Challenge and response at all levels in sustainable architecture education

Robert Špaček, Ján Legény & Pavel Gregor

Slovak University of Technology in Bratislava
Bratislava, Slovakia

ABSTRACT: Architecture as a profession has existed since the inception of humanity. Cities and buildings are part of the species' living space, directly affecting it and the surrounding environment, including the rest of the animal species. Climate change and the impact of human activity on the planet are significant and their relationship should be based on scientific facts. The constituent levels (or layers) of sustainable architecture can mitigate the impact of human daily activities on nature and the planet. Discussed in this article are issues at the global and local level, including cultural sustainability that preserves the long-term needs of future generations for access to cultural resources, and which the authors consider the basis for the survival of civilisation. They also argue for the use of solar energy mainly in urban structures. The smart city concept and innovations contribute to the creation of human happiness, preserving the quality of life and supporting carbon neutrality in Europe by 2050.

INTRODUCTION

Humans are facing climate change and discussions on how to mitigate their impact on world biotopes, as confirmed by the resolution on Climate and Environmental Emergency in Europe approved by the European Parliament only confirms this fact [1]. Some arguments are ones supported by research, whereas other arguments are more emotional, but probably do affect a wider public. Thomas More in 1516 presented his political, ethical and theological attitudes [2] in a book called *Utopia (Libellus vere aureus, nec minus salutaris quam festivus, de optimo rei publicae statu deque nova insula Utopia),* roughly translated as a *little, true book of benefit and enjoyment on how life should be on the island of Utopia*.

The Utopia envisioned by More represents an imaginary island the name of which conceals a reference to the Greek words for *blissful place* and *nowhere*. The utopian ideal is of a fair and harmonious organisation of society that provides every person a happy life, where everything is rationally arranged, so that there is no injustice or misery and the people do not have to steal and cheat.

Characterised by an *economic imperative* and population growth, society today must deal with many specific problems related to ecology; the extinction of species, depletion of energy sources or migration due to wars and climate change. Among these crucial issues is the city and its impact on the surrounding environment through the energy demands from buildings, transport or energy in construction materials. The main question is: should humans search for a sustainable world society and a model of an ideal city? If yes, what form does it have? Is the *smart (city, region, continent, world)* concept, utopia? In such a model, who is responsible for the cities and environment? Such questions need more attention in the pedagogical process.

TEACHING SUSTAINABILITY

Teaching sustainability can be pursued either bottom to top or top to bottom. In the *bottom-up* approach, there are several layers of teaching concerning product design, interior design, housing design, building design, urban design and spatial planning [3][4]. Hand-in-hand with these is the meeting of special requirements depending on the scale, such as specific individual needs; family needs in a family house; community need for buildings and districts with small energy demands and high quality of life; population needs such as cultural sustainability and sustainable development secured by the *smart city* concepts.

Education fulfils an irreplaceable role in dealing with the complexity of topics and fields in architecture. The overarching goal is to preserve the *quality of life* - of an individual, a family, community, of the population. The power of educators is limited and can only address a small number of issues of the sustainable *(smart)* city and

spatial planning, which contribute to the concept of *sustainable happiness* [5]. Such *happiness* supports an individual, community or global well-being and does not exploit other people, the environment or future generations.

After years of research, the authors believe that sustainable happiness represents the major approach through which humans can reach their visions and goals. Considering sustainable architecture, most people and nations want to save their *cultural* and *historical identity* for the future. Another aspect is that *architecture is sustainable only if it is also beautiful*.

The Faculty of Architecture at Slovak University of Technology in Bratislava (FA-STU) covers the whole of sustainable architecture: product design, interior design, housing design (all categories), civic buildings, urban design and spatial planning. Global issues and challenges are raised in lectures, from the informative to the philosophical. In particular, the emphasis is on environmental ethics and ethics in general. Individual morality and differently motivated ethical systems ultimately are decisive for the success of sustainability strategies.

