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Student Workshops in Engineering Education: Case Studies at the Faculty of Civil Engineering in Osijek, Croatia*

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This paper presents an application of the design-centric education through five interdisciplinary student workshops conducted between 2000 and 2010 at the Faculty of Civil Engineering Osijek, Croatia. The main workshop aims, namely the incorporation of contemporary educational tendencies and techniques into curricula and the socially responsible interaction between the Faculty and its environment, are described. Furthermore, a case study workshop entitled 'Where is the Railway?' is presented detailing performed activities, results and the evaluation. Positive and negative aspects of design-centric approach to teaching/learning are discussed from the students' and the teachers' viewpoint. The balance of project preparation and management with the freedom in creating project's contents and results is stressed. Finally, the role of universities is accentuated through choice of locations, buildings and institutions involved in the workshops.

Keywords: design-centric education; project based learning; interdisciplinary engineering education; student workshops

1. Introduction

Interdisciplinary students' workshops at the Faculty of Civil Engineering Osijek have first started in 2000/2001. They were created for students attending the final year of civil engineering studies and their aim was to integrate different architectural and organizational aspects of the construction processes. The educational and the social aspects were the two directions which were crucial in developing of these specifically tailored workshops. The educational reasons are rather transparent, i.e. the teachers of the three core subjects: *Revitalization of Architectural Heritage, Construction Management* and *Masonry Structures,* felt that the students who are close to completion of their studies, have rarely had an opportunity to treat a building as a whole and have predominantly dealt with specific aspects of civil engineering, within a particular course module. The social reasons were equally important to the Faculty; there was a strong conviction that students needed to be more visible and active in their social environment and that there was a need for them to identify and also deal with the actual engineering and working life problems.

We therefore created and conducted regularly since the 2000 a type of workshop that exposed students to numerous problems in their surroundings. In this workshop we guided them through potential solutions using various teaching methods and encouraging a multifaceted approach to building and construction themes through interdisciplinary and team work.

2. Presentation

2.1 Workshops' background study

In the last couple of decades the paradigm of learning/teaching has been changing from a teacher centred (teaching objectives) to a student centred (learning outcomes) approach to learning, i.e. from an input based to an output based approach. At the end of the educational process, students are expected to achieve certain competencies, defined as a combination of knowledge, skills and attitudes that will enable them to work in a professional environment [1, 2].

Two key surveys which researched knowledge and skills important for civil engineering managers in Croatia were considered in preparation of student workshops. The first survey was conducted in 1989 and the second in 2002. Based on the responses of the graduates of the Faculty of Civil Engineering in Zagreb in the period between 1955 and 1985, the authors of the 1989 survey at the time concluded that for a civil engineering manager, the technical knowledge was paramount while the 'ability to control expenses' was of the least importance [3]. The results of the 2002 research showed how an enormous political and economical change occurred in the period between the two studies. Today, the civil engineering graduates ranked the knowledge in project management and science management as the most important. The 2002 study also researched characteristics of project managers in general and the analysis stressed capability of making decisions, coordinating tasks and

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people, and possessing organizational skills, as the most important [4].

This observed importance of so called 'soft' skills was a powerful incentive in creation and structuring of the students' workshops at the Faculty of Civil Engineering, Osijek. Since the establishment of the Faculty in 1976, the width and the diversity of civil engineering studies have significantly grown as well as the variety of jobs a civil engineer can obtain. In the last ten years, construction market in Eastern Croatia employed almost all civil engineering university graduates, offering them a variety of jobs, respected positions, and good financial deals. Due to certain legal restrictions, employers were interested mainly in graduates diplomas and somewhat less in the quality of those qualifications. As a result of various factors, such as the complexity of civil engineering studies, the construction 'boom' and the scarcity of civil engineering graduates, most civil engineering graduates in Croatia now hold managerial positions.

However, the current global crisis hit the construction sector hard in 2008 and forced it to downsize and significantly reduce a number of job offers. So, for the first time in recent history, civil engineering graduates encountered unemployment as an option to reckon with. Suddenly, the specific knowledge and skills emerged as a highly important element of employability.

2.2 Workshops' overview

The workshops were oriented to the region Baranya, a rural area surrounding the city of Osijek, and a border zone between Croatia, Hungary and Serbia. Troubled historical periods have marked this area and its position influenced specific spatial and social phenomena. The students' workshops originated with a focus on Baranya's rich building history as a starting point for a positive view of this area [5].

