Education of Spatial Thinking and Aesthetics: Toward Humanization of Built Space

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***Abstract* — New trends and new requirements for road transport are connected with respecting safety, the environment and aesthetics. Philosophy behind road design is expressed in the four-component relationship, namely: *"driver – environment – road – vehicle"*. This work presents new concept and approach to aesthetic highways design education. The concept involves modern 3D/4D visualisation not only as a design tool, but also as a philosophy and a method of reaching the goal. Road geometry, together with all other visual design and environmental parameters can be evaluated as they would be perceived by drivers. An experimental course of "Aesthetics in highway design", offered to master diploma students specialising in Road and Traffic Engineering at the Civil Engineering Faculty of Cracow University of Technology, Poland, is presented. It covers interdisciplinary lectures on theory of aesthetic, driver's perception, environmental principles in road design, computer graphics and visualization methods. Perspective projection is a tool for 3D designing process, in which students individually consider the aesthetic, scenic, historic, and other cultural values, along with the safety and mobility requirements in their projects. Additionally, spatial designing based on modern 3D/4D computer visualization enhances student's perception and creative thinking, leading to environmentally friendly optimal design.**

Index Terms - education, spatial thinking, creative road design, visualization, humanitarian engineering

INTRODUCTION

Last decades of the 20th century brought new trends and new requirements for road infrastructure design, connected with safety, preservation of the environment and aesthetics. This has been widely documented in the European research project "SIZE – life quality of senior citizens in relation to mobility conditions" results [1]. Road users and a large group of experts from eight European countries agree, that aesthetics in mobility environment (road infrastructure, public space in urban and suburban environment) has a great impact into the quality of transport system. This new approach to road design practice is expressed in the four-component relationship, namely: *"driver – environment – road – vehicle"*. Modern designing of highways faces the challenge of incorporating community values and safety, efficiency and effective mechanisms to the movement of people and goods [2]. Engineers who make projects of modern highways should be able to find such a design solutions that take into account all, sometimes conflicting, objectives. Innovative thinking is required in the consideration of scenic, historic, aesthetic, and other cultural values, along with the safety and mobility needs of today's transportation system [3]. New directions in road research and education are emerging. The search for such a model of design [4] that respects all the four interrelated components of today's philosophy of a modern road is essential. *Computer visualization* is becoming the most promising link efficiently connecting all the components of the system.

AESTHETICS IN HIGHWAY DESIGN EDUCATION

An experimental course of "Aesthetics in highway design" is offered to the 5th grade (Master Diploma) students specialising in Road and Traffic Engineering at the Civil Engineering Faculty of Cracow University of Technology (CUT) in Poland. The course deal with all interdisciplinary aspects related to highway aesthetics. It covers the lectures on theory of aesthetics, driver's perception, environmental principles in road design, computer graphics and visualization methods. Perspective projection is a tool for 3D designing process, in which students individually consider the aesthetic, scenic, historic, and other cultural values, along with the safety and mobility requirements in their projects. Additionally, spatial designing based on modern 3D/4D computer visualization enhances student's perception and creative thinking, leading to environmentally friendly optimal design.
Theory of graphics and geometry plays an essential role in the basic knowledge as an introduction, which is lectured during the earlier courses of Descriptive Geometry and Technical Drawing by specialists from the Division of Descriptive Geometry and Computer Graphics from the Faculty of Architecture, CUT.

The first part of the lectures of "Aesthetics in Highway Design" course covers the filed of modern engineering graphics, namely: philosophy of aesthetics, social and psychological aspects of road view evaluation, driver's perception, safety aspects of road visual information, methods of visualization in highway design, theory of central projection and perspective vision for road visualization, applied geometry and computer graphical modeling. The principles of theory of aesthetics are the base of the course, unknown to engineering students before, so those are lectured exclusively at the beginning of the semester.

The second part of the course consists of the practical tasks for students, who are working on their individual design projects. Each one is supplied with a photography of a real road and its environment, with an individual unique task to design the reconstruction of this space, respecting all engineering requirements, safety aspects and aesthetical value of the newly created environment.

APPLICATION OF PERSPECTIVE PROJECTION

According to a traditional geometrical model of the central projection, but converted to the driver's eye position as a central view point (as a base of searching the view-point in the picture plane), the horizon and the scaling object in the picture, students are re-creating and describing all visual parameters related to the road and it's environment. The proper application of the perspective projection model is essential for successive evaluation and required design of the road view.

GEOMETRY AND GRAPHICS IN PRACTICAL DESIGN WORK

The following examples (Figures 1 - 7) of students work show the 'before" and "after" views, together with examples of how the geometry of the road was reconstructed and evaluated. The "before" reconstruction scenes are enriched by the graphical search of the central projection model. After recognizing the view point (eye of an observer), all necessary scaling features are found and the important edge lines of the existing "before" construction are added in perspective projection. The graphical process of 3D geometric design is based on the central projection theory and the methods used in the applied perspective projection. The road lane width, known from the road design standards, were often the only scaling feature in the "before" scene.

After making decision on the necessary reconstructions, which would enhance the aesthetics and safety of the elaborated road segment, the linear geometric design is produced in perspective. Finally, the computer graphic software is used to paste the proper texture and structure on each new-designed element, together with surrounding greenery and objects along the road.

The figures 1a and 1b present two phases of the student work, the first one (Fig.1a) shows the linear model of the applied perspective projection and the second one (Fig. 1b) shows the final effect of the reconstruction idea after pasting all re-designed parameters and objects onto the initial road view.

