Blue-green concepts in the design of rural settlements

Ľubica Ilkovičová & Ján Ilkovič

Slovak University of Technology in Bratislava
Bratislava, Slovakia

ABSTRACT: Blue-green (BG) design can be seen as a comprehensive way of designing in the field of architecture and urbanism, within the context of environmental sustainability. This approach is characteristic of cities, but is less significant in the development of rural environments. In the creative process, the fundamental objective is to achieve the integration of benefits and a new quality of the environment. In addition to the general postulates of blue-green design approaches, in this article, the authors address the search for a methodology for teaching architecture with an emphasis on outcomes in terms of sustainability of the rural environment. The result of the research is the classification of the components on a theoretical and methodological level, and the presentation of the solutions on the research area of the Gabčíkovo settlement, Slovakia, in the vicinity of significant waterworks. In the conclusions are evaluated the different approaches of students with the definition of prerequisites for the methodological use of the results in further pedagogical processes.

INTRODUCTION

The issue of environmental balance and sustainability is very important for everything in life. Disruption of these phenomena can lead to fatal consequences for humanity, and therefore discussions on eco-friendly solutions are important in the academic environment. In this article, the authors present research on balance and sustainability in rural environments.

A comprehensive perspective on the countryside is particularly important in the current environmentally complex period. In the recent past, interest in comprehensive solutions to rural problems has not been a priority. The terms *rural*, *village* carried an undertone of inferiority and second-classness, which at the same time carried over into the solutions and approach of many professionals who did not find rural projects lucrative in their conditions. A part of rural settlements in Slovakia was purposely suppressed due to the hierarchy of arrangement and territorial categorisation (the system of centre settlements).

On the positive side, the situation over the last 10-15 years has been changing, and the countryside is gradually being given a qualitative equivalent of importance compared to the city. Nevertheless, it should be remembered that the link between man and land, the emphasis on the values of the countryside, the focus on its components (land, farming, landscape, tradition) do not constitute new knowledge, but have rich historical roots in Slovakia. In the inter-war period, it was the orientation known as agrarianism [1].

Other terms, such as *agri-culture*, *agritecture* and *locavorism* have become frequent in the context of sustainability and eco-friendly solutions in the countryside. This is not just a fashion trend, but a need to integrate sustainability into the broad rural context in which agriculture and landscape are dominant. Elements of rural design and vertical farming are also seeping into cities, driven by advertisements about healthy living and the desired parallel with the countryside. The urban farming movement goes beyond food as it affects the way of living, working and consuming, too. It is impossible to live in cities without having the resources needed for basic sustenance and wellbeing nearby [2].

Today, green horizontals and verticals (public green spaces, utilitarian growing areas, ornamental green walls, green roofs on buildings) and blue lines (forming watercourses, storm water management, water recycling, creation of *sponge* areas are emerging in the urban environment. These green and water systems are then integrated into an ecologically sustainable unit (integrated design). Terminologically established coloured infrastructures (grey, red, blue, green) significant for urban design [3], are enriched by a combined blue-green infrastructure (BGI) regardless of the nature of the environment.

What is it like in the countryside? Given that the countryside is generally characterised by the extent of green areas and the abundance of natural water features, the question arises as to what extent one needs to address this issue. Is it enough if nature itself deals with the problems? Whatever the answer, there always remains an obligation to guide sustainable design in the context of rural architecture. The principles of urban BG solutions as a modern sustainable way of solving problems are being implanted in the countryside. The city is inspired by the countryside and the countryside is inspired by the city.

Some publications emphasise comprehensive BGI solutions, reducing negative impacts on climate change, positively influencing a healthy and safe environment, along with the expansion of downstream quality amenities and services [4]. The advantage of a blue and green infrastructure is its adaptability and ability to integrate natural processes, optimising conditions for human life and biodiversity, as opposed to mono-functional and non-adaptive grey infrastructures.

In this article, the authors focus on the possibilities of applying blue-green urban-architectural concepts in the creation of the countryside. The necessity to extend this principle as a way of thinking is supported by several studies and research that implant the concepts in both urban and rural environments. As Denekas et all write:

> *Rural areas in Europe play a special role in environmental management, in biodiversity preservation, climate change regulation, air, water and soil protection and landscape preservation* [5].

Inspiring research includes research where the multiscalarity and multifunctionality of BG solutions in reducing ecological and environmental problems are emphasised [6].

