

Impact of engineering education on sustainable local architectural practice

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ABSTRACT: In ecology and sustainable development, it is important to act not only globally but also locally, so as to be closer to the daily users of architecture. Responsibility and care for the natural environment and landscape lie at the heart of sustainable development. Technical educational units and majors related to architecture and urban planning are invaluable in expanding public awareness in this area. Architectural and urban planning education is of paramount importance in minimising negative impact on the natural environment, and so is extremely valuable for city residents. Presented in this article and discussed therein are the results of a survey conducted among architecture students of engineering studies, who participated in the National Congress of Urban Policy (Kielce, Poland in November 2019). The survey had two main objectives: the first was to present and evaluate the actions taken by students to protect and sustain the local environment, and the second was to assess the effectiveness and efficiency of teaching through practice.

INTRODUCTION

The main global problems include industrialisation, demographics and urban expansion. These result in the depletion of natural resources, degradation of the natural and built environment, thus increasing air and water pollution, soil erosion and the decline of natural areas. Hence, the need to protect the earth's natural resources and the need for rational management of natural systems is growing. It is important to strive for ecological and healthy environments in urban spaces. The challenges of the modern city in the sphere of architecture and urban planning are crucial. Therefore, the integration of environmental issues into architectural education is important in supporting sustainable development (SD), through co-operation with public institutions.

With ecology and sustainable development, it is important to act not only globally but also, and above all, locally, which is closer to the users daily of architecture. Responsibility and care for the natural environment and landscape lies at the heart of sustainable development. Therefore, higher education plays an invaluable role in promoting sustainable development and is an effective way of creating a sustainable future, viz. this is especially true for technical education, and architecture and urban planning majors [1]. They play an important role in expanding public awareness in this area, and design education still remains a rich and important area of research [2][3]. This is of paramount importance in minimising negative impact on the natural environment, which is extremely valuable for city residents. The basic issue for achieving sustainability is social awareness, because without understanding the idea and putting it into practice, the proper development of the civilisation is impossible.

The author opines that practice-based education and creative co-operation are the basis for effective and efficient teaching, and have a fundamental impact on regional sustainable development (SD). A balance is required in an era of rapid urbanisation with exploitation of resources and concomitant pollution, maintaining a balance is crucial. There is a role for architectural and urban planning education and architects in creating the concept of a sustainable built environment.

Purpose and scope

In this article are presented the results of a survey of students of Architecture of Engineering Studies at Kielce University of Technology (Poland), participating in the National Congress of Urban Policy (Kielce 2019, Poland). This survey had two main objectives: the first was to present and evaluate architectural activities undertaken by the students covering the protection and sustainability of the local environment, including the protection of natural resources and natural systems. The second objective was to evaluate the effectiveness and efficiency of teaching through practice. The survey involved analyses of the best student projects presented at the National City Forum; insightful observations by students; conversations; and in-depth interviews with students.

SUSTAINABLE ARCHITECTURAL PRACTICE IN THE LOCAL ENVIRONMENT: TEACHING THROUGH PRACTICE

Crucial in sustainable urban development is architectural and urban planning with concern for the local environment. In regional sustainable design it is essential to integrate a global perspective [4]. The need for local, regional sustainable development processes has been confirmed in the Brundtland Report [5]. However, in the context of the latest global research [6], there is little reference to the built environment, i.e. the architecture and urban planning that constitute the physical urban platform [7].

When searching scientific publications, such as books, magazines and conference material, nothing was found that would link the issues of the sustainable city with architectural problems in a region. The following terms appear in the scientific literature in discussing sustainable development: *sustainable city idea*, *ideal city concept*, *smart city*, *compact city*, *eco-city*, etc [8-11].

Sustainable architectural practice in the local context is addressed in this article, which is the author's contribution to the research on contemporary architecture and the regional spatial environment with sustainable characteristics.

In educating architects at Kielce University of Technology, emphasis is placed on the development of creativity and a commitment to sustainable development in the architecture and urban planning of the Świętokrzyski region [12]. Local projects are important in the urban space and suburban structures. This is confirmed by a survey conducted by the author with the participation of architecture students of engineering studies (2017-2019).

