Teaching sustainable architecture - *small* as a paradigm

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ABSTRACT: Small dwellings have started to receive more attention. Partly, it is caused by their extraordinariness in the context of standard dwellings; however, one should not overlook their sustainability potential. Moreover, the houses, small in size, but carefully designed, offer great use. In this sense, small houses are efficient in offering life quality by minimising economic and environmental costs. The study follows previous research on this topic at the Institute of Ecological and Experimental Architecture, where the potential of small scale architecture is researched in a theoretical way, as well as through studio assignments. The focus of the study is on the sustainability of small houses and their integration into the educational process. From a sustainability perspective, smaller size indicates lower consumption of materials, energy, building plot and goods, and it also comes with a change of a lifestyle to a more sustainable one. The *minimax* principle plays a key role. In architectural education, the small house presents a challenging task in space organisation, and it also connects building design with lifestyle, which is where the sustainability of the small houses lies.

Keywords: Small house, sustainability, minimax

INTRODUCTION

The history of small houses goes back to the first dwellings. Shortage of materials (African shacks) or space (treehouse), need for mobility (yurt, tee-pee) or effective energy use (igloo, earth-covered house) caused our ancestries to live in small houses. Two-room houses, of which one was intended for sleeping and the other for household activities, could be found in the rural areas of Central Europe from medieval times until the early twentieth century. Small houses also played a significant role in modernism when colony houses intended for workers, built after the style of garden cities (Zlín in the Czech Republic or Partizánske in Slovakia), were considered to constitute comfortable and affordable housing for people from the lower classes.

In the United States, mobile homes, representing affordable and adaptable housing, became widely popular after World War II, because of the poor economic situation. Though the improving economic situation led to less interest in small houses, attractive projects were also created during that period, often by renowned architects.

At present, small houses are becoming the centre of interest again. In today's context, they are of interest in several regards. A small house means low costs and environmental impact; it solves both the economic and ecological problems constituting a challenge for contemporary architecture. On top of this, living in a small house can provide an interesting alternative to a standard consumer lifestyle. A small house provides new options on the road to sustainability. It is linked to a specific way of thinking. It must be precisely designed, not forgetting to take into consideration the lifestyle of its residents. The following study depicts the small house, also enlightening specific features of small houses as an assignment to be accomplished in studio work.

ABOUT SMALL HOUSE

Jan Krieger in his book titled *Das kleine Haus - eine Typologie* defines small houses as:

> *Houses that are simple and clear, neither complicated nor all encompassing, not unnecessarily large, not out for image - and without unimportant, superfluous details* [1].

A small house is a modest one, which does not assume anything; at the very most, it is also a house, which is big as to the benefits it offers. Though a small house is defined as being small due to its size, neither the upper nor the lower limits of it are clearly specified. Krieger says:

Theoretically, there is no limit on how small a house can be, as long as the criteria - particularly that regarding permanent residence - *are met. However, the upper limit is more difficult to define because it has to be set arbitrarily. Simplicity, though, is paramount* [1].

The amount of space, which is comfortable as a permanent residence depends on the lifestyle of its resident. The minimum defined area differs: for refugee camps, it is 3.5 m^2 [2], minimum apartment has 9 m^2 [3], and the area of a single-family house intended for one person is 27 m^2 [4]. The limit 8 m^2 set based on the minimum air volume required for an adult person to comfortably survive the night has been amended, due to impact of mechanical ventilation.

In an extreme case, a small house could be no more than a sleep box the dimensions of which are similar to those of a coffin. While the lower limit is determined by a human body, the upper limit is based more or less on social standards. A small house is generally defined as a dwelling with a floor area not exceeding 100 m^2. The range between the maximum and minimum size of a small house is considerable; therefore, three size categories have been identified:

- Sleep box: it slightly exceeds the proportions of its resident's body; e.g. temporary housing or shelter for homeless.
- Tiny house: it ranges from space sufficient for walking to approximately 40 m^2.
- Small house: its size varies from 40 m^2 to 100 m^2.

a) b) c)

Figure 1: Size categories of small house: a) sleep box (shepherd's dwelling, open-air museum in Detmold), photo Robert Špaček; b) tiny house (Erich Boltenstern, Vienna, 1934, 13.5 m^2) [1]; and c) small houses (Erick Svedlund, Zlín, 1935, 85 m^2) [1].

