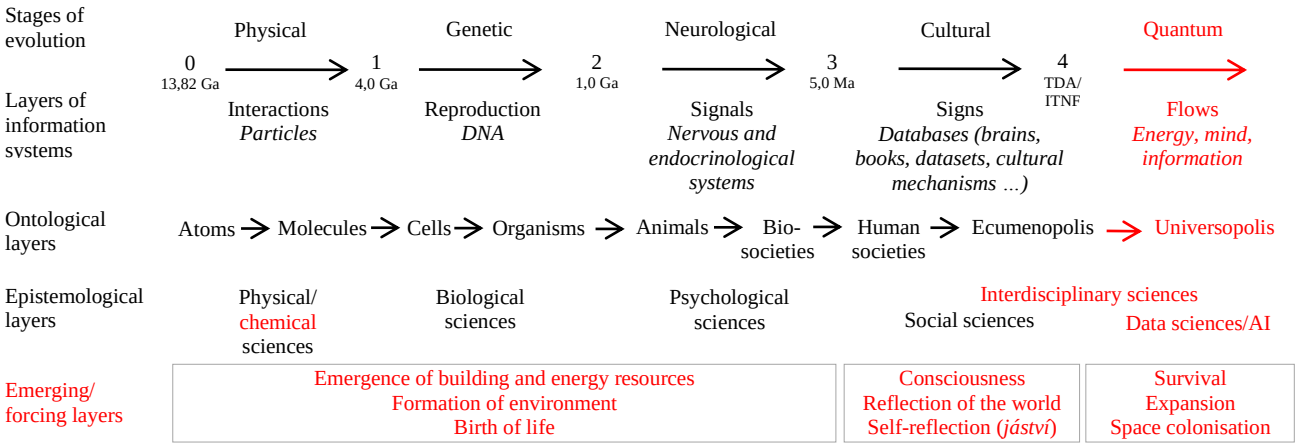


Figure 2: Ordered layers and the consilience of knowledge. The authors modified the original figure by Pertsemlidis with inputs of red colour [3].

INFORMATION AS A NEGENTROPIC ENTITY

According to the Czech philosopher Vilém Flusser, all spontaneous natural phenomena are entropic. In contrast, cultural systems are negatively entropic, trying to increase the organisation of surrounding systems as much as possible [4]. In this sense, compared to animals, humans receive, create, accumulate and transmit information, the result of which is a culture in the end. Flusser argued that humanity lies in typically cultural resistance to the natural tendency towards entropy [4]. Therefore, *negentropy* is defined as a *reverse entropy* (also known as negative entropy/enthalpy/syntropy), a measure of order, and is generally characteristic of non-ideal processes, information and culture included.

This process of higher organisation symptomatic mainly for modern/developed societies is performed through information generation/transfer representing novelty, originality, creativity, etc, or in the case of increasing the efficiency of human work and reducing the impacts of human activity, mainly through technical and technological innovations or research. Information as a data carrier can, therefore, counteract and resist entropy in some way. However, nature as a comprehensive system contradicts this effort because according to the second law of thermodynamics, information is naturally decomposed and lost in space and time. The world has been living in a permanent state of emergency since the invention of the steam engine, Koestler stated [5].

Claude Lévi-Strauss, the pioneer in the field of structural anthropology, defined the major difference between the so-called primitive societies and modern societies in 1959 as follows:

> *I would say that the societies studied by ethnologists, compared to our large society, our large modern societies, are a little bit like* cold *societies opposed to* hot *societies, something like horologe compared to a steam engine. These* cold societies *produce extremely little disorder that physicists call* entropy *and tend to preserve themselves in their initial state. Incidentally, it explains why they seem to us as societies without history or without progress* [6].

To be precise, the word entropy in his statement stands for a disorder, which means social conflict, political fights, social inequality, etc [7]. However, in terms of co-existence with nature, technological or political and social maturity is not always an adequate criterion. The term adaptation characteristic for humans of long-past periods denotes the ability to habituate/accustom. At present, the term resilience is gaining ground as a much-discussed term in relation to the city, the sustainable way of life, and climate change causing droughts or, conversely, floods. It is very significant that resilience is perceived, e.g. in engineering, as the goal of designing a machine resistant to the worst possible conditions. For the self-reflection of architecture, it is crucial to know how it was theoretically founded in each period of its existence and how it acquired this foundation/information basis since it has been existing in historical contexts, which are partly causal.