Two research problems are considered in this article:

- I.) Sustainable architectural practice in the local environment - two perspectives:
 - 1) Student as an innovator-visionary of form and function - focusing on environmentally friendly and human-oriented solutions.
 - 2) Student as an active researcher and educator-architect - bringing together different groups of stakeholders, educating society to promote new architectural solutions.
- II.) Effectiveness and efficiency of teaching through practice - the main goal is to learn the development of students' creativity, their cognitive abilities, ways of thinking, motivation, actions, independence and the creative acquisition of knowledge [13].

The following study methods were applied in the survey:

- Analysis of design material and results of the research undertaken by students. The work is from one stage of the undergraduate courses, reflecting the teaching, co-operation and interaction between academic teachers and students.
- Insightful observations, debates and in-depth interviews - conducted with authors of the best projects and participants of the National Forum of Cities - to evaluate the learning outcomes of practice, within the framework of co-operation between students, academic teachers, regional entities and local communities.

The Świętokrzyski region is distinguished from other Polish regions by the abundance of its geological structures and natural resources, determining the development of industry, trade, construction and regional architecture, an important element of cultural heritage. The capital of the region is the city of Kielce - one of the oldest centres in the Świętokrzyski region, with Church structures from the 9th Century. The religious buildings and places, merged with the landscape of the city and region, reflect various aspects of its history and shape its contemporary image [14].

On the one hand, the attractive image of the historical and modern urban structures is consistent with the image of a sustainable city. On the other hand, there are new housing estates in the city, neglected or chaotically developing, where it is difficult to identify a sustainable city. The differences between technological progress and the low quality of the built environment are becoming clear. Sustaining the existing spatial environment and studies on the implementation of new projects are needed. Architectural and urban planning education is crucial, as it develops the ability to observe and respond creatively to the conditions and needs of the community, and teaches the shaping of urban space that uses nature for ecological, economic and social benefit [15].

I.) *Sustainable Architectural Practice in the Local Environment: Students*

About 150 students of engineering studies (2017-2019) from architectural and urban design classes took part in the survey. The next stage involved co-operation between the Department of Architecture and Urban Planning of Kielce University of Technology and the Sustainable Development Smart Management Office - Smart City, Municipality of Kielce. A group of the best students took part in the National Congress of Urban Policy in Poland. Several best projects were presented. It was the largest event in Poland dedicated to urban sustainable development policies.

During *Urban Lab* sessions, students' proposals for spatial solutions for a sustainable city were presented and discussed. *Urban Lab* is a project financed by the Ministry of Investment and Development for the years 2014-2020 for improving the quality of life of city residents within a smart city. It is also an instrument aimed at improving the quality of life of the residents through innovative solutions to problems and generating additional value through urban resources.

- 1) Student innovators-visionaries aimed to sustain the existing spatial environment of the city of Kielce and the region respecting existing cultural values; the state of the natural environment; and protection of natural resources. The present living conditions and needs of the urban community are important, forcing a new perspective on the creation of sustainable urban space. In the first stage, the students conducted a participatory survey to diagnose the real needs of users, analysed existing structures within natural contexts, and conducted handwritten field studies. They developed detailed guidelines for design works and made assumptions concerning the aesthetics and functionality required of solutions [16].

In addition to the search for innovations in terms of vision, form and function, material and structure, the designs focused on environmentally friendly solutions that were human-oriented. The students assumed co-operation with nature, i.e. reconciling the city's development with preserving and restoring the value of the environment and using energy sparingly. The important principle is that the use of the city's present resources must ensure equal opportunities for citizens in everything that concerns their lives and with their participation and consent.

Results. An analysis of student designs revealed the potential of a programme-based, functional and spatial development of the contemporary city of Kielce. It suggested the need for new creative approaches in shaping the architecture and urban spaces to achieve the objectives of a sustainable city and region. The most important role in the putative creations was played by the interrelationships between architecture, nature and landscape. The designs combine the most desirable features of modern architecture - innovation for the benefit of people and the biodiversity of the local environment.

Apart from aesthetics [17] and visionary architecture, were activities aimed at the large-scale introduction of natural environmental protection and the application of ecological functional and spatial solutions. The ideas presented included individual references to important issues, such as: the use of energy from renewable sources; air and water purification; recycling and waste segregation; and the application of green infrastructure for environmental, economic and social benefits, such as extensive green roofs, green walls, protection of green areas from buildings and new green planting.