Every workshop addressed a specific engineering problem present in the region and was chosen each year according to the data researched by teachers in charge. The theme of the workshop was usually a building or a group of connected buildings—museums, millworks, abandoned railway stations—that are architecturally valuable, in need of renovation and revival, and have significance for the local community.

Workshop management was concentrated around several activities: architectural measurement of existing buildings, renovation design development together with cost calculation and activities scheduling. In that way workshops connected three faculty courses, opening the possibility for an integrated problem analysis. Students measured, drew and designed (within the course subject *Revitalization of Architectural Heritage*), calculated the process and costs of construction (within *Construction Management*) and designed and calculated bearing building structures (within *Masonry Structures*). At the end of each workshop they presented a joint proposal that included all these elements in one design.

The basic plan for the workshop developed in two parts—field work and classroom activities. The field work incorporated: the architectural observations and measurements, assessment of structural work, and the maintenance status of the building together with in-the-field interviews with interested parties (owners, local government, funding organizations, and rural tourist offices). The classroom work consisted of design solutions and renewal proposals for the buildings based on results of field work, the SWOT analysis and research of various sources such as archives, professional standards, legal framework and requirements of different stakeholders.

First workshop, conducted in 2000, tackled the issue of built heritage as an asset in Baranya's fast growing orientation towards rural tourism. After extensive communication with house owners and members of local community, four traditional farmhouses in the village of Kopacevo were chosen with the aim to document their present state and propose solutions for their possible re-use as tourist facilities. Students measured, drew and analysed those houses from various viewpoints, finally developing design solutions that included architectural, structural, organizational and financial aspects of proposed reconstruction.

Second workshop, conducted in 2005, dealt with rural industrial architectural heritage in Baranya—two mills and a family farm—with the aim of converting them to hunting hotels. In all of these cases, students were divided into groups and each group researched and designed one building from start to finish. Results of the workshops were detailed renovation designs for chosen structures, complete with price analysis, cost estimates, and the actual schedule of proposed activities.

Third workshop, conducted in 2007, concentrated on the abandoned and devastated ethnographic museum in Zmajevac that conserved the heritage of the Hungarian minority in Baranya. This time, students were divided into groups based on types of activities (one group measured, the other drew and calculated etc.) and their results were combined in three various proposals for the museum's future use. The design proposals for its revival were formed in close coordination with and support of local authorities and the resulting designs were used for the actual reconstruction of the museum (ongoing, started in 2011).

Fourth workshop, conducted in 2008, addressed revival options for a dismantled industrial railway

line in Baranya with seven stations left along the vanished railway tracks (detailed description is presented in the Case study chapter of this article).

Fifth workshop, conducted in 2010, dealt with the use of recycled materials. Classroom activities were performed prior to field work so that students started the workshop researching and designing elements of urban equipment, predominantly benches, made out of plastic bottles and concrete with recycled aggregate. During the same period, students collected plastic bottles discarded at the Faculty premises and, after a detailed and transparent selection process, chose three bench designs to be built. Field work consisted of processing (weighting, cutting, mixing) and testing recycled materials, constructing benches and setting them up along the entrance pathway of the Faculty building where they are still in use.

2.3 Case Study: student workshop 'where is the railway?'

Students' workshop named 'Where is the Railway?' has been conducted at the Faculty of Civil Engineering, Osijek during the winter semester of the academic year 2007/2008. The interdisciplinary workshop combined three obligatory study modules: Revitalization of Architectural Heritage, Construction Management, and Masonry Structures. It resulted in a joint project design of a rural pathway created through team work of 20 students and four teachers [5].

2.3.1 Problem

The original problem that the workshop addressed was a dismantled industrial railway line in Baranya. It was built at the beginning of the 20th century, connecting the Baranya triangle from the West to the North-East until the end of the 60's, when the road traffic took over and the railway became unprofitable (Fig. 1). Deconstruction of the railway track was carried out in 1968. What was left in the area were seven 'lost' railway stations located along the now missing line, silent witnesses of a disappeared infrastructure [6, 7].

Fig. 1. Plan of Baranya county traffic lines and structures.