On a side note, the authors remark that the historical stratigraphy noticeable in cities offers examples of different levels (including technological) of translating nature into the language of architecture. In the case of Gothic, which can also be perceived through the spiritual component of culture, the fight against gravity and increasing the potential energy of the material reached the technological limits of the construction process of that era. Art Nouveau, in turn, realistically articulated nature through its expressive elements. In contrast, the unification, typification, universalisation and normalisation of construction, characteristic of the second half of the 20th Century, brought too much simplicity to the language of architecture. To this day, this reduces the degree of existence and variety of connotations that influence the plethora of experiences/perceptions when perceiving buildings and the environment as a whole, and ultimately also their sustainability. Finally, globalisation has brought with it a generic or instant architecture that threatens culture and cultural identity, on the one hand. On the other hand, it enabled rapid technological and informational development, which in the context of the topic of the article is manifested in the smart city concept, the use of renewable energy sources and a wide range of miscellaneous convergent technologies operating on the basis of natural laws.

ENERGY AS A FUNDAMENTAL ENTITY

In fact, energy is the main force, origin, catalyst and merit of everything and all processes that occur in nature. The law of conservation of energy states that energy can neither be created nor destroyed, only converted from one form of energy to another. As already stated, energy is also behind the creation of all structures and materials that arose through the process of cosmic/natural evolution, while culture, in general, represented by man-made outputs, has always been a net beneficiary of the Earth's natural materials. The result is that the amount of anthropogenic mass, such as concrete, bricks, aggregates, metals, asphalt, etc, exceeded the weight of all global living biomass, which was estimated at approximately 1.1 teratonnes, in 2020 (±6). On average, for each person on the globe, anthropogenic mass equal to more than his or her bodyweight is produced every week [8]. The negative side of this phenomenon can, for example, be perceived through the recently announced sinking of New York under the weight of its own development approximately 1-2 mm each year on average, worsening the effects of sea level rise and flooding threat [9].

The current ecological crisis is a consequence of the decline in naturally arranged structures, places and spheres of the finite Earth's surface. It is the result of the spatial expansion of culture and its opposition to nature [10]. It is possible to state that homeostasis as the relative constancy of the internal environment, with the presence of man, is essentially an illusion in nature, culture, and the city as well. The dependence on materials, not only those utilised for construction, and especially on energy resources defines the heroic modern era through the energy imperative or counteracting climate change. The use of the environment and depletion of energy sources, therefore, put man in an offensive position against nature, which is driven not only by individual and group interests but also by general human-species selfish ones.

In general, the globally well-known report of the Club of Rome entitled *The Limits to Growth* published in 1972, which provided controversial scientific information and denied previously accepted opinions regarding the linear growth of the economy and the world's population along with the consumption of energy resources [11], is considered a historical turning point in mitigating the tension between man and nature through sustainability and increased energy efficiency.

In the context of sustainability and sustainable development regarding nature, the notion of the *ecological algorithm* of design proposed by Ralph Knowles and further developed by his fellow Julián Keppl from the Faculty of Architecture and Design at Slovak University of Technology (FAD-STU) must be mentioned. According to Professor Keppl, this algorithm:

> *[...] is based on the principle of designing in accordance with the environment (bioclimatic architecture idea) and the use of the characteristics of the environment, the location, and natural forces, especially the sun and wind, from which the operation of the designed object can benefit* [12].

Other determinants of this design concept include location attributes, use of vegetation, impact of surrounding buildings, built-up area and its density or, size and shape of the building, its orientation to cardinal points, physical interface with environment represented by energy transfer, construction, use of local material, or inner metabolism represented by local/continental migration of users or various energy transformation systems.