The interdependence of architecture with ecology and sustainable development creates a new spatial context and a new identity for the place. Architecture to provide optimal conditions for living in harmony with nature - not only in the Świętokrzyski region but worldwide - highlights the importance of architectural education in architectural design. These bold, innovative solutions, friendly to valuable ecosystems and conducive to landscape coherence, can be implemented in a modern city.

The potential inherent in the designs indicates a new creative approach to the architect's workshop and the right direction of teaching. The solutions proposed by the students are friendly to the natural environment and people. Young architects seem keen to develop independent thinking to solve environmental problems, so this material is an important measure of the impact of architectural education.

- 2) In the next stage young architects-educators presented their designs at the National City Forum (Figure 1). Within the framework of co-operation with the Sustainable Development Smart Management Office - Smart City, Municipality of Kielce, the young students participated in a debate on the vision of a sustainable city. Students listened to the discussion: what a new national urban policy in Poland should be like; observed the presentation of best practice of other cities; and actively participated in various thematic sessions devoted to selected issues, such as urban space development, housing, transport and urban mobility, environment and adaptation to climate change.

During the *Urban Lab* session, young architects presented the residents and the authorities with architectural and urban planning solutions, implementing ideas for an environmentally and human-friendly city. They presented a new image of sustainable architecture of the city and the region. Students provided conceptual solutions, focusing on contemporary problems to make life easier for users in a real built environment, where the number of inhabitants is growing. Through their designs they educated and convinced the local society of new architectural solutions that protect landscape and nature.

Proposals from students sparked lively discussion among interdisciplinary expert teams and representatives of the Visegrád Group of four central European countries, including Poland. Appealing and successful design elements included the aesthetics and functionality of architecture in urban space and the organisation of environmentally friendly squares and streets. Design presentations proved a great success thanks to new possibilities to revive the city. Constructive dialogue made it possible to gather opinions and ideas from the local community and the city's institutions on ways to revive urban areas.

Results. The students gained important new experiences from the congress, which they will be able to use in their student work and to develop in their future as designers of architecture and in urban planning. This new experience has directed their attention to the current challenges of sustainable development arising from rapid and uncontrolled urbanisation. The exchange of experience on sustainable urban development and the knowledge gained on sustainable urban design have proved invaluable. Students understood that to create a sustainable future, architecture should be environmentally friendly and a sustainable city, in the way it functions, should minimise the impact on the environment and should be inhabited by people who minimise pollution, save energy and make an efficient and symbiotic use of land [18].

As a result of these experiences, there is an increased awareness of sustainable development by students and the community. Young designers have understood that the concentration of human activity implies the need to reduce the negative impact of humans on the environment. At the same time, there must be adequate living conditions for the inhabitants of urbanised areas and effective links with other suburban and rural areas.