2.3.2 Proposed solution

Baranya of the 21st century can be described by the polarization of the population and the economy around the remaining road and railway corridors, in the North—South direction. The rest is viewed as a sub-area faced with depopulation and stagnation [8]. Profiling of these rural sub-areas in terms of rural, geo and sports tourism defined our main workshop task as 'recycling the railway track'. This concept set to define the revitalization of the traffic route for vehicles such as bicycles, horse carriages, pedestrians, and Nordic skiers, while the seven existing stations (located in Baranjsko Petrovo Selo, Petlovac, Širine, Karanac, Kneževi Vinogradi, Suza and Zmajevac) were to be used as en route stops. Recycling the railroad line that left only the imprint in the ground was done by connecting the dots/stations that still stand, visible and recognizable in space [7]. Each station had a different content: inn with a horse-stable, multipurpose building for gatherings (NGOs, groups, et al), museum and a souvenir shop, a restaurant, a wine house, a hotel and a cycle repair service. The traffic corridor was supposed to meet the needs and desires of their users, as well as to contribute to development of Baranya as a tourist region.

2.3.3 Activities

Several types of activities were performed, preparatory as well as field and classroom activities. *Preparatory activities* were largely carried out by teaching staff. They comprised of things such as site review and evaluation (Fig. 2), literature and

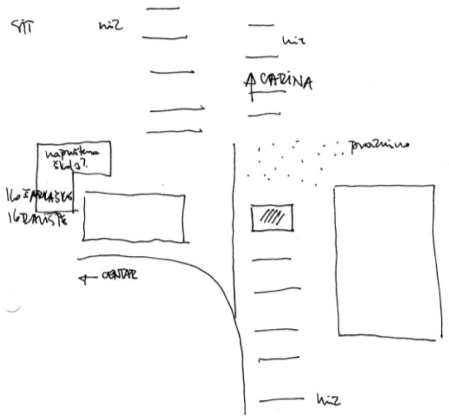

Fig. 2. Site review—sketch of the location of the railway station in Baranjsko Petrovo Selo.

Fig. 3. Field activities—checking the status of masonry foundations of the railway station in Suza.

Fig. 4. Classroom work on SWOT analysis.

archive analysis, interviews with owners and inhabitants of now defunct ex-railway stations as well as with local authorities. We also conducted a promotion campaign prior to the workshop including a student contest which was a recruitment model for the workshop. *Field activities* started with a survey of the whole location and the formation of seven work teams assigned to each station. Team members then measured all station buildings and reviewed their status based on structural and maintenance analysis (Fig. 3).

Classroom activities covered both technical and soft skills development of workshop participants (Fig. 4). Data gathered through field work served as the basis for further analysis in the classroom and a proposal for the whole railroad route was elaborated through a dynamic urban planning model of a transportation system consisting of sustainable vehicles. We decided to limit transportation facilities to sustainable forms of transportation in form of a menu from which one can choose from. Bikes, horses, ski-running, walking or skating were all offered. Students set out a full vision for the route and consequently defined contents from the West to the East and back. The SWOT analysis served to develop specific contents for each station building. The technical activities included production of digital archives—CAD drawings of existing buildings (Fig. 5)—and proposed renewal designs. Specific renewal proposals were designed for each of the seven buildings so that severely devastated buildings were revitalized by modern technical solutions, while stations in good condition were conservatively modified, with maximum respect to the original structure.

2.3.4 Results

The main result of the workshop was a joint design of a traffic route for sustainable vehicles with seven stops along the path. The design included technical plans (Fig. 6), construction and cost analysis, as well

