Non-linear design thinking in architectural education

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ABSTRACT: The impact of the building industry on climate change should influence what is built and for how long. In this article, the author has explored adaptability in architecture as the crucial emergent strategy embodied in buildings. Although it has recently been thought that embodied energy is a minority energy issue (10%), recent research shows that this is not always the case. This became apparent from buildings produced for a very short lifetime. The author suggests looking at the design process from different perspectives. Non-linear design thinking with associative logic can offer a new understanding of the role of sustainable architecture, and suggest innovative and alternative methods in education. Presented in this article are three strategies chosen by which to examine the non-linear approach in architectural education. These strategies are adaptive reuse, solids with iterative life-cycles, and scenario-based design loops.

INTRODUCTION

Climate change influences the natural environment as well as the built one. The author suggests looking at different approaches to environmental issues in architecture. Adding expensive technology on badly designed buildings should not be the solution. The starting point should be from a philosophical, ethical or social point of view.

As Špaček et al suggest:

Individual morality and differently motivated ethical systems ultimately are decisive for the success of sustainability strategies [1].

Many studies presage catastrophic scenarios, with negative impacts. Society lives in an age of information pollution, facing the question of sustainability and environmental protection. This raises the role of the architect in society who stands with the building industry, which is one of the biggest producers of pollution. Sustainability and ecology have been incorporated into the vocabulary of architecture and have become part of design [2-4], e.g. KieranTimberlake, whose integrated life-cycle analyses (LCA) is incorporated into 3D modelling software in the form of a plugin called Tally. This calculates the embodied carbon during the design phase and subsequently ...*teams could run iterative assessments, getting real-time feedback as design options are developed and evaluated* [5].

Environmentally responsible architectural education and literacy is the keystone to sustainability. However, there is still room for improvement in the methodology, in the understanding of different creative processes and in the new perspectives of ecology.

NON-LINEAR DESIGN

Architectural design based on strict typology uses preconceived spatial organisation, solutions and tectonic systems. This methodology is often limited by a set of formal and structural constraints that were rooted in the functionalist and modernist tradition. Mono-functionalism and standardised perception of architecture lead to limited spatial outcomes. It is often difficult to cope with costly refurbishment or even demolition. These solutions carry a lot of embodied energy, i.e. fossil fuels that contribute to carbon dioxide production and environmental pollution. Non-linear design thinking can lead to a new understanding of contemporary sustainable design.

Several approaches connect adaptability with non-linear thinking in architecture. According to Salingaros, Darwin's theory of evolution is optimal for achieving adaptable design [6]. He suggests, from competitive designs one is selected as the most adaptable. It is necessary to create a set of *selection criteria* for various alternatives.

Keppl and Špaček introduced the idea of *conflict between stability and transition* to understand the transition from the principle of *form follows function* of predictable systems to the non-linear chaos of unpredictable systems. The conflict turns on *stability*, i.e. the built environment and transition, movement in the social environment:

> *In a society of permanent change, a function is an ephemeral factor and it is in contradiction with relatively permanent building substance* [7].

The author's educational methodology is based on the collective intelligence of the city or the urban context of a project. The city is a product of the collective intelligence of generations of spatial groups and temporary perspectives. Legény writes about collective intelligence of the city, calling it …*the memory of the city* [8]. In this understanding, there are interventions in the urban structures that have affected their functioning and development. He refers to the representation of memory in the form of important buildings, from the memorial, the cathedral to the plague columns [8].

Important is the methodology for uncovering collective memory/intelligence. Salingaros argues that adaptability solutions are embedded in the collective intelligence of built structures and research into innovative solutions should begin there. However, there are shortcomings in approaches that draw on the collective intelligence of established building structures, with reference to the lifestyle of the past [6].

A contemporary concept referring to the collective intelligence and selective criteria is Schumacher's correlation. He states that systems and urban formation should be networked, correlated and adapted to each other [9]. He analyses the city and decomposes it into subsystems and components as: 1) a spatial and morphological framing; and 2) a socio-functional framing. Correlations explain the architecture that is determined by the events/social interactions within its territory.

> *The task of complex multi-system urbanism was now posed once more in terms of layered subsystems, each of which displays its own ontology and internal logic of differentiation as the basis for scripted subsystem-to-subsystem correlation (as oppose[d] to zoning or collage)* [9].