GLOBAL *VERSUS* LOCAL FRAMEWORK

Global strategies and challenges often are framed as declarations that are political in nature and which are rarely complied with. The layer of personal or family life is also framed through sustainability tied to personal decisions. A mix of professional, political and activist interaction takes place between these two layers.

The authors of this article have set up a discussion on the options architects deal with applied to greenhouse gas emission reduction and other sustainability issues. These directly follow the authors' previous study on *Sustainable solar urban design: education linked with research*, published in 2014 [6].

The main argument lies in the phrase, *think globally, act locally*, accredited to the Club of Rome (a group of people who include scientists, economists, representatives from business and politicians). The 1972 global report commissioned by Club members, *The Limits to Growth,* encouraged many researchers to think about future development linked to an exponential growth of population and fossil fuel usage. This forecast resulted in social and economic policy programmes, such as *Factor Four* or *Factor Ten*.

The Factor Four programme, proposed by L. Hunter Lovins and Amory Lovins of the Rocky Mountain Institute and Ernst von Weizsäcker, the founder of the Wuppertal Institute for Climate, Environment and Energy, explains how simple it is to reduce resource and energy use by 75 percent through doubling output and halving input to production.

The Friedrich Schmidt-Bleek Factor Ten proposal moves this concept forward, but requires a *dematerialisation* (i.e. using less or no material to deliver the same level of functionality), the creation of new technologies, policies and manufacturing processes along with sociocultural change to create a global economy that is sustainable for a long time. By reducing human resource turnover by 90 percent, the main goal is to ensure nations do not exceed the carrying capacity of the planet, but leave sufficient resources for future generations [7]. It must be stated that poverty is the biggest enemy of global sustainability.

Such thinking on the issue of *resource productivity*, which requires social justice, must be forced mainly by Western advanced countries and imported into developing countries. In a conversation with Schmidt-Bleek in 1989 at the International Institute for Applied Systems Analysis (IIASA) at Laxenburg, Austria, Stanislav S. Shatalin, chief economic adviser to President Mikhail Gorbachev of the USSR said:

> *We cannot afford the western kind of environmental protection at this time. We will first establish a market economy and then, when we are as rich as you are, we will take care of the environment* [7].

In reply to this quote, which is still essential in relation to developing countries, a new concept of the *circular economy* could be applied worldwide. Although the logic of using (relatively) closed material cycles is quite a fresh doctrine, parallels can be found in history.

In ancient times stone blocks of houses and columns were dismantled and recycled in the construction of walls and the Roman Colosseum served as a quarry in the construction of baroque houses in Rome, several centuries after its origin. There was recycling (exchange) of old Greek dignitaries' heads on the fixed bodies of statues. This approach to the circular economy is accepted by students at the FA-STU. Ranging from a trash design to recycling the building functions or revitalisation of brownfields, this concept is widely used at the level of the interior, the building or a city.

Efforts of humans and countries are appreciated by society, because these activities are necessary, but there are activities that cannot be influenced by humans. It must be stated that the overall dimension of human activities in some cases cannot compete with natural phenomena, such as volcano eruptions or forest fires, which contribute to CO_2 concentrations in the atmosphere.

Euphoria is often replaced by hysteria, followed by the scientific reality. For example, the actual CO_2 concentration on 10 November 2019 was 408.71 ppm. A year ago, the count was about 408.78 ppm [8]. The last measurement of such

a level of carbon dioxide concentration in the atmosphere on Earth was three- to five million years ago. According to scientists, the safe concentration level is around 350 ppm. Before the industrial age began, the CO_2, concentration was around 280 ppm, and had not risen much higher for hundreds of thousands of years [9].

Another warning published in the media in 2019 represents the so-called *acqua alta* (periodic exceptional tide peaks) in Venice. The St Mark's Basilica has been flooded six times in more than 1,000 years, four of which have been in the past 20 years and this year's floods in Venice were the worst since 1966. Such evidence of climate change certainly is disconcerting and requires actions to be taken. Partial solutions may lie in the education of present and future generations, and not just for the architects.