The main question posed in this research is as follows: What is the difference in the concept of blue-green design in a rural environment compared to an urban environment?

MATERIAL AND METHODS

As part of the research was created a basic scenario of BG approaches to rural settlements, subsequently verified in the educational process. As the main research area was selected the unused site of the former construction background of the Gabčíkovo waterworks (GWW), on the outskirts of the Gabčíkovo settlement in Slovakia. Currently, the area is undergoing a process of identification of function with an alternative of building, a science and technology park with the application of sustainable principles. The area is specific due to its strong connection with the Danube River and the technical work - a hydroelectric power plant with locks. The site is an intersection of four characteristic environments: *technical* with the mega-structure of the hydroelectric power station, *rural* with a typical rural scale, *agricultural* and *landscape*.

The site is a suitable area for the pedagogical process and academic research to test the students' ability to handle BG solutions. The challenge for the students was to build on the basic urban structure of the planned science and technology park (student designs) and to create a link between the existing engineering works (GWW) and the agricultural landscape. The content of the task was to design greenhouses and a small engineering structure in the area as typological types that would complement the idea of blue-green infrastructure.

Methodologically, the process progressed from a general model - a template for the creation of concepts (shown in Figure 1), to the creation of alternative BG concepts by the students. The concepts were then evaluated according to the scenario to see how the students grasped the problem. Hlaváček and Čeněk pointed out:

> *In contrast to engineering disciplines, the student of architecture is able to look at the issue of designing in a holistic way. However, he is overwhelmed by a large number of topics and subjects that must be addressed. The issue of* sustainability *thus often gets on the edge of his interest* [7].

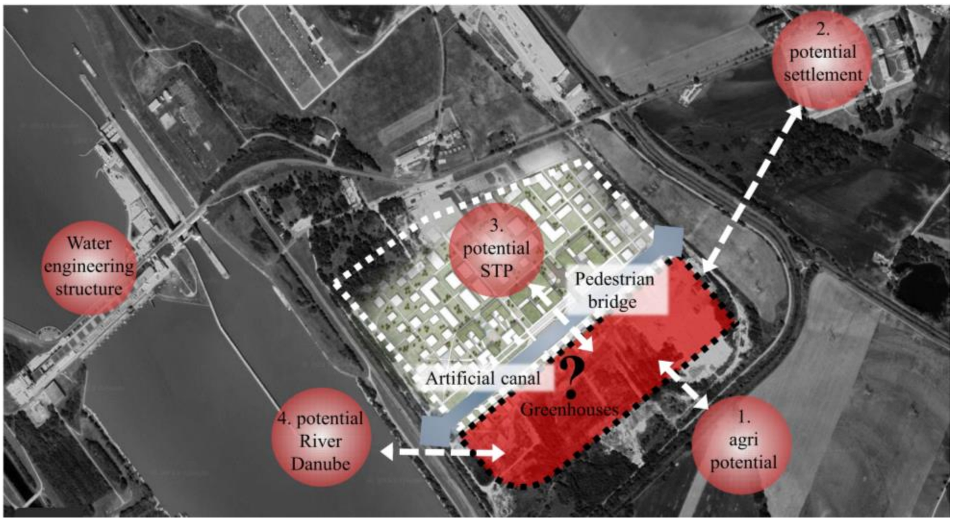

Figure 1: Territorial template for the concepts.

According to Jabłońska and Ceylan, sustainability is a multifaceted concept that needs to be approached from various perspectives. The implementation of sustainability issues into architectural education is not the concern of the design studio alone, but also of the curriculum as a whole [8].

The place of BG approaches should be found not only in the design studio, but also in the supporting subjects of a theoretical-typological nature (an example is the subject Typology IV - manufacturing and engineering structures in the Faculty of Architecture and Design at Slovak University of Technology in Bratislava, Slovakia). The teaching methodology focused on problem-based learning, creative approaches and the application of critical thinking. Problem-based learning with the possibility of creating one's own algorithm and scenario as a way of critical thinking in problem solving are among the methods that produce beneficial educational results [9].

RESEARCH

The research focused on the specification and basic comparison of BG solution components for rural and urban environments. The rural characteristics emphasised include open landscape, agro-production and the overall scale of spatial arrangement and development. For illustrative purposes, Table 1 lists the main components along the urban-rural line, highlighting the synergy of the components.