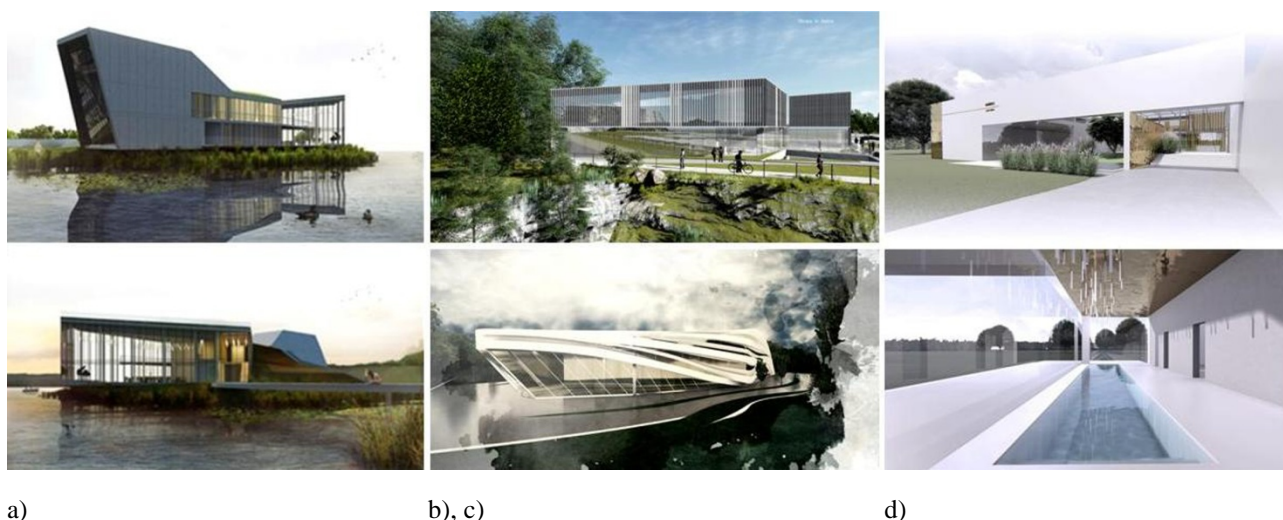


Figure 1: Students' projects for sustainable forms - architectural elements of the city and the region friendly to the environment and human needs - a) K. Karbowniczek, 2017; b) I. Dibelka, 2018; c) A. Raczyńska, 2019; and d) K. Piotrkowicz, 2019.

II.) *Effective and Efficient Education - Results and Assessment of Teaching Outcomes through Practice*

As part of the traditional design course and learning through experience, students' reactions to the teaching were observed carefully. Teaching should focus on equipping future designers with skills to learn and respond to the needs of conserving earth's natural resources. To increase students' interest in science, and to ensure their professionalism and self-confidence, various teaching models were adopted. The emphasis has been placed on learning through practice, with priority given to participation in research and co-operation with regional actors and local communities.

In the course of their education, young designers were eager to improve the work of the architect, to undertake various activities aimed at experimental and creative acquisition of new experiences, to develop skills in solving problems, communicating with others and co-ordinating activities (e.g. co-organising the University's exhibition booth, organising an individual exhibition of student works); thus creating lasting value for themselves.

Survey results were obtained by:

- 1) Observation in classes.
- 2) Discussions: where the authors of the best projects and participants of the National Urban Forum could discuss and learn from their experience.
- 3) Individual in-depth interviews, which lasted between 40 and 50 minutes, and were used to assess teaching outcomes through experience.

The main research questions addressed were:

- What changed during the process; was there any change in thinking and can such change be attributed to new teaching experiences?
- What was the value of the educational model emphasising practice and what did students value most?
- What are students' key goals and what have they learned for the future?

For each phase of the education, an in-depth analysis of the survey results was carried out. This has led to the following findings:

- 1) *Design course - observation of classes.* A traditional first-level design course requires links to practice. In basic and compulsory education, about 70% of students showed a high willingness to participate in additional classes, which contributed to their enthusiasm for work and their achievements. The overwhelming majority wanted an open space, where they could pursue interests and exchange views. This has become an important incentive for students to make the results of their work public. It has forced them to make more effort and commitment to design. It influenced the desire to acquire new knowledge, broaden skills and stimulate creativity [19]. An increased ability for critical analysis was also observed. On the part of the teacher, it has proved important to support their own skills and encourage innovative thinking and involvement in active learning [20].

Creative teaching and group teaching, active and participatory, such as in debates, turned out to be the most valuable in the course of learning. Mobility was important - going beyond the university walls: study trips, site inspections, survey walks. It manifested in gaining knowledge through participation in thematic conferences, various discussions and presentations of own projects.

The results of the survey imply that architectural education should be constantly modified. The more effective the educational process, the better the education [21]. Case study analysis develops thinking and creativity, supports and facilitates reflexive skill and puts emphasis on the creative acquisition of knowledge, but requires little practice. In turn, knowledge acquired through experience affects the development of learning styles, critical thinking, and deepening of skills, while shaping personality and motivating for bolder designs.

- 2) *Conversations.* The outcome of conversations was that students' experiences indicate they appreciated most the importance of active forms of education. In particular, the possibility of the simultaneous participation of students and teachers in the National Urban Forum. In the course of joint discussions, they considered that this experience provided them with an opportunity to understand social problems and broaden their knowledge of its practical application. They will apply this knowledge with a deeper understanding of the subjects and after graduation, in their careers. All participants stated that the experience fostered solidarity, co-operation and creativity, and stimulated reflection, dialogue and discussion.

