INTERDISCIPLINARY APPROACH TO EDUCATION IN THE AREA OF ROAD CONSTRUCTION

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Abstract

The paper describes an interdisciplinary approach to education of the students of the Faculty of Civil Engineering in Osijek in the area of road construction. This approach to education of students has been designed with a view to implementing the requirements and changes in higher education in the last couple of years, together with other modern accomplishments in teaching at the university level in education of civil engineers. This approach integrates designing and organizational aspects of the road construction process from the group of obligatory courses of the III year of the university undergraduate civil engineering study: Roads and Construction Management I. In the Roads course the students are taught designing of roads and they prepare a road design which includes the layout, longitudinal section, characteristic and normal road cross-sections. In the Construction Management I course the students continue working on the road designs and prepare calculation of quantities, price calculations, cost estimate, and construction works schedule.
Such mode of work enables to students to have a more complete insight into the complexity of the road construction process and monitoring of that process in all phases: from designing of horizontal and vertical road elements, defining the cross-sections up to the calculation of quantities, price calculations and preparation of cost estimate.
For purposes of the revision of the study program the paper further presents defined learning outcomes for the Roads course. Learning outcomes are described through competencies that the students will acquire after the completion of the course. The defined learning outcomes and acquired students' competencies are compared with the results of the opinion poll of employers whose objective was to identify to what extent the competencies acquired in the course of the study are consistent with the expectations of employers.

Keywords: higher education, designing, learning outcomes

1 Introduction

The labor market is in demand of competent engineers for whom it is possible to describe exactly what they are able to do after completing a specific level of a study program or after they have taken a specific course. An interdisciplinary approach is highly valued. Those were the guidelines for designing a common work and cooperation of the Roads and Construction Management I course. Learning outcomes for the course were defined for purpose of as precise as possible definition of competencies of graduate students.

2 Roads Course Program

In the v semester of the university undergraduate study of the Faculty of Civil Engineering in Osijek students take the Roads course under which they prepare a term paper. The term paper consists of the preparation of a road design outside of a settlement between the points A and B on digital contour line plans [1]. The level of road design in the term paper is not consistent with any of the usual, real levels of road designs, due to a reduced number of annexes, detail of preparation, but also the scales in which specific parts of the program are prepared. Such level of the design was selected in order to give students opportunity, within the envisaged number of hours of exercises (45 hours) to become familiar with all the parts of the road designs, to work on them, but not dealing with specific details of each part. Preparation of the term paper starts with the design speed definition for the given input data (road categories, configuration of the terrain), by determining the limit elements such as the minimum radius R_{min}, minimum transition curve length L_{min}, maximum vertical alignment inclination $s_{max,}$ and the selection of road cross-section and its elements.

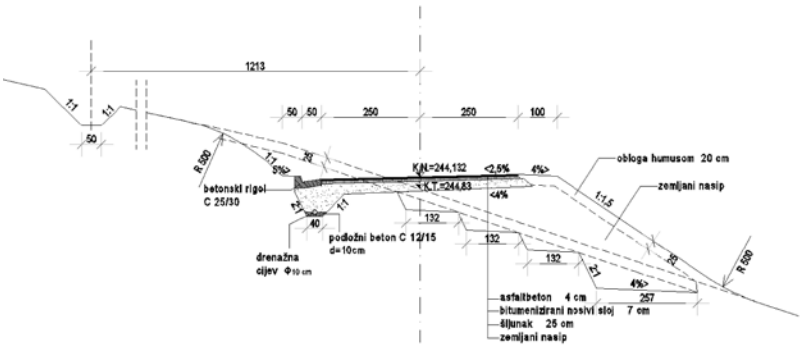

Figure 1 Example of a Normal Road Cross-section from a Term Paper

Plan elements of roads are designed in the layout in the 1:1000 scale, taking into consideration the characteristics of the terrain, the principles of horizontal alignment, and the Croatian technical regulations in force. Vertical alignment and of pavement screwing is resolved in the longitudinal section in the 1:1000/100 scale, after which road cross-sections are prepared. In setting of horizontal and vertical elements minimization of construction costs should be taken into consideration (as little cut and fill as possible, and as many side cuts as possible), as well as their optimization (balancing of masses).

Characteristic cross sections are done in the 1:100 scale on each 20 m along the axis of the roads and in characteristic terrain spots. For specific forms of cross-sections (side cuts, fills, cuts) normal cross sections in the 1:50 scale are drawn. They contain elements of a cross-section with all the necessary dimensions, the mode of formation and protection of embankment and layers of pavement structure (Fig. 1). Normal cross-sections in the 1:50 scale are done in chainages in which concrete culvert pipes on the road route are designed, which contain all the necessary elements, dimensions, and details of culvert construction.

The final term paper from the Roads course contains the following annexes: technical description, layout (1:1000 scale), longitudinal section (1:1000/100 scale), normal cross-sections (1:50 scale), and characteristic cross-sections (1:100 scale).