Table 1: Main blue-green components.

	Blue-green infrastructure components	
	Urban	Rural
Green components/ dominant	Areas of horizontal greenery - public greenery of parks, vegetation roofs	Areas of horizontal greenery: forest stands, areas of ecological agriculture
	Areas of vertical greenery - walls and façades of buildings, urban farms	Utility vertical green farming
Additional	Private recreational areas of greenery, community greenery	Private recreational areas of greenery, community greenery
Blue components/ dominant	Waterways and water areas	Waterways and water areas
	Rainwater retention systems, creation of sponge surfaces, water recycling	Rainwater retention systems, storm water protection systems, water recycling
Additional	Private recreational water areas	Private recreational water areas
Manifestation of component synergy	BG paved areas and parking lots	BG paved areas
	CW (constructed wetlands), urban water management	CW (constructed wetlands), water management in the territory
	Use of renewable energy systems (RES) and smart energy systems	Use of RES and smart energy systems, agrivoltaics

The research focused on the extent to which the above general components of BGI are applied in the student work. The process of selecting the components went through notional filtering steps in the scenario (Figure 2), so that the designs took into account the potentials and sustainability of the environment and respected the strengths of the territory, namely:

- *Landscape* (values of open and agricultural landscapes, their use and transformation, integration of the landscape with the proposed watercourses and water areas, landscape panorama);
- *Water* (use of water potential in the site and wider area, application of overall water management);
- *Energy* (use of RES, local energy, waste heat);
- *Buildings and construction-technical work* (orientation, efficiency of the building envelope, architectural expression of the work, sustainability of building materials).

A positive phenomenon was that the students independently pursued an in-depth exploration of the BGI components. This approach brought diversity, e.g. blue, green and hybrid alternatives emerged in the greenhouse designs. The opposite of the greenhouse design integrated into the agricultural landscape was the design of a bridged man-made canal or the design of a small observation tower interacting with an engineering work (GWW). In this assignment, the synergy of the GBI components was more difficult to apply.

RESULTS AND DISCUSSION

The results of the research do not represent students' studio work, but are the result of the teaching methodology in the form of a *small creative task* in a typology course with the implementation of team consultation by professors. The BG approaches are characterised by a strong planning phase. They emphasise linked-in thinking and holistic, rigorous analyses [10]. Students were encouraged to think critically, to be creative and to work independently or, by choice, in teams. In this regard, the aim of the research was a pedagogical and methodological experiment.

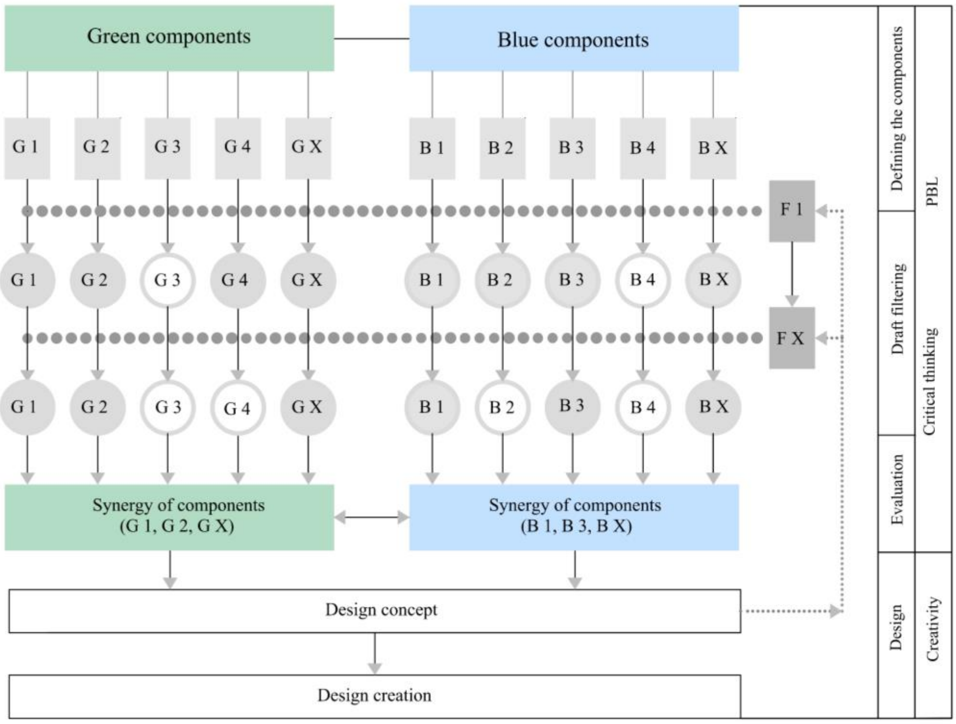

Figure 2: Scenario of BG approaches.