This nature-based design approach along with other mitigating measures and synergic relations with nature minimising human impact/interventions on the environment through the biocentric, ecological or minimax approach became an integral part of architectural education at the FAD-STU. Since these approaches are nowadays predominantly relatively well mastered and applied by architects in designing new small-/large-scale structures, the authors of the article and many world authorities are of the opinion that cities and their existing built environment must become very

crucial topics of interest (Figure 3). Undoubtedly, a single building has never demonstrated the presence of mankind on the mother Earth, and thus has never been the issue of global sustainability.

Figure 3: Panoramic view of the Castle Hill in Bratislava, Slovakia. On the left, next to the bridge exit under the castle, a large part of the hill mass for the Vydrica development project has been dug away. According to the ecological algorithm, the excavated material should be used in the construction. The enormous volume of excavation for this project required a large amount of energy to remove the hill-mass created by nature (Photograph: R. Špaček).

The city as a very complex system has been fascinating numerous representatives of many fields of research, such as historians, urban geographers, demographers, psychologists, sociologists, urban economists, or statistical and theoretical physicists, who built cumulative theories about how the form of cities determines their functions/operation and *vice versa*, respectively, contributed to knowledge defining their particular characteristics and cultures.

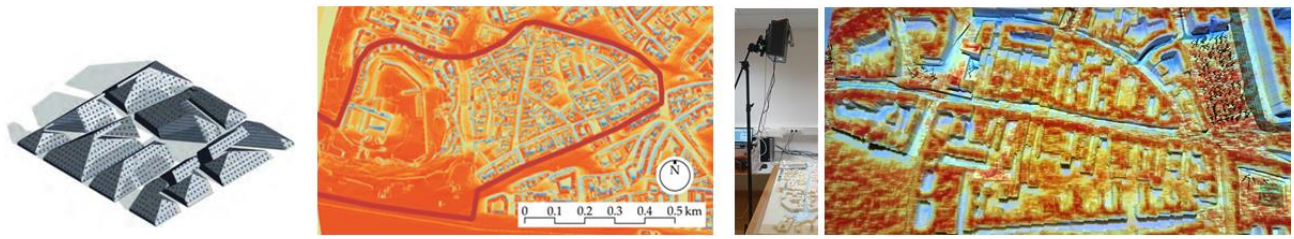
In general, the city is distinguished as a set of flows of energies, information, materials, people, goods and services. A new paradigm of city planning and understanding of urban resilience and economics came up with the so-called *urban scaling laws*, which relate socio-economic, behavioural and physical variables to the population size of cities. In addition, the well-known Zipf's or Kleiber's law could be stated [13].

Work with a large amount of information in time and its post-processing is one of the cornerstones of the smart city concept, which today is considered a mantra and a solution to global problems related to the growing number of the world's population living in cities. C.A. Doxiadis, the founder of *ekistics*, the science of human settlements, defined the terms of *eperopolis*, an immense conurbation covering a significant part of a continent. Surprisingly, this title was devoted to three cities of New York, London, Hong Kong in 2008, as a result of the information connection [14]. Moreover, Doxiadis promoted the idea that humans do not need *utopia* (no place) but *entopia* (in place), a real city they can build, a place that satisfies the dreamer and is acceptable to the scientist [15]. He was also convinced that:

> *The ultimate goal of a human settlement is to satisfy the needs of its inhabitants, and of the other it serves - particularly those needs leading to happiness and safety* [16][17].

Big data influences and manages energy flows (including virtual ones) within the city, for example, by involving the *positive energy district* (PED) concept in which a district generates more local renewable energy than the energy consumed by the outer districts, while maintaining a net zero carbon emissions balance [18]. Climatologists focus on urban climate and the energy and water balances of cities and investigate, e.g. *urban heat islands* (UHIs), which are closely associated with climate change.