SMALL HOUSE - SUSTAINABLE HOUSE

In recent years, the sustainability requirement has become a natural part of every area. Lack of natural resources, the increase in the global population and climatic changes have brought new challenges for contemporary architecture. Generally, sustainability can be defined as the capacity to continue [5]. Sustainable architecture has neither a specific formal style (unlike for example modern architecture) [5] nor any precise design method. It is a universal way of thinking about problems. The approach described in this study is based on the reduction of the size of the house - the original one does not always correspond with the real needs of people. A small house offers a possible answer to some demographic, economic and environmental problems to be solved by contemporary architecture.

Recent decades have brought radical changes in the structure of society [4]. In the past, most people lived in bigger households. Having two or even three generations living together and families with many children were common. In contrast, now households comprising one to three people - couples without children, single-parent families with one or two children or just individuals are more prevalent. The growing number of small households goes hand in hand with growing demand for small dwellings, where not only the size of the dwelling, but also the costs and the ecological footprint are smaller.

A small dwelling takes less space, uses less material and after its clearance, there will be less construction waste. Moreover, less energy will be used for heating and air-conditioning, and there will be a decrease in energy consumption in general. A small dwelling is usually a small flat. However, blocks of flats are not suitable for every environment. Quite often they are not the preferred type of housing. In comparison with a small house, they fail to offer the comfort of immediate contact with the external environment and the possibility to expand the living area outdoors. Despite their lower economic and environmental efficiency, small houses are an important complement to small flats.

Sustainable lifestyle means that architecture should also be modest and its quality should surpass the *lack of quantity* [5]. It is important to know what is necessary for life, while curtailing pointless consumerism. Besides the unavoidable reduction of property, which a person owns or acquires, the reduction of the living space may also initiate other changes in the lifestyle of the inhabitant. Modernist segregation of areas depending on their function created a lot of specialised, rarely used areas. Sharing of some of them within the house or potentially even a group of houses can simply decrease the size of the dwelling and, thus, make it more efficient (and, therefore, also more sustainable). The principle of sharing was applied in the minimum dwelling by Karel Teige [3], who designed cubicles designated for sleep, relax and intimate life of an individual. All other functions (hygiene, eating, social life) were supposed to take place in the common areas of the collective house.

Figure 2: 1) change in household size; 2) smaller house = smaller ecological footprint; and 3) from spatial segregation to sharing of areas (diagrams by Veronika Trnovská).

It is necessary to bear in mind that a small dwelling is a solution that is neither perfect nor universal. The disadvantage of small houses with respect to energy efficiency is the proportion of the external surface to the interior volume (A/V ratio). Although the lower costs of construction and operation of a small dwelling could be expected to result in less debt and more savings for its inhabitant, there is a completely different perspective concerning the investment value, which depends on the quality of construction and the overall context. Finally, one must not forget that not everybody enjoys living in a small space. One of the decisive factors is the personality of the users and, possibly, also their special needs. In addition to minimising the size of the house, there is an equally important ambition related to the quality of the space in which a person lives.

MINIMALISM

Small architecture can also be referred to as minimalist architecture. In aesthetics and the history of art, minimalism as a term has two meanings. The first interpretation is associated with the paring-down of formal means. In the history of art, minimalism denotes the work of sculptors of the 1960s and 1970s. In architecture, it is often associated with simple and clean aesthetics of functionalism and international style based on the motto of Mies van der Rohe *less is more* [6]. The second interpretation of minimalism is related to the *minimax* theory by Herbert Spencer, a 19th Century philosopher [6]. This theory was based on the biological principle of the effort to achieve maximum results, while expending minimum energy. The *minimax* principle was also applied during the modernist era when one of the most important roles of architecture was to create healthy and comfortable living for the working class. Karel Teige, already mentioned above, focused on creating minimum space with maximum benefit for the *existential minimum class* [3]. Due to economic and environmental problems, the *minimax* concept is still very relevant. A small house should minimise the inputs (costs and environmental impact) and maximise the benefits (the quality of living and quality of the living space) [7].

At the Institute of Ecological and Experimental Architecture, three interpretations of minimalism are used [6]. The first interpretation: minimalism in spatial differentiation offers a concept of a house with an open-space living area open to interpretation by its user and complemented with stable technical and sanitary facilities. The second approach studies aesthetic minimalism, which is based on working with a minimum number of elements with the aim to achieve maximum visual effect. The underlying principle of the third approach, which is described in more detail in this study, is the minimisation of the environmental impact through the house size reduction, among other things. The objective is to seek unconventional solutions for diverse social groups. Various concepts have been tested; for example, transformations of little garden houses, parasitic architecture or house design within a limited volume (cube 6 x 6 x 6 m) [7].