The World Meteorological Organization calculated that this year (2019) in June, 50 megatonnes of carbon dioxide, due to fires, were released into the atmosphere (see Figure 1a). This is an amount equal to Sweden's full-year's CO_2 emissions or all the emissions of fires beyond the Arctic Circle between 2010 and 2018 [10][11]; Europe at night is shown in satellite view, in Figure 1b, with illuminated cities and motorways (NASA) [12]; and a global flight map using the data from OpenFlights.org is shown in Figure 1c [13].

a) b) c)

Figure 1: What are the real problems of civilisation and where are the potentials? a) forest fires across the Central Siberian Plateau in 2019, which influenced the melting of an iceberg; b) illuminated Europe at night, in satellite view (NASA); c) global flight map (OpenFlights.org).

A general fact relevant for architecture and town planning is that concrete is the most widely used manmade material. It is second only to water as the most-consumed resource on the planet. Cement, the key ingredient in concrete, has a large carbon footprint of about 8% of the world's carbon dioxide emissions. If the cement industry was a country, it would be the third largest emitter in the world, behind China and the US. It contributes more CO_2 than aviation fuel (2.5%) and is not far behind global agriculture (12%) [14].

The American business magnate and philanthropist, Bill Gates, came up with a start-up company called *Heliogen*, which uses an artificial intelligence algorithm that could position a massive array of mirrors, so that they all redirect sunlight onto a single point heating it to over 1,000 degrees Celsius [15].

This technology of solar ovens produces enough heat to manufacture things, such as steel and cement, raising the possibility of eradicating a major source of greenhouse gas emissions at cement manufacturing plants by switching to solar power. Such sunlight-focusing technologies have been known since the 1960s. Computer sciences and technologies have great potential for industry. Only the future will reveal whether they are a real, beneficial and applicable device or whether they just have their roots in marketing and economics.

INTERNATIONAL, NATIONAL AND SITE-SPECIFIC ISSUES

For sustainability in architecture or town planning, the fundamental determinants of design are location with specific climate and weather conditions, traditions in buildings or availability of materials and technologies. However, given the globalisation and interconnection of the world, these basic design inputs are sometimes no longer valid. Increasingly, in practice, there can be seen a preference for ostentatious architecture as a symbol of economic or other types of power.

What are called *image-first* concepts and projects presenting the economic and innovation dominance can be seen in Dubai, Singapore or resource-rich nations, with an emphasis on scale (see Figure 2a and Figure 2b). An extreme example is Qatar, which is developing air-conditioning systems for open-air public spaces as part of an intensive effort to adapt to life on a progressively hotter planet. Because of the country's immense wealth, derived from oil and natural gas reserves, in places such as Qatar climate change is merely an engineering problem and not an existential one.

By contrast, the Office Building in Lustenau, Austria, designed by *Baumschlager Eberle* (Figure 2c) is a minimalist building that guarantees yearly comfortable temperatures of between 22°C and 26°C, without heating, cooling or mechanical ventilation. It represents a *manifesto* against technology overkill in modern buildings. Humans on one side of the planet are trying to reduce energy consumption, but on the other side, they are cooling open public spaces! Here, the words of Shatalin from 30 years ago are relevant (see earlier quote [7]).

a) b) c)

Figure 2: a) artificial islands in Dubai [16]; b) Singapore's Gardens by the Bay, with giant tree-like structures (Photo: Robert Špaček); c) office building in Lustenau, Austria [17].

CULTURAL SUSTAINABILITY

It can be difficult to distinguish between facts, hoaxes, latent conspiracies and purposeful arguments. Based on previous arguments and examples, the simplest solution presumably would be to reorganise the global settlement of the Earth. The problem with such a solution is the implied loss of cultural identity and ties to the place of origin. Thilo Sarrazin, a German politician and writer, began such a debate on cultural sustainability and identity through his book, *Germany Abolishes Itself* [18]. He argues that the German nation and its culture will be threatened due to migration and will be replaced by Turkish immigrants and Islamic culture. At the time of writing this was generally not an acceptable position and the debate is still open.