Solution Characteristics

The students worked mostly with stand-alone BGI components. The *blue solutions* reflected the proximity of the water body and the watercourse. They implanted water into the concepts in the form of linear elements, ponds, reservoirs mostly to retain the water and improve the climate. Water features form a very inspiring area of water sensitive design, it is a broad issue that appears at the level of landscape and the architecture of designed greenhouses (also indoors), and also in water management [6].

In the *green group*, green walls, avenues, fences and vertical growing technologies - all of them appeared. The vertical method allows for site-independent production, which can take place in different structures and, therefore, also in greenhouse buildings [11]. It should be stressed that green infrastructure is defined by the European Commission as a strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity [12].

The fact that there are enough green areas in the countryside is not (yet) enough. In the presented research were confirmed the findings that designs with a strong green concept have a higher design quality compared to a purely blue concept [13].

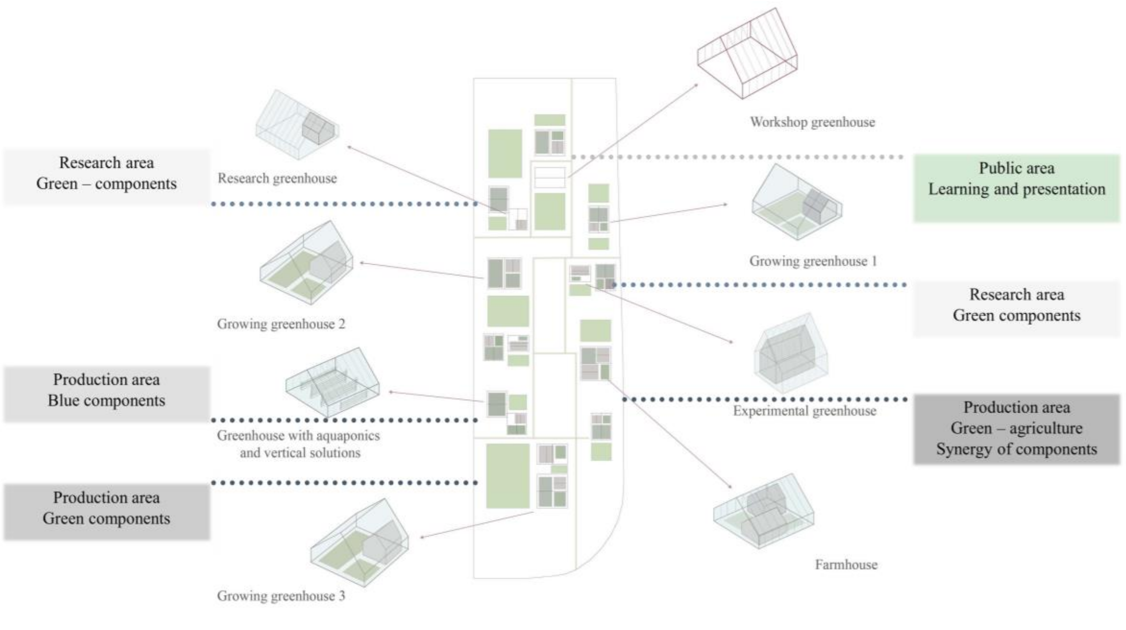

Figure 3: BG concept of the greenhouses design (student: V.M. Bertová).

Some designs applied the *principle of synergy*, with BGI components not just additively layered. Nature-based solutions (NBS) were used with a confluence of benefits between green and blue solutions to create a rural type/character area of a *rural biopolis*, presented in Figure 3 and Figure 4. The integration of water use and recycling, the creation of sponge systems in the area, hybrid energy solutions and the integration of BGI into the concept of greenhouse and small engineering architecture contributed to the synergy [14], see Figure 5. Well and Ludwig stated that:

> *Integrated planning for blue-green architecture offers the possibility to pursue aesthetic, ecological and climatic goals in equal measure* [15].