Figure 3: Minimalist house as the topic of the *Minority Housing* design studio projects (students Tomáš Krištek and Dalibor Vidiečan, tutor Henrich Pifko).

SMALL HOUSE AS A STUDIO ASSIGNMENT

As students acquire a variety of skills and develop their own approach to design during their study, they should be given assignments that are diverse as to their type. The *Small House* studio assignment may enrich the education of young architects in several ways. First, it is a way of thinking based on sustainability and on the idea that an architect should respond to problems present in society and, in addition to designing buildings, architects should design a lifestyle. Students are taught to question conventional solutions and instead of blind fulfilment of client's requirements, to create a life concept, not just a building. As Teige proved in his work, in the case of small dwellings, when designing the house, the necessary approach is to think ahead - about the (new) lifestyle to which the house is to be adjusted.

The small-scale assignment is suitable both for students and for young architects. Its approachability enables covering the whole designing process from the concept to details relatively easily. This way, a more in-depth test of the concept can be performed and a comprehensive project can be prepared [5]. Furthermore, small architecture is an excellent

material for experiments in the field of technology, construction, materials and typology. However, small house design is also an interesting topic for well-known architects. A textbook example is Le Corbusier's house for his mother at Lake Geneva (1923) or the house by Herzog and deMeuron in Oberwill near Basel (1980). An example from contemporary design can be seen in Diogene by Renzo Piano.

The downsizing of a house increases requirements related to its precise organisation; that is why designing a small house is always a challenge. When space is scarce, each detail must be well thought-out. The purpose of a small house is not to reduce comfort and usability, but to use the space efficiently and to achieve high comfort of living. In this respect, as a studio assignment, this is a surprisingly difficult task and students have to learn precision in organising the living space. To reach this level of precision, thorough knowledge of human dimensions, ergonomics, movement and activities is needed. In addition to theoretical study, it is important to observe one's own body, movements and activities - that is the best method how to understand how much space one really needs to live comfortably.

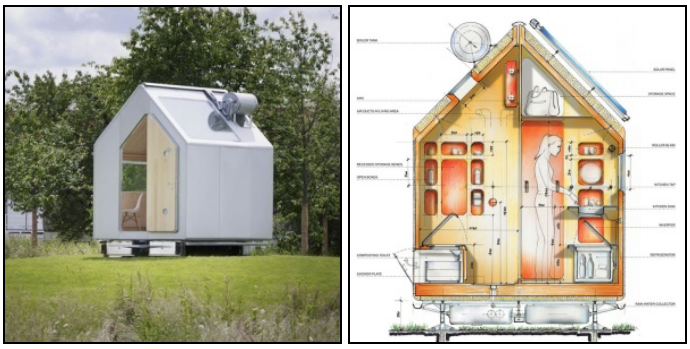

Figure 4: Diogene by Renzo Piano (source: www.dezeen.com/2013/06/12/diogene-by-renzo-piano-at-vitra-campus).

ARCHITECTURAL CONCEPT: DOWNSIZING A HOUSE

As mentioned above, methods of designing small architecture are specific as the task is not only to reduce the size, but also to maintain the quality of life (and, possibly, to create some new quality too). Simply, a house can only be downsized to a certain point. As Teige found out during his research, minimum dwelling has to function differently, because a house that is *just downsized* fails to offer a good quality of life [3]. In his work, *Minimum Dwelling*, Teige shows three types of small flats that are based on different principles of size-reduction:

1. A flat with kitchen serving as a living space uses the reduction of the number of specialised rooms and combination of different human activities into single multi-functional space. Such a flat may consist of one room where all functions occur or activities may be divided between bedroom and kitchen (and nowadays one would add a sanitary block).
2. A flat with a small kitchen and one to three rooms. Such a flat uses maximum optimisation and compression of the kitchen, which can go so far that the kitchen becomes only a kitchen nook in the living room, which again creates a kitchen and living room combination.
3. A flat without kitchen. This changes the organisation of life. Teige designed a separate room for each adult person, with one piece of furniture used for preparation of food. Such a flat implies a change in the lifestyle, which includes utilisation of public services (for example for eating out) and their collective sharing. The lifestyle of many young people nowadays is close to these ideas of Karel Teige.