The key to adaptability and correlation is feedback. Without feedback, it is not possible to incorporate surrounding information into system growth - dead matter has no feedback. Contemporary architecture that follows early modernism is freed from feedback. Architects are trying to present a dead abstract form to people without questioning it [6].

Feedback in architecture is based on several inputs that influence an outcome. For adaptability, the main outcome is a long life and an effectively infinite life-cycle. To achieve such a state, it is necessary to consider a manifold of scenarios. Achten's concept of interaction narrative is defined as:

> *Interaction narrative is an organisation of moments of interaction between the user and the system following a story that is consistent with an interaction style … it allows the design team of interactive systems to bring all possible moments of interaction into a coherent whole* [10].

Such thinking of non-linearity can bring to students a better understanding of design that is based on adaptability and scenario-based design thinking.

METHODOLOGY AND STUDENTS' WORK

In the field of design, research and education, there are two approaches: an initiated (top-down) approach and an evolutionary (bottom-up) approach. The main difference is based on the selection criteria chosen.

The initiated (top-down) approach has two stages: a) exploring prototypes from the past (even recent past), that were satisfactory, but are now unsatisfactory; and b) using imagination to design or achieve a desired result. The result might be comfortable, organised, human-scaled, but might also turn out to be static, generalised and preconceived.

The evolutionary (bottom-up) approach is one in which the same problem as the initiated approach is tackled, but different selection criteria are employed. Instead of relying on prototypes, it applies behavioural and response models of inputs and outputs during the design process and during the life expectancy of the building.

As Salingaros states:

> *Because of their fundamentally different approaches, the top-down design relies more on geometry and inherited form language, whereas the bottom-up approach dispenses with geometrical prototypes and instead works within the design constraints represented by patterns* [6].

Christopher Alexander's patterns offer a new approach to designing architecture and urbanism: a generalisable and shared *pattern language* [11]. The author works with students on architectural design methodologies, following previous research [12], that are based on the associative logic of the evolutionary approach and correlations, to perceive connections among

concepts, strategies and scenarios. The author presents three approaches to architecture education: adaptive reuse; solids with iterative life-cycles and ideas on scenario-based design loops.

ADAPTIVE REUSE

Recycling architecture is applied when the original architectural and structural substance is still viable, but does not meet the present functional requirements. It is not necessary to recycle the material substance, but to recycle the function [13]. Adaptive reuse has been popular for industrial heritage and other attractive building stock. However, with the economic imperative driving building activity, there are cities left with unattractive, obsolete and unpleasant structures, such as chain grocery shops, abandoned halls or prefabricated warehouses. This provides an opportunity to show the students a new view on sustainability.

The main goals of the adaptive reuse strategy are:

a)   saving the embodied energy and resources invested in the original structure;
b)   discovering new options;
c)   exploration of new economically and socially sustainable functions.

An example is the diploma project for the rehabilitation of an abandoned grocery store. The store was moved to a new location while its structure remained. The new site is in a small city in Slovakia and a careful investigation into new functions took place. The essential goal was to obtain a sustainable business model, with custom-made community services and other options. This led to the concept presented in Figure 1.
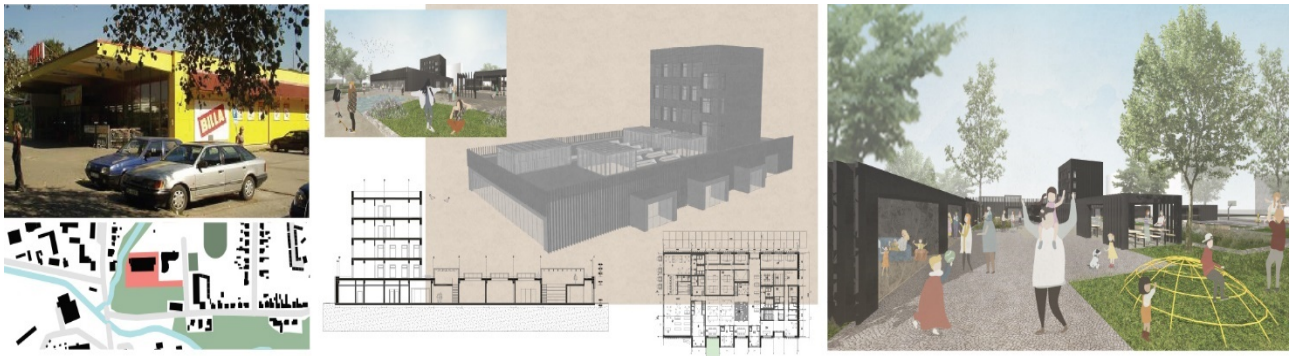

Figure 1: Adaptive reuse of an abandoned grocery store, with an empty parking lot as an adaptable city hub for co-working, small business opportunities and community usage (diploma project: S. Trimlová; supervisors: H. Pifko and M. Lüley, 2019).