The issue of architects and urban planners is generally to incorporate as much interdisciplinary knowledge into their designs as possible. In this respect and in accordance with the topic of this article, the authors are systematically focusing on understanding the natural laws and processes and their transcription into academic work. They consider the education of future generations to be a part of information flows, whereas natural systems educate themselves in the process of evolutionary selection.



a) b) c)

Figure 4: a) urban structure generated based on the solar-access principle; b) analysis of the roof surface solar potential located in the Monument Reserve of the city of Bratislava, which has served for the identification of the appropriate application of photovoltaics with respect to cultural sustainability and preservation of cultural identity; and c) use of the Tangible Landscape tool in the education process at the FAD-STU (Figures: the authors).

In their research and education, the authors are concerned with ecological and cultural sustainability for a long time, primarily with the use of solar radiation as an *a priori* source of energy that will be available to mankind for approximately the next five billion years. Some of their research outputs on PEDs, UHIs or the implementation of active solar appliances in historic structures that preserve cultural identity are presented in Figure 4 and Figure 5.

a) b) c)

Figure 5: a) automation of the process of determining albedo values of city surfaces through machine learning based on orthophoto maps; b) sensing probe located on the FAD-STU rooftop recording various parameters that influence the formation of urban heat islands, such as the intensity of solar radiation, reflectivity, rate of evaporation, etc; and c) example of recorded measurement dataset (Figures: the authors).

IS THE FUTURE REALLY SO FAR AWAY?

The previous paragraphs of this article dealt with the relation of nature, culture and the built environment, and highlighted the role and importance of energy and information management in the current era. In fact, the development and exploitation of information technologies has affected architectural practice and education. The use of information and knowledge technologies (IKTs), such as geographic information technologies or simulation software based on direct user control, has become an important part of the design process that is more positively than negatively influenced.

The issue of using artificial intelligence (AI) came to the fore last year, not only in the real environment, but especially in the education process. According to Lovelock, humanity has entered the age of the Novacene, an era defined by supercomputers and artificial intelligence - a time from which *beings* more capable than man will emerge. But even this new species will need a healthy Earth and its functional temperature regulation, as a human [19]. Thus, the issue of energy consumption needed for their operation and cooling will increase. Above all, the cloud has a great advantage in the economy because of its size. Its three global providers count physical servers in the millions, and they already today devour 2% of all electricity consumed in the world [20].

AI created by man can be perceived as the new abiotic cultural structure that consumes extra energy. The question arises whether mankind starts to leave the human-driven relation between nature and culture by creating a silicon-based form of life similar to carbon-based, at this stage. On the other hand, it is supposed to provide people with a hands-on information system that will most likely reveal the unknown connections of human knowledge so far. This risk of misuse, although eliminated by cryptography, stenography or blockchain, it seems, people have decided to take. Apparently, one's alibi is represented by the argument that all available on-line information originated from one's personal initiative, and it is not possible to generate new knowledge based on its iteration and correlation. But the question still remains of the consequences when artificial intelligence starts assigning tasks to itself or if an emotional component enters purely rational processes, which one can define as a chemical process governed by natural laws.

AI has already proven that it is capable of recognising the difference between good and evil based on statistics and historical events. The report published by Microsoft researchers states that GPT-4 shows signs of what is called *artificial general intelligence*, the capability to reason like a human that it is not quite consciousness, but it is close [21]. The evolution of AI is indeed really rapid. According to Frazer, evolutionary systems seek design solutions that have the *symbiotic behaviour* and *metabolic balance* found in the natural environment [22]. The issue is whether the AI can recognise the natural environment as humans do for their/its profits and survival.

Regarding the upper-mentioned nexus, one author of the article performed an experiment on how the AI depicts the ideal solar city using the Midjourney on-line application since authors have been dealing with this topic for several years. The results can be seen in Figure 6 and Figure 7.

Figure 6: Depiction of future scenarios with the Midjourney software. Command entered: /imagine/ideal solar city with flying cars and wind turbines, respectively, /imagine/ideal solar city (Authors: © Midjourney and J. Legény).

Figure 7: Post-processing and modifications of the variant selected by the user (Authors: © Midjourney and J. Legény).