Based on Teige's typology of small flats, three approaches to downsizing of dwellings can be defined:

1. Compression - size reduction and change of organisation based on the efficient use of space with respect to movement. Compression of facilities for individual functions enables their condensation and design of multifunctional areas; it also offers potential for mobility. A good example is a kitchen on a train or a kitchen on a plane.
2. Reduction of functions of a dwelling where their sharing outside the house is anticipated. Such a dwelling is dependent on amenities, such as public baths, restaurants, bars, laundry services, etc. The amenities may be part of collective houses or cohousing groups, where the added value is the community created by the inhabitants.
3. Reduction of living areas and combination of their functions, which forms a multi-functional space. In a way, this type of dwelling is a return to the past, when it was common that a house comprised a single open space.

There are several ways different functions can be combined. The result may look like universal space with specialised corners; furniture does not have a fixed space and can be easily adjusted for other use - with a yurt as a traditional example. Another approach is the design of hybrid elements: Furniture House designed by Shigeru Ban is characterised by simple prefabricated partition walls dividing the area, shifting the load and providing storage space. Another approach is based on the interaction with the user: by moving, pulling or folding, the inhabitant adjusts the space for different activities. This principle is applied in the form of sliding walls, such as those in a traditional Japanese house or in Rietveld's Schröder House. The physical basis for various activities can be hidden in the walls, floor or ceiling.

An interesting example is Suitcase House by Gary Chang, which hides all functions in the floor of a large room without a defined function. Another possibility is the creation of multi-functional furniture for universal space, the function of which is defined only by its use.

OPERATION OF SMALL HOUSES

If one wants to minimise the environmental impact of small houses, *downsizing* is most obvious at the beginning and at the end of the life cycle of a structure (lower consumption of raw materials and other materials, smaller production of non-recyclable waste). However, in the case of buildings, the most important stage of their life cycle is the middle one; during decades of their operation, they must do with the smallest possible amount of energy and other resources. In a small house with an unfavourable A/V ratio, it is a difficult challenge, especially for architecture students who might be encountering sustainability and efficiency requirements for the first time. However, it is also an opportunity to learn how to use support tools in the architectural design process (for example tools for calculation of energy consumption or sustainable architecture assessment schemes) in a small scale and easily understandable assignment.

Energy efficiency at the level of a nearly zero energy building means constructions and technologies at the level of a passive house standard, complemented with the use of renewable energy, and must be commonplace for small houses these days. Such a house, with annual energy consumption of only hundreds of kWh should be also modified with respect to the expected climatic changes and have the smallest possible impact on nature. Another challenge is its relationship with the urban environment: small houses require an innovative approach primarily in relation to transport efficiency and accessibility of amenities, which is especially critical in case of function-sharing.

SMALL HOUSE IN A STUDENT STUDIO

When giving the small house assignment as a topic for the student studio, marginal conditions can be added, either with respect to physical restrictions (e.g. a house in a cube 6x6x6m; a house with a minimum floor plan area; or a house as an addition to an existing structure), specification of its function (e.g. a dwelling for minorities; nomadic architecture; or solutions for the homeless and refugees) and construction (e.g. a container home; a treehouse) or emphasis on operation parameters (e.g. a passive or zero house; or a mobile dwelling). Sometimes requirements regarding the technique used for designing can be added (simulation of participatory approaches; defining the target groups and expected lifestyles; seeking innovations in dwelling typology) and, these days, an assessment of the operational efficiency of the building (work with pertinent support tools) is also required. This has involved the preparation of some of these tools in-house (CESBA tool - [9]) or arranging for their localisation (PHVP) and support (design PH). Free solutions are preferred, with the hope that students will continue using them after they have completed their studies, which is less likely in case of expensive professional tools. In the creative process, both virtual and physical models are used - sun access simulation with a gnomon is less precise than output from the CAD-programme, but it helps students to understand the principles of solar architecture better.

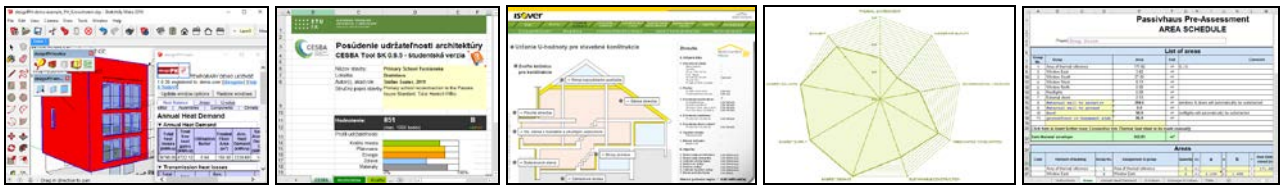

Figure 5: Tools that can be used by students in the process of designing a small house: designPH, CESBAtool, MCHD, AH-Radar, PHVP (screenshots Henrich Pifko).