The outcome of the debate shows that the group was agreed in evaluating the experience for sustainable development in the region. The survey underlines that the most popular (80%) form of teaching by students is active. Traditional methods, such as passive or individual teaching, yield a much lower effectiveness rating of about 20%. The open debate during the organisation of design reviews and evaluation proved to be important for students.

- 3) *Surveys.* The results of the individual surveys indicate that in the course of multi-stage teaching, interdisciplinary and creative ways of thinking about human-environment interactions have become particularly important as a prerequisite for a sustainable future. The young people considered that, thanks to the initiatives and activities undertaken, they have become *more sure-footed* and *creative* in gaining knowledge and improving skills related to their future profession. They concluded that education must go beyond knowledge and practice and involve different experiences that lead to the transformation of subjects.

Therefore, it is inevitable to *...combine teaching with different forms of practice/activity*. Only in this way will they gain *valuable experience* that will *bear fruit* in the future and affect their careers.

Thanks to various forms of education and scientific activity, they will have *greater awareness on sustainable development* and a *better understanding of the future work of an architect-urban planner*. Therefore, one of the most important objectives is *acquiring good knowledge and practice* and *gathering valuable and varied experience*. They will achieve these goals through a continuous process of exploring and developing their abilities and skills. After graduation they will be *well prepared to implement the principles of sustainable design* and *to take up employment*. As graduates with professionalism they will perfectly *recognise reality and rebuild it*; they will become *bolder* in introducing individual and innovative ecological solutions.

In conclusion, the surveys performed showed that the students' experiences support the teaching process, and teaching through practice undoubtedly forms the basis of the global effort to achieve sustainability for the future environment. The architectural education demonstrates the relevance and validity of the teaching content. This result is important, because it shows that architectural education can focus on justifying students' actions, achieving goals and constructive dialogue between teacher and student, regional entities and local communities; it can also:

- open the prospect of a better future for the local built environment;
- educate the contemporary generation of designers and persuade society to introduce new solutions - in the context of contemporary humans and environment-friendly challenges;
- by pre-design participatory surveys, recognise the needs of city users for reliable knowledge-based co-creation and joint design with local communities;
- change the view of certain aspects of spatial and social policy of municipalities and entities preparing development plans and directions of economic development;
- promote the development of the idea of a sustainable city - friendly to the environment and human needs.

CONCLUSIONS

The involvement of technical universities in education for sustainable development significantly contributes to architectural practice, based on specific regional needs. Through the transfer of *knowhow* and the practice-based, interdisciplinary co-operation-based teaching presented in this article, the technical university acts as a leader in supporting regional sustainable development. It is a place to initiate *smart* and *sustainable* solutions with concern for the sustainable development of a region.

Designing sustainable architecture and urban structures is the responsibility of an architect and an urban planner, and their *design and creativity* have the power to change the world, influence living conditions and solve many social problems, such as improving the life of the global society and reducing environmental pollution [22].

The results of the survey conducted with the participation of students highlight the great importance of education in preparing future engineers to undertake architectural practice taking into account social, economic and environmental factors. They complement many important issues, such as accessibility of buildings and space for all, as well as environmental problems linked to architectural design. Innovations in architecture are possible, while respecting and consciously exploiting the natural environment. These skills are particularly important for the architect and, realising their importance, gives hope that they will reflect this in their own design practice.