When preparing the term paper from the Roads course, the students do not calculate the quantities of work, they do not prepare the cost estimate or any part of tender documentation, or any annex or part related to the organization of construction. The course program also includes field instruction, which is implemented through visits to construction sites (Fig. 2).

Figure 2 Visit to the Construction Site of a Section of the AC5 Motorway, Đakovo, May 2008

Figure 3 Students' Visit to a Construction Site in Čvrsnička Street in Osijek

3 Program of the Construction Management I Course

Program of the Construction Management I course is carried out in the VI semester of the university undergraduate study. In terms of substance it includes topics of the development of organization, specifics of civil engineering production, application of system analysis, decision-making in respect of costs, time, and quality, and organization of construction site layout [1]. During exercises a particular attention is paid to details of the examples and tasks related to the site establishment, bill of quantities, breakdown of prices, and cost estimate. By means of an assignment related to the site establishment the students are referred to visit a construction site in the city and the surrounding area to acquire knowledge from designing temporary structures and the most significant elements of organization of construction, supervision, and control of works (Fig. 3). On the basis of examples and data from the exercises the students prepare a program. The program consists of the technical description, a bill of quantities, a breakdown of prices, and cost estimate for a given preliminary design of a smaller structure. The bill of quantities is done for all construction works in the design, whereas the scope of the preparation of the breakdown of prices (and the corresponding cost estimates) is somewhat smaller. The breakdown of prices is prepared for 3 given types of works. In the preparation of the program particular control is carried out as regards the accuracy of calculation in the preparation of the bill of quantities, because in that manner it is established if the students know the constructive elements of a given structure. Also, it is established if they recognize the types of works and if they are able to expound the structure into constituent parts. On the basis of the preparation of the breakdown of prices it is established if the students are able to recognize the basic elements of the calculation: the required material, work of people and machine operation, and whether they are able to analyze and calculate the unit price for a defined cost estimate item by using standards. In the preparation of the breakdown of prices students are instructed to study various construction technologies. This knowledge will enable the right choice of the technology depending on the conditions on the site, the concept of the structure, the available mechanical equipment, and human resources. In the preparation of the cost estimate it is insisted that a detailed description of the item(s) be provided to ensure non-ambiguity of the description and designed work.

The most frequent base for the preparation of the program is a preliminary design of a ground-floor structure on the basis of which the students prepare the bill of quantities, a breakdown of prices, and a cost estimate for works in building construction. The same program is used later on in the Construction Management II course as the basis for the preparation of a construction works schedule. So far the course has not included a detailed elaboration of the issues of the preparation of the breakdown of prices and cost estimate in road construction or other areas of civil engineering (geotechnics, railways, hydrotechnics). Given that the gra-

duate students of the Faculty of Civil Engineering work within a broad range of activities in the civil engineering works, we are trying to address this problem, i.e., gap within the envisaged number of academic hours of the course.

4 Interdisciplinary Approach to Education of Students in the Area of Road Construction

Since a similar type of issues has been observed in both courses, we have tried to find a solution. One gap has been observed – that the students never resolve a given problem, i.e., a design as a whole, but each time a new assignment is given within the course program. In order to ensure a continuity and comprehensiveness throughout the education of the students in the area of road construction, an approach aimed at the preparation of a joint program from the Roads course and Construction Management I course has been designed. This concept has been successfully implemented since academic year 2006/2007. In the course of the V semester the students prepare a program from the Roads course and then working on it in the Construction Management I course. Thereby comprehensiveness is ensured in resolving the problems of designing and planning of road construction. Also, students work on their own template, on the design that they prepared themselves and the one which they know. This additionally facilitates their work. Such an approach ensures comprising of all elements related to the road design – from the concept to the preparation of construction (since in the preparation of the site establishment scheme special attention is paid to the principles of site establishment schemes in linear structures and road construction structures).
Developing a specific competency of a student requires identifying the required knowledge (educational content), the required skills for the application of knowledge, the necessary attitudes to the acquired knowledge, the methods and procedures by which those competencies will be realized, the manner of valuation of the acquisition of competencies, as well as the required teaching media.

5 Learning Outcomes

The objectives of teaching at the level of the study and each course are defined as learning outcomes. Learning outcomes are described as competencies that a student acquires after fulfilling all the obligations in the course of the study. The learning outcomes, i.e., the acquired competencies should be recognizable and objectively measurable. The learning outcomes are connected with student workload in terms of hours and ECTS points. Determining the learning outcomes and student workload is the basis for the development of the strategy of teaching, learning, and verification of the learned matter [2].
The learning outcomes are intensively investigated and elaborated in various documents related to the Bologna Declaration. They represent one of the bases for a transparent higher education and qualifications.
The approach based on the learning outcomes has a big impact on the development of the syllabus, the teaching process, the learning process, and quality assurance. Application of learning outcomes in the development of new syllabi represents the basis for a change in comparison with the approach so far. The learning outcomes represent a change from a system focusing on lecturing into a system focusing on learning, i.e., from a professor-centered system into a student-centered system. Development of courses by using learning outcomes means a shift of attention from the substance of the course to its output, i.e., what the student is capable of doing after a successful completion of the course.
Learning outcomes are helpful to the students because it is clear to them what is expected from them during a study or a course, and this is also reflected in a better studying performance. Further, learning outcomes help the professors focus exactly on the desired level of knowledge and skills of students acquired for a specific course. Learning outcomes also