Constructed wetlands (CW) were extensively applied. CWs offer an environmentally friendly approach and have a high potential for being applied particularly in small rural communities [16][17]. On a positive note, this economically and environmentally sensitive method of water use was brought to the attention of the students. The popularity of such solutions also stems from the possibility of their harmonious integration into the landscape.

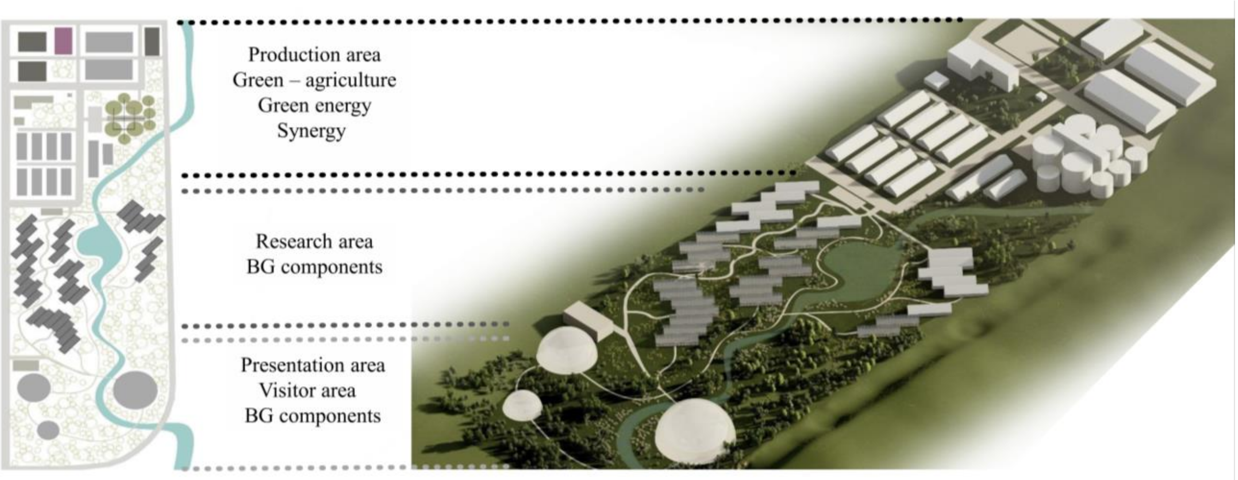

Figure 4: BG concept of the greenhouse area (student M. Grác).

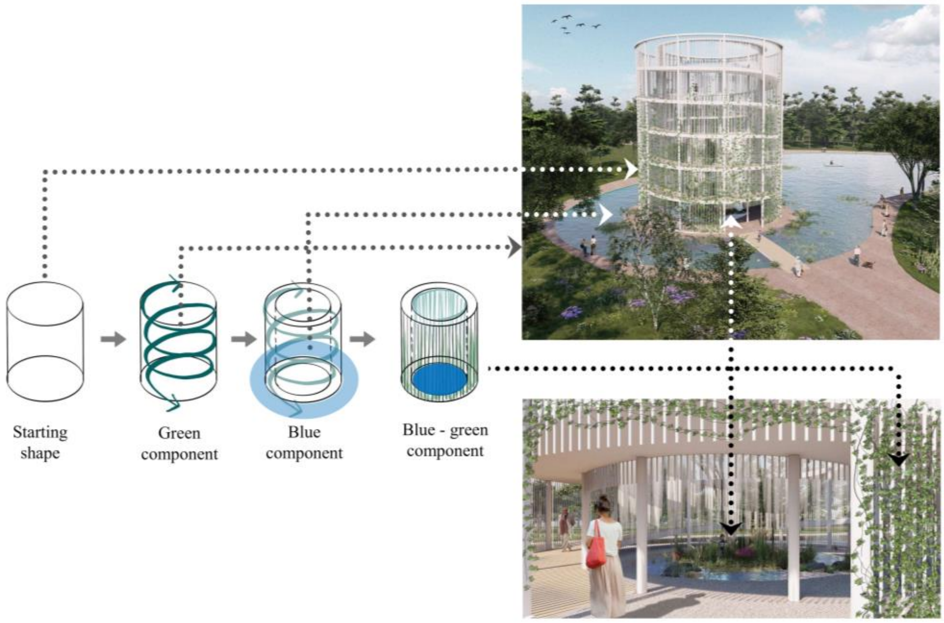

Figure 5: BG concept of the small engineering structure (student: Z. Chamulová).