REFERENCES

1. Sun, C.J. and Chiou, S.C., The comparison of campus planning development at the initial stage of school establishment: a study of the two newly instituted private universities of science and technology in Taiwan. *Sustainability*, 11, 1525 (2019).
2. Tu, J.C., Liu, L.X. and Wu, K.Y., Study on the Learning Effectiveness of Stanford Design Thinking in Integrated Design Education, 5 May 2020, <https://ideas.repec.org/a/gam/jsusta/v10y2018i8p2649-d160423.html>
3. Kamrowska-Zaluska, D. and Parteka, T., Design thinking (DT) for the design and planning education of engineer-architects. *World Trans. on Engng. and Technol. Educ.*, 18, 2, 97-101 (2020).
4. Mader, M., Mader, C., Zimmermann, F.M., Görsdorf-Lechevin, E. and Diethart, M., Monitoring networking between higher education institutions and regional actors. *J. of Cleaner Produc.*, 49, 105-113 (2013).
5. Brundtland, G.H., Our Common Future: Report of the World Commission on Environment and Development, 13 December 2019, <http://www.un-documents.net/our-common-future.pdf>
6. Vinod Kumar, T.M. and Dahiya, B., *Smart Economy in Smart Cities*. In: Vinod Kumar, T.M. (Ed), *Smart Cities, Local Community and Socio-Economic Development: the Case of Bologna*. Berlin, Germany: Springer (2017).
7. Mardacany, E., Smart cities characteristics: importance of built environment components. *Proc. IET Conf. on Future Intelligent Cities*, London, UK, 4-5 December (2014).
8. Anastasiadis, P. and Metaxas, G., Formulating the principles of an eco-city. *World Trans. on Engng. and Technol. Educ.*, 11, 4, 394-399 (2013).
9. Höjer, M. and Wangel, J., *Smart Sustainable Cities Definition and Challenges*. In: Hilty, L.M. and Aebischer, B. (Eds), *ICT Innovations for Sustainability, Advances in Intelligent Systems and Computing*. Zurich, Switzerland: Springer, 333-349 (2014).
10. Elgazzar, R.F. and El-Gazzar, R.F., *Smart Cities, Sustainable Cities, or Both? A Critical Review and Synthesis of Success and Failure Factors*. In: Conference on Smart Cities and Green ICT Systems; SCITEPRESS-Science and Technology Publications. Setúbal, Portugal: Lda, 250-257 (2017).
11. Trindade, E.P., Hinnig, M.P.F., Moreira da Costa, E., Marques, J.S., Bastos, R.C. and Yigitcanlar, T., Sustainable development of smart cities: a systematic review of the literature. *J. of Open Innov. Technol., Market, Complexity*, 3, 11 (2017).
12. Kamionka, L., Seruga, W. and Wehle-Strzelecka, S., *Architektura Kielc: Teraźniejszość i Perspektywa Jutra*. Kielce: Politechnika Świętokrzyska, Wydawnictwo PŚk (2019) (in Polish).
13. Van Vliet, V. and Kolb, D., Toolshero (2013), 24 May 2020, www.toolshero.com/toolsheroes/david-kolb/
14. Gil-Mastalerczyk, J., *Wpływ XX-wiecznej Architektury Sakralnej Kielc na Otoczenie i Przemianę Struktury Funkcjonalno-przestrzennej Miasta*. Kielce: Politechnika Świętokrzyska, Wydawnictwo PŚk (2018) (in Polish).
15. Gil-Mastalerczyk, J., Architectural education in the formation of the built environment with sustainable features. *World Trans. on Engng. and Technol. Educ.*, 18, 2, 146-151 (2020).
16. Białkiewicz, A., Propaedeutics of teaching drawing to architects. *Global J. of Engng. Educ.*, 21, 2, 115-120 (2019).
17. Żychowska, M.J., Aesthetics in education at technical universities. *World Trans. on Engng. and Technol. Educ.*, 18, 1, 40-44 (2020).
18. Oberfrancová, L., Legény, J. and Špaček, R., Critical thinking in teaching sustainable architecture. *World Trans. on Engng. and Technol. Educ.*, 17, 2, 127-133 (2019).
19. Białkiewicz, A., Architectural competitions support student creativity. *World Trans. on Engng. and Technol. Educ.*, 18, 2, 157-162 (2020).
20. Ilkovičová, L., Ilkovič, J. and Špaček, R., Ways of rationality and effectivity in architectural education. *World Trans. on Engng. and Technol. Educ.*, 15, 4, 331-337 (2017).
21. Avsec, S. and Jagiełło-Kowalczyk, M., Pre-service teachers' attitudes towards technology, engagement in active learning, and creativity as predictors of ability to innovate. *Inter. J. of Engng. Educ.*, 34, 3, 1049-1059 (2018).
22. Brown, T. and Katz, B., Change by design. *J. of Product Innov. Manage.*, 28, 381-383 (2011).