An interactive model of a small house is exactly what one uses for pedagogic purposes, especially for teaching the principles of sustainability and energy efficiency. On a cube with a six-metre edge, the effects of a change in location, orientation, window area, quality of insulation and the technology used can be simulated. A concrete demonstration of the impact of such changes in designPH programme (plugin for the SketchUp 3D-modeller) enables students to prepare an optimum architectural concept of their own design faster.

CONCLUSIONS

A small house may offer sustainable, high-quality and comfortable living. Fulfilling all the listed qualities is neither simple nor a matter of course. Such a small house reflects the lifestyle and its location corresponds with the every-day life of its inhabitant; its interior layout can meet all individual needs of the inhabitant and uses the relevant space efficiently. To prepare its design in high quality requires specific know-how, which the authors endeavour to teach their students.

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REFERENCES

1. Krieger, J., *Das kleine Haus – eine Typologie*. Switzerland: Verlag Niggli AG, 6-20 (1995).
2. The Sphere Project, *Humanitarian Charter and Minimum Standards in Humanitarian Response*. Northampton: Belmont Press Ltd, 259 (2011).
3. Teige, K., *The Minimum Dwelling*. Cambridge, MA and London: The MIT Press, 412 (2002).
4. Havaš, P., *Typológia budov – obytné a občianske budovy*. Bratislava: Edičné stredisko SVŠT, 73 (1980) (in Slovak).
5. Špaček, R. and Pifko, H. (Eds), *Rukoväť udržateľnej architektúry*. Bratislava: Slov. komora architektov, 14-31 (2013) (in Slovak).
6. Špaček, R. and Zervan, M., Minimalizmus ako aktuálny problém. *Eurostav*, 4, **6**, 28-31 (1998) (in Slovak).
7. Pifko, H. and Špaček, R., *Efektívne bývanie*. Bratislava: Eurostav, 23-24, 40-42, 48-52 (2008) (in Slovak).
8. Schittich, C., Small Structures. *Detail: Compact Dwellings, Temporary Structures, Room Module*. Basel: Birkhäuser, 8-11 (2010).
9. Krajcsovics, L., Pifko, H. and Jurenka, Š., Building sustainability assessment method CESBA in Slovak conditions. *Proc. SGEM 2015, Vol. II: Green Building Techn. and Materials*, Albena, Bulgaria, 385-390 (2015).

BIOGRAPHIES

Henrich Pifko is an architect and associate professor in the Institute for Ecological and Experimental Architecture at the Faculty of Architecture of Slovak University of Technology in Bratislava, Slovakia. He graduated from the Faculty of Architecture STU (1983) and started his professional career at the Institute of Civil Engineering and Architecture of the Slovak Academy of Sciences. Since 1993, he has been teaching at the Faculty of Architecture STU. His field in research, in education and in design practice is energy-efficient and sustainable architecture. He has been the lead-author and/or editor of books entitled *Efficient Housing* and *Manual of Sustainable Architecture*. He is the Chairman of the Passive House Institute in Slovakia, a founding member of ArTUR (Architecture for Sustainability) NGO and the leader of the *Architecture 2020* Centre at the Faculty.

Veronika Trnovská graduated from the Academy of Fine Arts in Bratislava in 2013, where she studied architecture. During her study, she went on a study visit to the Estonian Academy of Art (Urban Studies, 2012), had an internship in the studio FABRIC (Amsterdam, 2013/2014) and worked on a research project called Urban Metabolism for the International Architecture Biennale IABR (Rotterdam, 2014). Since 2015, she has been a postgraduate student in the Institute of Ecological and Experimental Architecture at the Faculty of Architecture of the Slovak University of Technology in Bratislava, where she primarily focuses on her research theme *Small House of the Future*, but she is also teaching in design studios and seminars.

Robert Špaček finished his study of architecture in Slovak University of Technology in Bratislava in 1976. In 1981-1982, he was a post-graduate student at the University of Hannover. He is a member of the Institute of Ecological and Experimental Architecture of the Faculty of Architecture of the STU, which he founded in 1990 together 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 an author, co-author or editor of dozens of scientific and popularisation texts, including books *Efficient Housing*, *Manual of Sustainable Architecture* and *Solar Cities*. He is a member of scientific and publication boards and other associations. Since 2010, he has been the Vice-Dean of the Faculty of Architecture of the STU for Research, PhD Study and PR.