Summary of Solutions

The evaluation showed that 27% of the concepts benefited from the synergy of the BGI components. The solutions focused on the interaction of sustainable agro-production and energy self-sufficiency. The notion of quality architecture and spatial design became an added value of the BG solutions. Forty-four percent of the works focused mainly on concepts with separate blue or green components, but demonstrated the idea of quality architecture. Eighteen percent of the works touched marginally on BG issues, i.e. they acknowledged it but did not critically work further with it. Eleven percent did not address it at all. Forty percent of the students graphically accentuated the given solution, creatively and clearly presenting critical thinking.

The overall quality of the outputs and the depth of their elaboration indicate a well-defined teaching methodology and, in terms of relevance, an appropriately chosen topic. It could have been expected that a greater percentage of students would engage critically and comprehensively with the BG approaches. The authors of the present article are therefore inclined to the opinion of Avsec and Savec that the necessary relationship between creativity and critical thinking needs to be further emphasised. Critical thinking implies the interaction of one's own thinking, judgement, presenting solutions to problems, but also iterative evaluation [18].

The results of the research also answer the basic research question. The difference in the concept of BG design in a rural environment compared to an urban environment is in the setting of the dominant components of BGI, in the way synergies are addressed, in the integration of components aligned with the rural character and contributing to eco-agriculture.

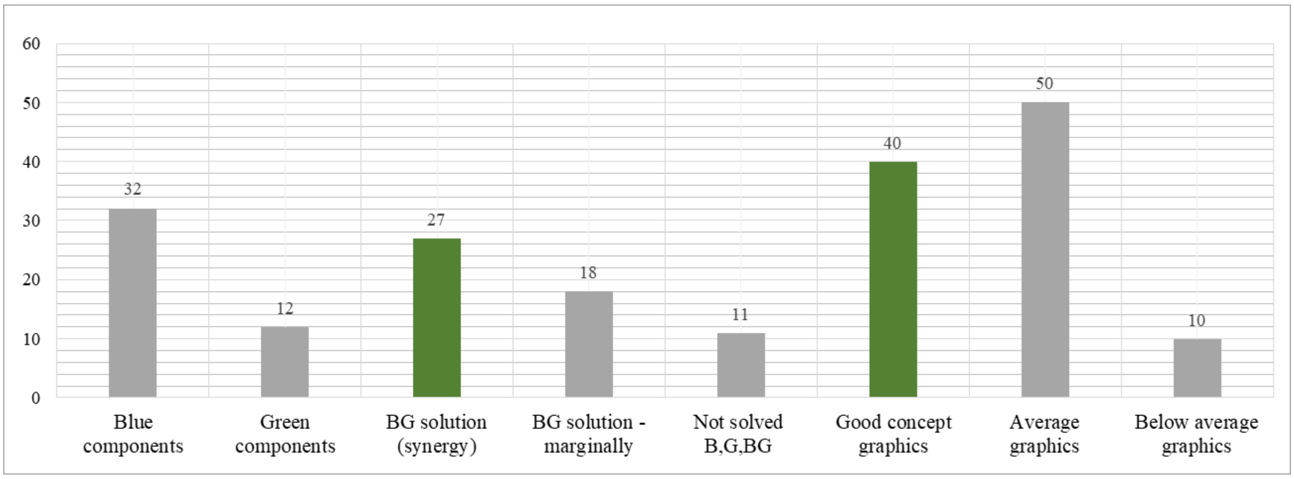

Figure 4: Evaluation of the 94 students' concepts (in percentages).

CONCLUSIONS

Highly topical blue-green projects using NBS contribute to the concept of resilient settlements and to the quality of an environment where it is pleasant and safe to live. Synergy between the two systems (blue and green) is essential, and a transdisciplinary approach is necessary to achieve multifunctional and flexible problem-solving outcomes. Well and Ludwig pointed out that:

> *Crossing disciplinary boundaries is no easy task. It requires time and commitment, which makes it essential that everyone involved is willing to learn* [15].

The results of the problem-based learning training focused on BG approaches in the context of the solution of a research area in the vicinity of the Gabčíkovo hydroelectric power station confirmed the appropriate choice of teaching methods. It is extremely important that BG issues are progressively mastered by students within the educational process right at the Bachelor's level of study, in the group of theoretical-typological subjects. The results form the basis for further pedagogical processes. Students can apply the acquired knowledge, then critically and creatively develop it in follow-up design studio courses.