The issue of using such a tool in education, design process or various chatbot used for writing seminar works or other assignments is widely discussed mainly through the inability of tutors to check data these systems are using and dealing with. Other accompanied problem that emerged is recognition of copyrights, as these IKT systems use on-line available objects already designed by someone to generate the required outputs. It must be stated that the detail of the information entered in the command line affects the result, as the AI works on pre-defined requirements and commands, which it translates together with the available information into the desired product/result of the client. Such technologies and improvements will undoubtedly help architects and urban planners deal with global issues and shorten the design process or they will eliminate human errors. Until AI starts making its own errors!

Astronomers perceive energy as the basis of development, existence and survival of all civilisations, while revealing a specific classification of civilisations based on energy consumption according to the *Kardashev scale* first presented in 1964 and further majorly re-evaluated by Carl Sagan and Michio Kaku. There exist three types of civilisations according to their ability to utilise the available energy. Our civilisation as a society is ranked at a level of 0.73, which means that humans do not even reach the level of civilisation of the first type. It is predicted to reach the level of 1 on an horizon of 200-300 years. A type I civilisation is usually defined as one that can harness all the energy that reaches its home planet from its parent star (for the Earth, this value is around 2×10^{17} Watts), respectively, it can conquer all natural processes within the planet, such as its climate, energy of volcanoes, movement of lithospheric plates, etc.

Large-scale interventions in the Earth's climate system are a domain of collectively known *geoengineering*, which have been proposed to moderate anthropogenic climate change, e.g. through *direct air capture* to extract CO_2 from the air or increasing the albedo of arctic ice or Earth's atmosphere using aerosols to reflect incident solar radiation. However, the unpredictable consequences of such actions on a global scale represent a major risk. Furthermore, the type II of civilisation is capable of harnessing the energy radiated by its own large star in our galaxy, the Sun. Incidentally, this perception was also adopted by the film industry and the science-fiction genre, which identify many more types.

It is perhaps relevant in this context to refer to the theory of the *heat death of the universe*, concretely to the *Finale* passage of *Mythologiques: L'Homme nu*, in which Lévi-Strauss evokes the ultimate end of all life [23]. According to him, human existence is only an episode in the development of nature, and human interference itself is just a part of this. The final destiny of life is the ultimate destruction implied in the second law of thermodynamics, which states that entropy always increases in time [23]. One of the possible ways to secure human life is by which a man will no longer exist as a biological entity. The reasoning that only a humanoid that is dehumanised/transformed into artificial intelligence can colonise space because of the time travel and energy needed to deal with travelling anywhere in the universe is certainly correct. Therefore, the question arises of whether humans are already facing a post-human era, a delegated form of the human race in order to resist entropy and the Lévi-Strauss' final destiny of life.

DISCUSSION AND CONCLUSIONS

Beyond controversy, Charles Percy Snow divided a great culture into two separate considerable areas of human intellectual activity - science and the arts. Using his words:

> *Culture allows a rapid adjustment to changes in the environment through finely tuned adaptations invented and transmitted without correspondingly precise genetic prescription. In this respect human beings differ fundamentally from all other animal species* [24].

Architecture, construction and urban planning represented by the built environment, in general, are subjects of both areas of such human intellectual activity. Knowledge of natural and cultural systems arises to enable their existence, adaptation and evolution. The level of interconnection between nature, culture and architecture varies from geographic location, the level of maturity of the given culture, its knowledge base, the possibilities of transport or the intellect of the architect/urban planner/engineer.

Each creative process is based on information and lived experience, not excluding architectural and urban design. In order to secure sustainable development, it is necessary to understand the coevolution of nature and culture, nature laws, and to translate them into basic objectives of the education strategy and new or existing structures. Interdisciplinary approaches are immanent, in this context. The global effort should result in the formation of a *biofile culture* that can be comprehended as the new contract, respectively, an alliance with nature because of finite sources. Prospectively, this *status quo* could change in the near future by space/asteroid mining or addressing the space resources value chain.

Among others, the ekistics of Doxiadis works with the theory of the *ecumenopolis*, a network of urbanised spaces that create a universal world, a global settlement that extends across entire continents [25]. In Figure 2, the authors proposed the continuation of his concept by *universopolis*, the space colonisation of the quantum epoch, with respect to current findings and knowledge of information technologies. Keeping in mind the selfish gene of Dawkins, such topics are relevant for architectural education, indeed.

