

Developing engineering competence and engagement in the sustainable development idea through a flexible and creative approach

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ABSTRACT: The author presents an interdisciplinary experiment as part of an extracurricular module of classes: *Sustainable Architecture: Space for Imagination or the New Future?* and the emerging discussion. The module has been organised for motivated young architects fascinated by science in Kielce University of Technology, Poland. In the article is highlighted the significance of transformation acquired during the interdisciplinary studies combined with a flexible and creative approach in the architectural expertise. Launching various forms of activities motivates students and compensates for hitherto failures, boosts the efficiency of teaching and, first and foremost, increases the level of knowledge-based society. In the light of the students' accomplishments and engagement, and considering the author's observations and the results of interviews with the students, the author takes a stance in favour of this form of tertiary education, as it leads to new, progressive results, positively affecting the formation of a highly specialised expertise of an engineer architect essential for a long-term, successful practice.

INTRODUCTION

Doubtless, the extent to which sustainable design is applied in architecture is decidedly influenced by local and state policies, the material and technological sustainable solutions, as well as social awareness and unceasing environmental education. In such a context, what gains unparalleled relevance is the broadly conceived ecological education of the society with regard to a healthy and friendly living environment.

Of singular importance is the academic education in city planning and architecture, constituting one of the key elements of the implementation of the guidelines for sustainable development in architecture [1-4]. In the light of the current studies, it is of vital importance to introduce changes to architectural education, in particular in the area of sustainable development, as this is a very complex process encompassing, among others, theory and practice based on interdisciplinary knowledge and experience [5].

The concept of sustainable development in architecture is related to design, construction and the use of buildings with care for tomorrow. That is why a wide range of diverse topics and activities is carried out among the youth, as well as new imaginative approaches to the architect's skillset are being undertaken directed at experimental and creative ways to gain new experience [6]. These actions are certainly an important element in the process of implementing the guidelines for sustainable development, especially regarding the use of innovative solutions, which meet the standards of environmentally-friendly and sustainable architecture.

Purpose, Scope and Methods

In this article, the author presents and discusses key benefits stemming from involving academic youth from the Student Research Group - ARCHED, Kielce University of Technology (KUT), in Kielce, Poland, in the concept of sustainable development in architecture. This project was initiated within an original set of extracurricular classes: *Sustainable Architecture: Space for Imagination or the New Future?* - and aimed at developing an interdisciplinary model for educating the future designers of architecture.

The project involved direct observation of initiated experiments and conversations with students. It had two main goals: to present and evaluate various initiatives undertaken by students in the field of environmental protection and sustainability.

The evaluation of the benefits of experimental, extra-curricular forms of teaching by action was based on the analysis of achievements and the best student projects presented at the Polish academic forum and international conferences.

INVOLVING THE FUTURE GENERATION OF ARCHITECTS IN THE CONCEPT OF SUSTAINABLE DEVELOPMENT IN ARCHITECTURE

Due to the great involvement and industriousness of young people when exploring modern forms and technologies for designing pro-ecological and energy efficient buildings, the year 2015 saw the setting up of the ARCHED Student Research Group at the Chair of Architecture and City Planning in the Faculty of Civil Engineering and Architecture of the KUT. Young people prove to be more than eager to carry out the goals set for them, which include developing their interests and gaining further insights into theoretical and practical knowledge of contemporary architecture and sustainable civil engineering, including not only luxury civic buildings or residential areas, but also lodgings for less affluent social groups. In that context, an important goal of the Group's members is the promotion and dissemination of research work in these fields, particularly, the promotion of energy-saving technologies and renewable energy, traditional and climate friendly solutions, and striving for a shift in social awareness.

ORIGINAL SET OF CLASSES: SUSTAINABLE ARCHITECTURE: SPACE FOR IMAGINATION OR THE NEW FUTURE?

With the aim to involve the youth in the idea of sustainable development in architecture, an original set of classes promoting and disseminating sustainable, eco-friendly architecture of the future had been developed. At this juncture, it should be underscored that the applied teaching method provided an unrestricted freedom of gaining and developing knowledge, thus helping to promote pluralism. This ensured an enthusiastic approach of students to their education and fuelled their motivation. Young people focused on the forms of learning they themselves chose and strived to achieve perfect results. Within the set of classes, out of the compulsory curriculum, an interdisciplinary model of academic education for the youth had been elaborated. Its objective crystallised as a way to provide advanced expertise in sustainable architectural design, including innovative solutions which would meet the standards of environment-friendly and sustainable architecture. An important goal was also the task of raising students' awareness of the diverse needs of investors and users of the architecture.