SOLIDS WITH ITERATIVE LIFE-CYCLES

The author's methodology builds on the Dutch heritage of solids as objects that are designed to accommodate any function. Bijdendijk defines *solids* as sustainable buildings in terms of economy, functionality, technology and emotion [14]. This can be achieved by:

• *accommodation capacity* in terms of being able to adapt. This capacity is targeted at the individual, which means that the building can offer each occupier the freedom to adapt space to their needs;
• *preciousness* in the sense of emotional value and uniqueness. Bijdendijk claims that this capacity is targeted to collective values; it is about the identity of the building: the degree to which people can build a relationship with the building, like it, feel connected, and then want to keep it.

Vašourková and Eberle apply the term *solids* to even more abstract forms, where the building does not need to have any programme at all. They claim that the programme is a matter for one generation. To build for a long period, consideration should be given to programme-less buildings [15].

On the other hand, Dubbeldam understands solids as generated forms that are custom made for the user. They break the limits of agglomeration of orthogonal planes and straight lines resulting in full bodies with specific meaning [16]. The author proposes a middle-ground approach. In doing so, a strategy can be introduced for students to understand the need for iterative life-cycles for buildings.

An example is a multi-purpose building designed from an existing public urban structure and an existing university campus. The proposal was to design an object that is solid, but can accommodate in different stages different functions. The changing gradient of public, private and campus (student) use has been taken into consideration - see Figure 2. Another example of a multi-purpose building proposal based on the philosophy of *solids* is shown in Figure 3.
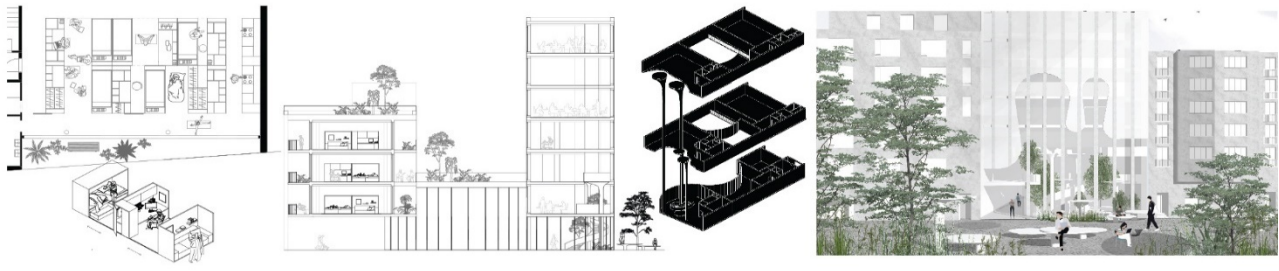
a)   b)   c)

Figure 2: Multi-purpose building proposal based on the philosophy of *solids*: a) dormitory for students is inserted into generic wide-spanned rooms. The mechanism was inspired by a librarian moving shelves; b) gradient from the public to private space in the common area; and c) *preciousness* projected on to the façade and transparency of public spaces (core studio project: L. Korkošová, supervisors: R. Špaček and M. Lüley, 2019).

Figure 3: Multi-purpose building proposal based on the philosophy of *solids*. The essential concept is the connectivity and division of spaces for future adaptation without losing any initial quality of open and fluid common spaces (core studio project: M. Kotásková; supervisors: R. Špaček and M. Lüley, 2019).