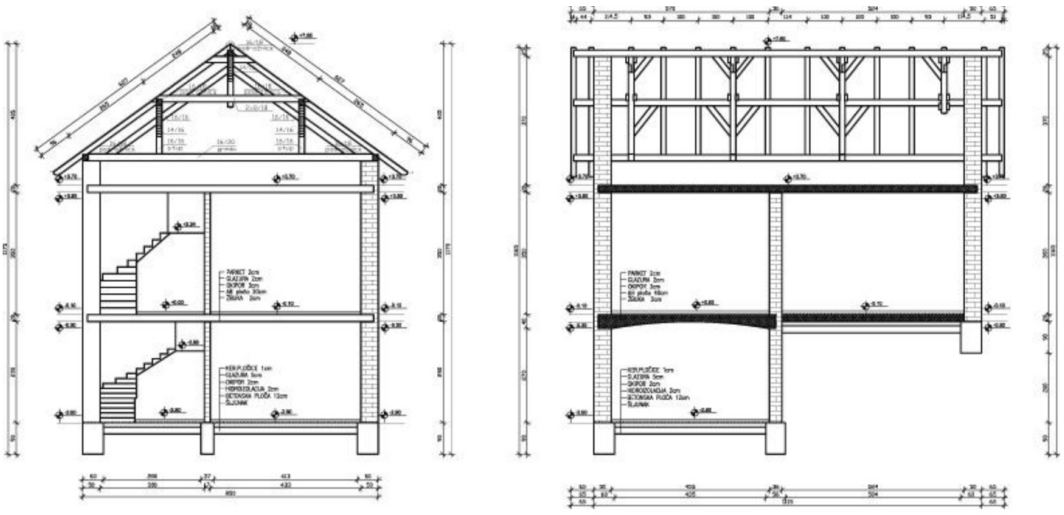

Fig. 5. Documenting the existing state of the Širine station.

Fig. 6. Different treatment of existing station structures based on current status—radical (left, station in Širine) and conservative intervention (right, station in Kneževi Vinogradi).

as activity schedules. All of the above covered the knowledge and skills that were defined as learning outcomes within the three obligatory courses. However, a direct application of the recycled railway track model in Baranya would have to be supported with additional environmental inputs: natural, anthropological, and contextual.

Students' hard work on designing solutions to a real and complex question resulted in promotion of the extensive but frail architectural and cultural heritage of Eastern Croatia as students presented their achievements on several occasions both in Croatia and abroad (ICAMES, Turkey). Except for the programme aims, we also enjoyed the atmosphere of the workshop, and celebrated its end in a relaxed and friendly atmosphere, shared by both students and their teachers.

2.3.5 Evaluation

After the completion of the workshop, a poll was conducted with the goal of getting the feedback from the students on both the positive and the negative aspects of the project. The poll was conducted by the teachers that moderated the workshop. Out of twenty students that took part in the workshop, fourteen turned in completed questionnaires. Following are some of the statements from those questionnaires:

'I became interested in the project because of the way it was presented and because of its name. First, at the Faculty there was a teaser flyer with just the name of the workshop 'Where is the Railway?' and every consecutive day another flyer surfaced; a countdown began, 10 more days, another 5 days . . .' (Mario Galic, student)

'I applied for this workshop because it sounded interesting. It combines three courses and until now we've been doing only classical individual assignments for each course. We worked in groups, draw the entire route and together with the teachers, we discussed functions for our station building and in the end we opted for a wine bar as Knezevi Vinogradi are known for its wine.' (Anita Orsolic, student)

'This was something new, different and, at last, something practical! We have already had lots of field trips but it was always talk, talk, talk so this was the first time that we did things ourselves. I am glad that I participated in this project because it merged the knowledge of several courses. All these were real projects that could potentially be realized. My expectations were fulfilled!' (Marina Glavota, student)

In grading the contents, results and organization of the workshop students had three options: not satisfied (1), satisfied (2) and very satisfied (3). The contents were graded 2.57 (out of maximum 3), the results were graded 2 and the organization was graded 2.14. In grading the workshop as a whole, students had five options ranging from the lowest (1) to the highest grade (5). Overall numerical grade of the workshop was a very respectable 4.62 out of a maximum 5.

3. Discussion—Benefits of workshops' design centric structure

A systematic analysis of activities and achievements was performed upon completion of every workshop. In the following analysis, we tried to detect

both the benefits and the defects of such a design-centric approach to learning in comparison to the use of more traditional teaching methods. The analysis was based on comments and open discussion between students, teachers and workshop participants outside the academic community. Each interested party formulated suggestions and conclusions that resulted in improvements of the next workshop.

As one of assessment tools, we used work products and experiences of a control group of students that executed their specific tasks for every course subject individually, outside the workshop. The accomplished learning outcomes for every course could in that way be compared between those two groups and the workshops' success could be judged objectively.