Within the comprehensive activities, young people were very keen to master their architectural skillset and undertook various efforts aimed at hands-on, creative amassing of new experience. They participated in lectures, seminars and interdisciplinary workshops with representatives of construction companies, architectural design studios among others, widening their knowledge and skills in new technologies used in architecture and civil engineering and in the future work of an architect [7]. They were interested in talks and readings on sustainable development in architecture. During educational study trips, they learned hands-on of trailblazing technological solutions in sustainable construction investment projects. They had a unique opportunity to observe the most recent architecture - attractive in its form, convenient in use, economically available and friendly to the natural environment.

An equally significant point for the set of classes was to invite students to develop their own understanding of the notion of *sustainable architecture* and to foster their deeper involvement in sustainable architecture, one that does not shun from wider sociological, physiological issues, etc [8][9]. Sustainable architecture is also identified as *green architecture* - the architecture of the 21st Century [10][11]. There are three priority areas within the sustainable architecture: ecology, economy and the society. The *green building* concept is related to the direct challenges of the contemporary world, such as energy-efficient buildings. It is reflected in numerous systems of certification: LEED, BREEAM, DGNB, Green Star, CASBEE, and others. Indisputably, it is green architecture that may provide the answer to climate changes and the shifts in lifestyle, in work habits, in the manner of inhabiting cities, and people's recreation and leisure activities.

Ecology has gained ever greater importance in architecture and civil engineering of the 21st Century - which was given special attention by young designers. However, though the notion of ecological architecture cannot be completely equated with sustainable architecture [12][13], buildings designed according to the guidelines of sustainable development ought to meet environmentally friendly requirements and introduce such solutions. Besides, ecology does not only entail modern technologies, but also down-to-earth thought on, and governing of, what nature brings.

It should be stressed that despite many years of conducting research work - in the field of architecture - the above issues constantly generate further questions. Finding the golden mean, i.e. a perfect balance between technology, without which one can hardly imagine the life of today, and nature, without which life is not possible at all, is an extremely challenging and complex task. Therefore, the greatest asset of meetings with the youth was finding openness to dialogue about the future of architecture and its relationship with both nature and technology. The field of interest thus delineated became a great launchpad for further discussion and activity.

INVOLVEMENT IN ORIGINAL RESEARCH WORK

Motivated students, enthusiastic about science, supervised by one of the researchers at the University, carried out their own original research work in fields directly related to sustainable architecture, e.g. *Use of Natural Light and the Reflection Effect in Passive Architecture, Household Wind Farms - the Future of Passive Building Engineering*. They presented their findings during international and local conferences.

The culmination of the students' work was the organisation by them of the mentioned earlier ARCHED Group at an international conference for students, PhD students and research staff: *Development in Urbanised, Endangered and Difficult Areas*, in the Faculty of Civil Engineering and Architecture at the KUT. Young people took active part in the event. They presented numerous academic posters and presented papers. Two works by freshman students of architecture were awarded prizes by the Academic Committee. Their works served as an example of how sustainable architecture can make life better. Besides aesthetic and technical requirements and energy-efficiency, the key factor in the undertaken projects was the sustainable use of space, e.g. *Unlimited Horizon or Houses on Water*.

The acquired knowledge was used and further developed by the students by participating in a design workshop and competition, *the Garden of Nursing Home in Plaza - Therapeutic, Sensory and Activating Space*, within the framework of a social innovation project organised by the Chair of Housing Environment at Cracow University of Technology, Poland, in co-operation with the Nursing Home in Płaza (Figure 1). The KUT team was awarded a joined first prize for their design and presentation of a project imaging the method of making use of the indicated area. They proposed locations for outdoor training were in the form of motor sensory paths and other features with the potential to reinvigorate the wards of the nursing home, as well as people living in its neighbourhood.



Figure 1: Design workshop *The Garden of Nursing Home in Plaza - Therapeutic, Sensory and Activating Space*, the Faculty of Architecture of Cracow University of Technology, Poland (photographs by the author).

EXAMPLES OF GOOD PRACTICES, EDUCATION AND RESEARCH WORKSHOPS WITH ON-SITE LECTURES BY MASTERS OF ARCHITECTURE

As a result of such a comprehensive activity, young people got willingly involved in lectures, readings, presentations of private collections of travel photographs, notes and sketches - focusing on the display of the masterpieces of world architecture. They subsequently engaged in discussions, which fostered elaboration of new attitudes towards actual, physical transformations of the most recent architecture and phenomena in the city space. That type of method allowed for amassing comparative material and establishing exemplary specimens to follow, as well as for adjusting the research solutions to the local needs and surroundings. The accumulated material concerned various ranges and scales of spatial solutions, including various features of sustainable architecture (Figure 2).