SCENARIO-BASED DESIGN LOOPS

Non-linear design thinking results in the synthesis of strategies based on scenarios and feedback mechanisms to help build the concept, programme and geometry of architectural design for the greatest degree of adaptability. The main tool for the strategy is a feedback loop based on a variety of scenarios to optimise settings and assuming eventual changes within the building - *a feedback process of alternative development anticipation.* The variability of solutions and different perspectives should correlate with the collective intelligence (see Figure 4).
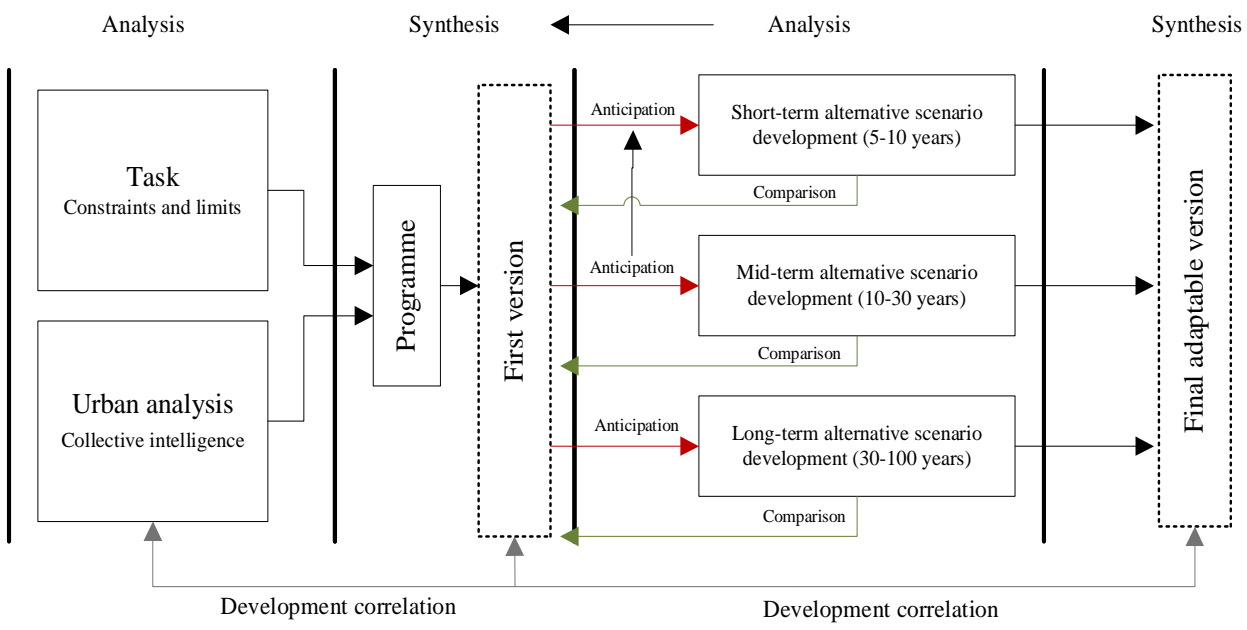

Figure 4: The feedback process of alternative development anticipation and subsequent comparison in three-term ranges resulting in adaptable and resilient architecture. The design methodology is based on the alternation of the analytic and synthetic parts of the design process, resulting in non-linear design thinking.

The aims of the strategy are:

a) customising the programme and building functionality by observation and evaluation to generate the dimensions, geometry and capacities of a building for future adaptation;
b) understanding the spatial properties and the complex mapping of input data in relation to the design. Working in various scales; from the scale of the city, through the details of the neighbourhood, to the study of specific spaces;
c) fluid (free-flowing) and reactive spatial functioning of the building programme within the proposed geometry in anticipated time sequences;
d) an ecological and sustainable focus.

An important aspect of the methodology is subjective judgment. It encourages critical thinking. As Avsec and Jagiello-Kowalczyk imply: …*critical thinking enables convergent thinking and rationality, which can improve the usefulness of design* [17]. On the other hand, critical thinking questions the overall process and creates constant feedback.

CONCLUSIONS

Ecology and sustainability are embedded in architectural education and the main ideas are the new norm [18]. Unfortunately, many architects or engineers pursue the minimum needed to obtain permits or other certifications. The environmental issues are still understood more as constraints than solutions. With the proposed methodologies and strategies, the author has tried to provoke discussion and critical thinking in education.

The need is to implement these, not as additional values or extensions of knowledge, but as natural thinking. On the other hand, there is a question of whether the vocabulary of sustainability still excites students to try the new or to experiment. For example, David Benjamin proposes that ecological thinking can be viewed as designing or shaping embodied energy [19]. The narrative design process ought to be able to *re-think* the application of every single material in architectural proposals. There are still areas and topics to explore and educators should always explore them.

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