Learning outcomes for the three courses were already defined at the time we started with the workshops but only the amount and type of knowledge was described, without detailing desirable skills and attitudes. Within Revitalization of Architectural Heritage students had to acquire basic principles of heritage protection and characteristics of architectural styles and periods, accentuating local values and traditions. In the field of Construction Management they had to learn how to plan scheduling and construction activities' structure, together with cost calculation and analysis. The course Masonry Structures deals with analysis and research of brick structures and structural elements [9].

Each workshop was created and set up with the aim of accomplishing these outcomes within one specific theme. The resulting design was a joint product that connected different participants and various activities, both in type and sequence. The design encompasses multiple aspects of civil engineering, all part of the reconstruction process of a single building (or group of buildings) as it usually happens in „real life'. These aspects include learning the methods of heritage protection in situ and documenting present status of protected buildings. They include producing calculations and scheduling plans for a construction while continuously adapting and changing these plans in communication with the owner or current user. Students had to design creative solutions for the revival of existing buildings but also had to figure out how to present those plans to the community and to the media and how to „sell'the cost of these interventions to the investors. They found out that construction is always a multidisciplinary team effort even if team members are not always their friends or diligent workers. Based on the designs that were submitted after the semester ended, both from students that participated in workshops and from students within the control group, the teachers concluded that the knowledge acquired through the workshops was broader in scope and had a more lasting effect, due to its practical nature. Students' observations centred on satisfaction with skills development (use of specific instruments for architectural measuring, digitally documenting built heritage), dealings with real life problems, situations and people that add to complexity of construction management tasks. Students also commented on potential inadequacies of the team work (unequal division of work within the team, necessity to cooperate and negotiate with different personalities), as well as issues such as short project deadlines, large number of students within the team, and the notion that they had to put in more hours than their colleagues outside the workshop for the same grade value [10, 11].

Teacher's experiences documented excessive workload (extensive workshop preparation); coordination issues with academic schedules as well as with their own colleagues and a need for harmonization of course programs and course evaluations. Furthermore, the additional information on modern teaching techniques and approaches to engineering education such as 'design-centric' and 'project/problem' based learning was deemed necessary. Therefore, after ten years of student workshop experiences, the workshop creators published a book in 2011 on contemporary teaching and learning methods in civil engineering education [3].

Both groups stressed the need to balance detailed preparations and guidelines (which will simplify coordination and management of all project participants) with a certain degree of freedom within the project as freedom is crucial in development of imagination and creativity and is intrinsic to an engineer's mind.

Observers from the local community, institutions in culture and heritage protection like the Croatian Railway Museum in Zagreb and Conservation Office in Osijek, Croatian Civil Engineers' Society and various civil engineering faculties in Croatia, NGOs, and independent experts—all active in workshops to date—positively evaluated the outreach of regional academic society into their surroundings. This role of the university which promotes proactive social engagement and social responsibility was never as important as it is today, as Osijek, once a bustling industrial town, has the University as the single biggest employer today.

Finally, students had a rare opportunity to see one of their designs built! The community of Zmajevac received a government grant for the reconstruction of the Museum in 2011, based on the documentation elaborated within the workshop, and the ongoing reconstruction works are following a student design proposal.

4. Conclusion

Since the 2000, numerous students' workshops have been conducted at the Faculty of Civil Engineering Osijek, Croatia. Workshops were devised with two main goals in sight; one was to acknowledge significant changes in higher education in Croatia in the last few years and incorporate them, together with other contemporary accomplishments in teaching at university level, into civil engineering curricula. The other goal for the Faculty was to stress its social role and take an active and responsible approach to society's problems.

The interdisciplinary students' workshop 'Where is the Railway?' tried to devise sustainable, environment friendly and cost effective solutions for the reconstruction of an abandoned railway line in Baranya, Eastern Croatia. The workshop integrated different architectural and organizational aspects of the construction process and was a result of cooperation between twenty students of the final, fourth year of civil engineering studies and a group of teachers of the three course modules: *Revitalization of Architectural Heritage, Construction Management* and *Masonry Structures* at the Faculty of Civil Engineering Osijek.

The workshops' results, organization and impact were evaluated after completion by its participants and graded with the overall high mark. Positively evaluated aspects of the workshop included the contents of the workshop, its combination of field and classroom work, regional issues, interdisciplinary nature of the project, the team work as well as considerable autonomy in completing given tasks. Suggestions were made in the direction of augmenting the time for consultations and enhancing coordination between teachers.

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