Studying instances of good practices, getting acquainted with exemplary foreign and Polish achievements constituted important features of the activities carried out. It enabled participants to further elaborate the set of conclusions, which served as the basis for the actions performed later.



a)

b)

Figure 2: a) original architectural forms in symbiosis with urban landscape: 30 St Mary Axe (the Gherkin) in London, UK, 2004, design: Norman Foster; and b) innovative and prestigious architecture in the city's vertical structure: CapitaGreen, Singapore, 2014, design: Toyo Ito & Associates Architects (photographs by the author).

Within the original programme developed for the needs of the ARCHED Group, titled *The Most Recent Architecture of Civic Buildings in Poland*, students participated in on-site research and education workshops, study trips, as well as lectures on selected issues concerning the most recent architecture designed according to the notion of sustainable development. They had a wonderful opportunity to come into direct contact with the shaping of forms of the freshest architecture of civic buildings developed in recent years in various regions of the country. Such method of learning placed particular emphasis on practice and hands-on participation in field activities. During educational workshops combined with on-site lectures by masters of architecture its participants had a great opportunity to get to know the best contemporary projects striving to protect and shape of both cityscape and landscape. They gained first-hand experiences of interesting architectural and technological solutions used in world-renown buildings, each with its individual and contemporary flair (see Figures 3):

- The ICE Kraków Congress Centre, meeting the requirements of international congress organisations and the highest standards in acoustics and stage machinery, was developed by the experts from ARUP Acoustics (London, UK), Ramboll Acoustics (Cambridge, UK) and ARUP Theatre Consulting (Winchester, UK). In the ICE, students got acquainted with the ins and outs of design and construction in one of the most prestigious locations in Poland, directly opposite to the Wawel Royal Castle in Kraków. The building constitutes a spatial dominant, a symbol of a city-gate and of a novel strategy for development Designed by: Ingarden & Ewy Architects, Poland, in collaboration with Arata Isozaki & Associates, Japan, completed in 2014 (Figure 3a).
- The Silesian Museum in the area of the former *Katowice* coal mine. The revitalisation of the post-industrial area included the adaptation of post-mining facilities and the construction of new facilities with a museum function, along with the creation of an attractive park space. The architectural concept is a reference to the industrial history of Silesia and assumes a slight interference in the post-industrial landscape, which is why most of the complex is underground. Designed by: Riegler Riewe Architekten, Graz, Austria, completed in 2014-2017 (Figure 3b).



a)

b)

Figure 3: a) *ICE* Kraków Congress Centre, Poland - a general view of the structure; and b) Silesian Museum at the site of the former *Katowice* coal mine, Poland (photographs by the author).

INTERDISCIPLINARY TRAININGS, SEMINARS, THEMATIC DISCUSSIONS

With much interest the students busied themselves with organising interdisciplinary trainings to perfect their knowledge and design abilities, and their professional skillset as future architects. Such a form of learning is predominantly focused on the transmission of particular skills and assistance in developing a proper understanding of the potential of sustainable architecture. Without a doubt, a well-designed building improves the quality of life and contributes to a better mood of its users [14].

Young people were actively involved in seminars, they delivered their own presentations and provided each other with mini-lectures in order to subsequently instigate discussions, confront one another from various standpoints and exchange experiences. To participate in these discussions, they invited members of local authorities responsible for spatial policies and municipal investment projects, representatives of construction and architectural and other companies. During these interdisciplinary discussions, students were furnished with relevant knowledge on energy-saving activities becoming a priority in eco-friendly architecture and spatial policy. Hence, the great importance of focusing one's attention on an integrated public and private-public activity in line with the guidelines of sustainable development. Providing a proper direction for infrastructural efforts of the public, private sectors, as well as private-public endeavours will result in an opportunity to introduce harmony into built areas.

The conclusions of the undertaken considerations reflected the commonly assumed interpretation of the concept of sustainable development. Most of them directed the attention of future designers to the cardinal rules of incessant integration of four dimensions of activity: the political, the economic and the social in compliance with the rules for

preserving the natural balance. The above notions find expression in spatial policy through ensuring spatial order, which allows for a balance of many factors stemming from the above functions.

Students' knowledge of, and skills in, new technologies used professionally by architects and constructors were complemented by interdisciplinary seminars and trainings, joined with presentations of the state-of-the-art technologies and products available on the market. These were aimed at familiarising them with novel technologies and solutions regarding construction glass, systems of building structures, solar and photovoltaic systems, automation, as well as their use in sustainable investment projects. They could almost palpably get acquainted with construction details of selected products. The above concerned mainly:

- Developing awareness of contemporary technologies for designing eco-friendly and energy-saving buildings;
- Trainings in the existing architectural systems: façades, door and window systems, fire protection systems, winter gardens, ventilated façades;
- Challenges faced by contemporary architecture, including unique glass solutions: solar control glass, thermal glass, fire resistant glass; and acoustics: acoustic insulation and privacy protection;
- Seminars on energy-saving architecture joined with presentation of novel trends and technologies in eco-construction along with examples from world architecture.