Today, in the era of misinformation and hoaxes, relevant information or correct interpretation of scientific facts and findings plays a key role. Literally, academic ground represents a battlefield in this sense and should act as a guarantee of correctness, reliability and moral/ethical principles. It has a great responsibility for the future survival of mankind. On the one hand, it is a space for developing more or less realistic concepts. On the other hand, as a very conservative environment, which often reacts with considerable delay to current issues, it is exposed to the great challenges of today. Educators have reached a turning point that architectural education and architectural design have not yet experienced.

Artificial intelligence brings with it both advantages and disadvantages, as well as threats and unknown implications. Independently, spontaneously or mechanically automated programs that design and optimise the operation of objects (e.g. ArchitectGPT, the Slovak start-up DEVS) are generated. Ultimately, there is some kind of backlash against academics that can threaten their jobs and suppress the importance of erudite opinion in the relationship between nature, culture and the built environment. From the architectural point of view, such tools, together with the generation of optimal dispositions, can affect the rate of the author's own contribution without crossing the usual frameworks. It is apparent that in this new relationship between tutor and student the same AI tools, such as GPT antiplagiarism systems will be used, but due to the level of possible error and incorrectness of outputs generated by AI, it will be necessary to rely on traditional sources of information and *horse sense*, at least in the near future.

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BIOGRAPHIES

Associate Professor Ján Legény was born in 1985 and graduated in architecture from Slovak University of Technology in Bratislava (STU), Slovakia, where he earned his PhD in 2013. He was awarded twice a postdoctoral position at the STU with his research topic intensification of solar energy use in urban space. Presently, he is working as a researcher and teacher at the Institute of Ecological and Experimental Architecture of the Faculty of Architecture and Design, STU in Bratislava, Slovakia (FAD-STU). He has authored or co-authored many scientific and professional articles on solar town planning, solar design, sustainability, urban democracy, architectural education and the scientific monograph titled Solar Strategy of a Sustainable City. He has been involved in various national and international research projects. He is a freelance architect and co-founder of the TRESarchitects architectural studio and has gained experience from the Office of the Chief Architect of the City of Bratislava. Between 2018 and 2022, he was the Vice-Dean of the FAD-STU for Research and PhD studies. He is a member of its scientific and artistic boards and many other boards and committees or editorial boards of scientific and professional journals.

Professor Robert Špaček, born in 1952, finished his study of architecture at Slovak University of Technology in Bratislava (STU), Slovakia, in 1976. In 1981-1982, he was a postgraduate student at the University of Hannover. He is a member of the Institute of Ecological and Experimental Architecture of the Faculty of Architecture and Design, STU (FAD-STU), which he founded in 1990 with Professor Julián Keppl. In his research, teaching and publication work, he focuses on sustainability, urban democracy and ethics, as well as architectural theory and review work. He is the author, co-author or editor of dozens of scientific and popularisation texts, including the books, Efficient Housing, Manual of Sustainable Architecture, and Solar Cities. He is a member of scientific and publication boards, as well as other associations and committees. Between 2010 and 2018, he was the Vice-Dean of the FAD-STU for Research, PhD study and PR.

Dipl.-Ing. Manfred Sonnleithner, MSc, was born in 1967. He holds a diploma in architecture from the Vienna University of Technology, Austria, and earned his Master's degree in refurbishment and revitalisation at the Danube University Krems, Department of Bauen und Umwelt, Austria, in 2012. Since 2019, he has been a doctoral student at the Faculty of Architecture and Design in Bratislava, Slovakia (FAD-STU). Since 1June 2023, he has been a research associate in the newly founded research laboratory for sustainable building culture heritage. His current positions include the head of the research project *Monumentum ad usum* or the course director of *Master of Energy Consulting*. His research activities are in the fields of energy innovations, refurbishment, revitalisation, and sustainable utilisation of historical and listed buildings. He has authored or co-authored scientific and professional articles and led or participated in many national and international research projects.