Figure 1a: The "before" view was enriched with geometric model of central projection, in order to reconstruct the road segment in an aesthetic way.

Figure 1b: The final effect "after" designing the new road segment geometry and the road architecture.

The left and right edges of the two-lane curved section of the road (Fig. 1) are recognized as hyperbolic shapes, tangent to the road section in front of the observer (the driver) approaching the curve. The junction geometry is designed with respect to the same model of perspective projection. The smaller radii circles creates the junction edges, which are viewed as hyperbolas tangent respectively to the main and secondary roads edge lines. This design solution is based on the theory of central projection of a circle.

Figure 2a: The “before” view of the straight road segment (right edge), when bus stop and pavement are to be constructed.

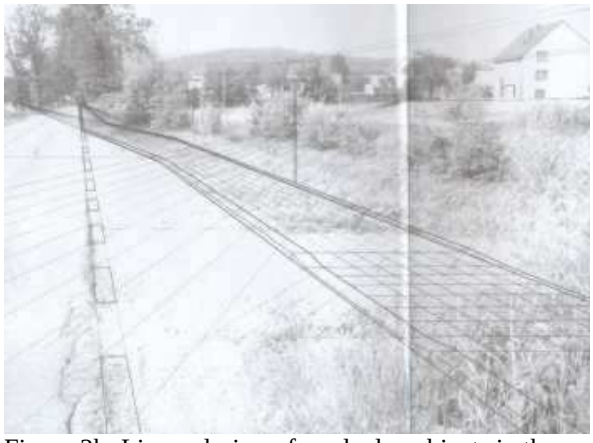

Figure 2b: Linear design of road edge objects in the reconstructed model of central projection.

Figure 2c: The “after” view of the reconstructed road, in which new edge lines were painted, the bus stop and bus lane was created and the aesthetic pavement was designed with the junction road in the middle.

The next figures (Fig.2a-c, Fig.3a-c) present three phases of the road view elaboration, namely: (a) the starting point “before” reconstruction; (b) geometric modeling of reconstruction in linear perspective; (c) the final result “after” redesigning of the view.

Figure 3a: The “before” view of the dangerous segment of the road and wild parking.

Figure 3b: The designing of reconstruction in central projection linear model.

Figure 3c: The redesigned view, “after” change.

Visualization can be a helpful method in decision making process not only for road engineers, but also for landscape architects and environmentalists who works with road aesthetic problems. The problem of monotony of the rural road is presented in the figure 4a. The solution (Fig. 4b) offers some aesthetical changes on the

road pavement and road shoulders, as well as greenery on the right side of the road. The proper design of trees along the road requires visual assessment of the final effect, against the unpredicted distractions of the field of vision to the road users. In order to design an optimal visual corridor for drivers and for other road users (bikers, pedestrians), analysis of the perceived road view is needed.

Figure 4a: Monotony in the "before" view of the rural road.

Figure 4b: The "after" redesigning view with engineering and landscape changes, against monotony of the road, with enriched aesthetic and safety.

The successive use of visual methods in road architecture design process is shown in figures 5 and 6. The first example (Fig. 5a) shows an elevated road of a new intersection construction "before" the final works. The task covered building the pavement of the road and safety barriers in aesthetically organized shoulders on the left road side.

Figure 5a: The "before" view of the road construction.

Figure 5b: The "after" view of the new road segment, in which pavement, road lanes, safety railings and barriers were designed, creating the graphical simulation of the future road picture.

The final view (fig.5b) simulates the picture which drivers are to observe while driving "after" finishing construction of this intersection. Eventual distortions in visual field can be corrected during design phase.

Purely aesthetical works are presented in the Figure 6, where road side elements were intended to enhance the quality of the road view. Original road is built according to the road design manuals, but its environment influences monotony and, as a consequence, unsafe driving conditions (Fig. 6a). In order to correct both safety and aesthetic of the road, new pedestrian pavements, variable greenery and road lamps system were added on both sides of the road (fig. 6b).

Figure 6a: The “before” view of the monotonous road segment.

Figure 6b: The “after” view of the road with newly designed elements of road side architecture and greenery.

DISCUSSION

There are several aspects of the course which highlight its educational value for students. First of all, the use of computer graphics made it possible to increase student’s spatial imagination and creativity. Civil Engineering students are not very often trained in multi-dimensional design. Also their hand drawing abilities are rather limited. The possibility of producing as many as they like design options in a very short time would not be possible without the use of modern computer graphics. Furthermore, students are able to evaluate an aesthetic value of their design by visual comparison of the final effect – the photo-realistic, virtual view of the road scene. The perceptual aspect of the road view, which is related to the road user behavior and road safety, has been incorporated into the teaching process. Another important aspect of this course is time saving. The proper use of computer graphics software let students to produce the final view more than ten times faster, than while using the traditional hand drawings. It has also been observed, that students are more enthusiastic about learning, especially because their design work effects are more attractive and easier for evaluation.

Finally, the course meets interest of more and more students, who will start their engineering professional work with better skills and wider knowledge on aesthetic value of man-made environment.

CONCLUSIONS

Engineering education faces the challenge of upgrading human quality of life. Humanization of built environment, especially transport space, is essential, but can not be afford without incorporating aesthetic values into design process. Teaching process requires wide interdisciplinary knowledge, in which spatial abilities, spatial thinking and creativity are most important. The course, presented above, has shown that computer visualization can be helpful in education of aesthetical design of highways. The future course should also apply 3D/4D virtual road view, better provoking spatial imagination, innovative thinking and in this way providing the basis for creating safer roads of 21st century.

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