ACKNOWLEDGMETS

This article was prepared under the financial support from the Cultural and Educational Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic for the grants' numbers 029STU-4/2021 and 037STU-4/2021.

REFERENCES

1. Stanková, M., Hronský´s philosophy of life in the context of *agricultural novel*. Hronského filozofia života v kontexte *roľníckeho románu*. *Ostium*, 14, **3** (2018) (in Slovak).
2. Vasquez Alarcon, C., Amsterdam and Paris exchange on Urban Agriculture Practices (2021), 13 February 2023, www.agri-city.info/fr/dossiers-et-articles/alimentation-circuits-courts/amsterdam-and-paris-exchange-on-urban-agriculture-practices
3. Poórová, Z., Green and blue infrastructure in modern cities and buildings. Zelená a modrá infraštruktúra v moderných mestách a budovách. *Eurostav*, 24, **10**, 27-29 (2018) (in Slovak).
4. Leuderitz, C., Lang, D. and Von Wehrden, H., A systematic review of guiding principles for sustainable urban neighbourhood development. *Landscape and Urban Planning*, 118, 40-52 (2013).

5. Denekas, J., Jaszczak, A., Gotkiewicz, W., Pawlewicz, A. and Žukovskis, J., Agri-environmental programs in rural development: case of the Ostfriesland region in Germany. *Manage. Theory and Studies for Rural Business and Infrastructure Develop.*, 36, **2**, 255-263 (2014)
6. Perini, K. and Sabbion, P., *Urban Sustainbility and River Restoration: Green and Blue Infrastructure*. Oxford, UK: John Wiley & Sons, 3-42 (2017).
7. Hlaváček, D. and M Čeněk, M., Hands-on: sustainable approach in architectural education. *Proc: Central Europe towards Sustainable Building. IOP Conf. Ser.: Earth Environ. Science*, 290, 012047 (2019).
8. Jabłońska, J. and Ceylan, S., Sustainable architecture in education. *World Trans. on Engng. and Technol. Educ.*, 19, **1**, 96-101 (2021).
9. Nyka, L. and Marczak, E., Frontier education for a sustainable future - speculative design in architecture as a transdisciplinary experiment. *Global J. of Engng. Educ.*, 25, **1,** 6-11 (2023).
10. Bozovic, R., Maksimovic, Č., Mijic, A., Smith, K.M., Suter, I. and Van Reeuwijk, M., *Blue Green Solutions. a Systems Approach to Sustainable, Resilient and Cost-Efficient Urban Development*. London: Climate-KIC Limited, 9-24 (2017).
11. Van Delden, S.H., SharathKumar, M., Butturini, M., Graamans, L.J.A., Heuvelink, E., Kacira, M., Kaiser, E., Klamer, R.S., Klerkx, L., Kootstra, G. and Loeber, A., Current status and future challenges in implementing and upscaling vertical farming systems. *Nature Food*, 2, **12**, 944-956 (2021).
12. European Comission: Green infrastructure, 14 May 2023, www.environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en
13. Well, F. and Ludwig, F., Blue-green architecture: A case study analysis considering the synergetic effects of water and vegetation. *Frontiers of Architectural Research*, 9, **1**, 191-202 (2020).
14. Zevenbergen, C., Fu, D. and Pathirana, A., Transitioning to sponge cities: challenges and opportunities to address urban water problems in China. *Water*, 10, **9**, 1230 (2018).
15. Well, F. and Ludwig, F., Development of an integrated design strategy for blue-green architecture. *Sustainability*, 13, **14**, 7944 (2021).
16. Magalhães Filho, F.J.C., de Souza Filho, J.C.M. and Paulo, P.L., Multistage constructed wetland in the treatment of greywater under tropical conditions: performance, operation, and maintenance. *Recycling*, 6, **4**, 63 (2021).
17. Gorgoglione, A. and Torretta, V., Sustainable management and successful application of constructed wetlands: a critical review. *Sustainability*, 10, 3910 (2018).
18. Avsec, S. and Ferk Savec, V., Creativity and critical thinking in engineering design: the role of interdisciplinary augmentation. *Global J. of Engng. Educ*., 21, **1**, 30-36 (2019).