The most interesting feature and the most spectacular attraction for the youth were, without a doubt, seminars entailing direct observation of selected architectural realisations in the field, with a discussion thereof as examples of practical use of certain solutions. That is why young people participated in specific workshops, during which they learned about construction issues, design and realisation processes concerning passive solutions employed in energy-saving buildings. Among these, one can list:

- *Training ground of energy-saving* - entailing a visit to the Lesser Poland Laboratory of Energy Efficient Housing located on the campus of Cracow University of Technology in Kraków, developed in 2015 in compliance with strict standards for low-energy buildings. It is the only full-scale laboratory of that level of comprehensiveness in Poland. Students got to know the structure of the laboratory, the analyses performed in it within research on novel technologies and scientific work on improving energy efficiency. They got hands-on experience of advanced insulation systems used in the laboratory.
- *ENERGIS* - an energy efficient, intelligent, education and laboratory building within the campus of Kielce University of Technology in Kielce, completed in 2012. It is in itself an interdisciplinary laboratory. It employs the most recent energy-efficient technologies for providing utilities, as well as cutting-edge information technologies for controlling and monitoring them. One of the teaching rooms was designed with the intention to present the novel solutions used in the building, along with an opportunity to observe and continuously monitor energy-saving effects, as well as the applied solutions in automation, control and systems balancing energy, and environmental factors. Here, one could monitor and control the operation of the installed devices and solutions regarding to operation of photovoltaic batteries, solar panels and heat pumps.

DISSEMINATION OF THE IDEA OF SUSTAINABLE DEVELOPMENT IN ARCHITECTURE, PRESENTATION OF ACHIEVEMENTS

The members of the ARCHED Group were always keen to help organise and then take active part in the events held at the Kielce University of Technology, Municipality of Kielce and many other bodies, promoting the idea of sustainable development in architecture (Figure 4).



Figure 4: Students from the ARCHED Group present their activities and achievements, and conduct workshops for junior high school students (photographs by the author).

These predominantly included:

- *Congress of City Policies in Kielce - 2019*, devoted to the process of developing and implementing municipal policies in collaboration with institutions and communities involved in issues of sustainable development of cities.

Students participated in a debate on how the city should develop. They presented and subjected to public discussion their own architectural projects fostering the valuable aspects of landscape, designs of buildings contextually fitted into a location, its surroundings and the entire region. These constituted intriguing proposals of spatial solutions in line with the notion of a sustainable city, related to the promotion of eco-architecture [15].

- Individual exhibitions of student-made projects: *Sustainable Projects as the Paradigm for Spatial Design in the 21st Century, Sustainable Architecture of Tomorrow*, during the IV European Exhibition of New Museum Technologies, Art Conservation and National Heritage EXPOSITIO in Kielce.

SUMMARY AND CONCLUSIONS

The undertaken observations and conversations with students indicate their high opinions concerning the block of classes. In general, all forms of education were considered by the students to be of *high* or *very high importance*. It should be emphasised that it was particularly important for students to be free and have flexibility to take action and initiate active forms of education. They most eagerly wanted to pursue their various passions, exchange individual views and broaden their skills - through participation and organisation of workshops and research trips outside the university premises. They claimed that study trips combined with direct observation of objects in the field *most accurately stimulate their creativity and ability to critically analyse*. They agreed that *this way of acquiring knowledge motivates them to bolder and individualised design solutions* and that *in the future it will best influence their design workshop*.

As a result of the undertaken observations, it should be stated with satisfaction that the idea of sustainable development in architecture became more familiar to the students.

- As presented in the article, the interest in alternative modes of cognition, which is growing among the students, affects the improvement of their skills and competence, as well as it increases the level of knowledge-based society. In the light of the students' accomplishments and engagement, and considering the author's observations and the results of interviews with the students, the author takes a stance in favour of this form of tertiary education, as it leads to new, progressive results, positively affecting the formation of a highly specialised expertise of an engineer architect essential for a long-term, successful practice.
- The effects of the observations prove that interdisciplinary architectural education, subject to constant modifications and modernisation - in line with the expectations of an outstanding group of students - can achieve excellent results and may become a valuable contribution to the architecture of the future.
- It has been observed that resulting from the exercised effort, the range of activity and the subject matter of students' projects, as well as the attitudes of their authors to a significant extent started to focus on shaping the friendly architecture of the future. The topics of student diploma theses are the best evidence of this. Since the academic year of 2015, i.e. the time when the set of classes described here had been implemented, the subject matter of graduation projects of both future Bachelors and Masters in the vast majority of cases reflected the rule and met the standards of sustainable architecture [16][17]. It is consistent with European and world-wide trends in shaping the human living environment in a rational and balanced way.

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