The Spanish philosopher, sociologist and writer, José Ortega y Gasset, argues that it is not clear how war can destroy a culture. War conflicts can, at most, affect those who create or move it forward, but culture itself remains intact. No-one even knows for what reason culture might die other than as a result of its own *seizure*, when it ceases to create new ideas and new rules. If yesterday's idea is corrected by today's idea, there is no *cultural wrecking* [19]. Throughout history, an idea is the initial point for change, whether positive or negative. Inhibitors of changes include technical innovations, discoveries or political regimes. But which ideas are relevant in the field of architecture or town planning? With energy sources and the city, the authors believe solar energy plays a key role.

For instance, each hour 430 quintillion (430×10^{18}) Joules of energy from the Sun hits the Earth. In comparison, the total amount of energy that all humans use each year represents 410 quintillion Joules [20]. Humans have a virtually unlimited source of clean energy in the form of solar power, which will be accessible for another 5 billion years. It only needs to be harvested.

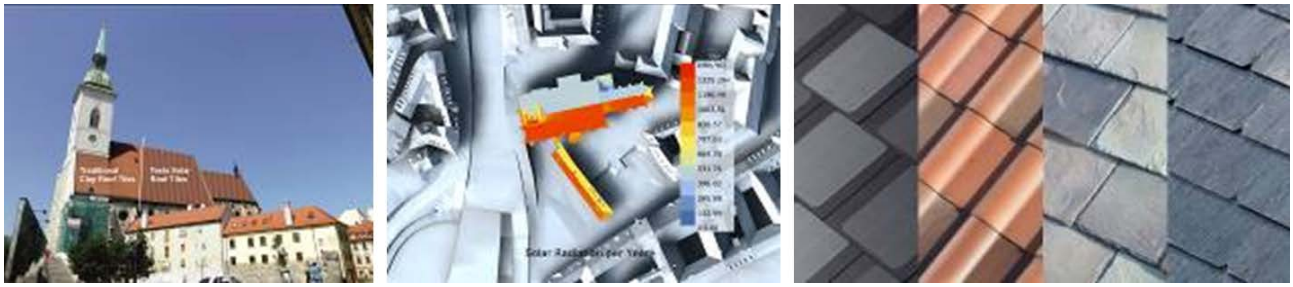
ASSESSING THE ARCHITECT'S OPTIONS

Architecture is, by its very nature, a visionary field based on designing future real estate. First, it formulates a vision of what things might look like in the future, and then creates a plan and instructions on how to realise such a future. The first university course in architecture at the Massachusetts Institute of Technology was developed by architect William Robert Ware in 1865. His vision of a university programme aimed to synthesise professional, artistic and humanist pedagogies with a target to ensure that, in his words …*the architecture of the future shall be worthy of the future* [21]. The amalgamation of knowledge within architecture allows for an in-depth comprehension of the relationship between its form and function and its socio-economic implications.

To respect the innovations in various fields of industry and research, architects should keep abreast of the times. The city does not necessarily include the concept of sustainability in terms of energy efficiency and cultural identity. By comparison, the Rem Koolhaas *generic city* is *without qualities* [22]; in the Central European context preserving cultural-historical identity is deeply rooted. It is particularly evident on the roofs of historical towns. The example in Figure 3 is one possible way to approach the use of solar energy in historical structures.

St Martin's Cathedral (Figure 3a) is a significant monument in Bratislava, Slovakia, and a comparison can be made of the visual style of traditional clay roof tiles and energy-generative Tesla solar Tuscan glass tiles. The surface area of south-oriented pitched roofs is 1,374 m^2, which can produce about 339,240 kWh/year. Solar radiation analysis performed by the authors (Figure 3b) involved using a 3D model by the company, Eurosense, s.r.o., based in Slovakia. Figure 3c shows the Tesla solar roof tiles with integrated photovoltaic cells shown in various designs, such as Smooth glass tile, Tuscan glass tile, Slate glass tile and Textured glass tile [23].