represent a very useful information guide for prospective students, but also for employers, about the level of knowledge and understanding that a graduate will possess.
At the Faculty of Civil Engineering in Osijek, as well as at the whole University of Osijek, introduction of learning outcomes and the related development of the program is at an early stage. It is, therefore, necessary to start developing a system for the introduction of learning outcomes and their implementation at all constituent parts of the University.

5.1 Learning Outcomes from the Roads Course

For purpose of planning the substance and possibilities of further cooperation in the Roads and Construction Management I courses, the following learning outcomes have been defined. Having taken the Roads course and having prepared the term paper, an undergraduate study student will be capable of the following:
· Defining and describing elements of a cross-section of the road
· Defining and calculating the horizontal elements of the road
· Defining and calculating the vertical elements of the road
· Preparing a design of a road outside of a settlement in simple conditions at the preliminary design level
· Differentiating between methods of road construction depending on the terrain on which the road is being constructed and the available material (the basic level due to compatibility with geotechnical courses).

Attaining the learning outcomes is checked by means of an oral colloquium of specific parts of the design as a prerequisite for the continuation of the work in the part that follows. It is followed by a written and oral examination. There is an option to take the colloquium of the course by means of passing two colloquiums.

5.2 Learning Outcomes from the Construction Management I Course

Having taken the Construction Management I course and having prepared the program, a student of undergraduate study will be capable of the following:
· Proving by a calculation the quantity for structural elements of the structure
· Proving by a calculation the quantity for the elements of a cross-section of the road
· Calculating the unit price for the given item of the cost estimate
· Writing the item of the cost estimate
· Preparing a site establishment scheme.

Attaining of learning outcomes is checked by a written colloquium of specific parts of the course program. It is then followed by a written and oral examination. It is possible to take a colloquium of the course.

5.3 Linking Learning Outcomes and Teaching

Linking is defined as a degree of compatibility between defined learning outcomes, planned activities of the students (in comparison with the awarded number of ECTS points at the course), the teaching method, and the assessment method. Linking of learning outcomes, teaching methods, and assessment methods make the education process transparent to all process stakeholders. On the basis of defined learning outcomes the teaching methods and assessment criteria are linked [3].
With the completion of the term paper and by passage of the examination from the Roads course the student acquires the following competencies:
· understanding of the basic principles of road design
· defining and resolving of the principles of road survey outside of settlements, in simple conditions

· preparation of technical drawings, manually and by using the CAD program
· applying of acquired knowledge in further professional and academic education.

On the basis of a comparison of the results of an opinion poll of employers about the learning outcomes implemented as part of the project *"A Systematic Approach to the Introduction of Learning Outcomes in the Education of Students at the University of Josip Juraj Strossmayer in Osijek"* with defined learning outcomes for the Roads course, it can be concluded that employers are satisfied with learning outcomes since they gave their employees high grades for competencies acquired through education at the Faculty of Civil Engineering in Osijek [4]. For employers whose primary activity is performance of construction works, in terms of the importance of the competencies, those ranking the 1st are professional competencies (professional knowledge and competencies, application of concepts, methods, and techniques characteristic of the profession), those ranking the 2nd are general competencies (rational thinking, independence in decision-making, competence to select information, analysis and synthesis), whereas the 3rd ranking one is motivation for the profession (developing a positive attitude toward a certain profession and its ethical principles). For employers whose primary activity is designing, competencies ranking the 1st are systemic competencies (adaptability, creativity, a driving force, and entrepreneurial spirit), those ranking the 2nd are general competencies and motivation for the profession. In recruitment the employers are guided by various criteria. In selection of new employees, as a rule, contractors focus more on their competencies and quality (three criteria with the highest importance are the impression during the interview, professor's recommendation, and the reputation of the faculty where the incumbent has studied). On the other hand, employers whose main activity is designing, besides the impression during the interview, focus primarily on performed internship in the company and only thereafter the recommendation of a professor. And, while the impression and recommendation are subjective, although by no means negligible values, another selection criterion – performed internship in the company – enables the employers a selection of a good quality future employer.

6 Conclusion

Trends in education indicate that there has been a shift of focus from teacher-centered teaching to student-centered teaching. This is an approach based on learning outcomes, i.e., the need to define objectives as a measurable learning performance. For the employers, the three most desirable competencies are general competencies, motivation for work, and professional competencies. When evaluating performance of their employees, former students of the Faculty of Civil Engineering in Osijek, employers rate highly their professional competencies and technical knowledge and skills.

The described interdisciplinary approach to education of students in the area of road construction enables development and acquiring of competencies that correspond to expectations and demand of employers.

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