Nothing should be changed in terms of visual properties. Photovoltaic technologies are now responding to the needs and requirements of architects and residents. It is about authenticity and historical values, not just about visually perceived surfaces. The crucial point is if the result of the competition between cultural identity and resources-based sustainability will lead to a generally acceptable equilibrium. Ultimately, it is about who has the power to make the final decision.



a) b) c)

Figure 3: a) St Martin's Cathedral, a significant monument in Bratislava, Slovakia; comparison of the visual style of traditional clay roof tiles and energy-generative Tesla solar Tuscan glass tiles; b) solar radiation analysis performed by the authors with a 3D model from Eurosense, s.r.o., in Slovakia; c) Tesla solar roof tiles with integrated photovoltaic cells in various designs, such as Smooth glass tile, Tuscan glass tile, Slate glass tile and Textured glass tile.

INFORMATION SPHERE AND COMMUNICATION

While there is a focus on the protection and sustainability of the *biosphere* and the *anthroposphere*, sustainability of the *information sphere* is only marginally considered. There is the notion of the *noosphere*, a philosophical concept established especially by the biogeochemist Vladimir Vernadsky and Pierre Teilhard de Chardin, who represented a combination of Jesuit-educated philosopher and naturalist [24].

The noosphere can be interpreted as the information sphere; or, as Vernadsky called it, the planetary *sphere of reason*. In the context of the smart city, the *information sphere* mainly is about the security of smart systems of buildings and settlements. Artificial intelligence raises philosophical questions of human existence. The Teilhardian combination of philosophy and technology opens up the question of future models of human evolution, in which individual and collective human consciousness will not exist independently of the information sphere and communication systems.

Therefore, sustainability related to smart systems raises concerns whether gradually evolving artificial intelligence becomes independent and begins to make decisions. The collapse of local networks can be compared to a breakdown of local ecosystems and cultural entities. What would be the consequences of a downfall of the global network? Can it ever be imagined? Historical examples of US power outages called *blackouts* can be a warning.

In the fantasy movie, Mortal Engines, by Peter Jackson (Figure 4a), cities can be considered mortal engines. They can predate on other cities in their surroundings. Living in these cities is from the neighbourhood or at its expense [25]. But humanity as a whole has a problem with the information sphere (Figure 4b). At present, without much hope for agreement, there is no globally respected personality with enough reasoning power [26].

a) b)

Figure 4: a) two scenes from the fantasy movie, Mortal Engines. Cities are considered *mortal engines*; they spill predatory-like into the surroundings; b) global information sphere: humanity as a whole has a problem with this sphere.

DISCUSSION AND CONCLUSIONS

Architecture is at a turning point with innovations to better understand the capability of space and place. What should the architect answer to the emotional question put forward by environmental activist Greta Thunberg: *How dare you*? In 2010, the American documentary filmmaker Sam Green presented in his performance the line, that …*Today we are people who know better, and that's both a wonderful and terrible thing* [27].

Present knowledge cannot allow humanity ever again to have such utopian grand dreams as Thomas More's. Instead, there needs to be an alternative which is in equilibrium with nature. If architects can neither save the Earth nor mankind, the question is, who can? Rather than just architects in this struggle with nature, there will be help and intervention from key innovations in the construction process, industry and transport.

The issues faced by humanity at both global and local level, including that of cultural sustainability, suggest the roles of architect and architecture are shifting increasingly toward the modelling of lifestyle and education for responsibility. Engineers and architects will have to apply these aspects to their concepts and designs. The monitoring and transfer of knowledge and findings, therefore, are two of the most important tasks for teachers at schools of architecture worldwide.

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