Digital Architectural Composition - 30 years of experience and experimentation

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In this paper the evolution of architectural composition teaching will be presented and discussed. The main point of these deliberations is to consider how digital methods and technologies have influenced the teaching methods and the understanding of compositional rules/principles by students. Another important factor which will be analysed, is the difficulties faced by teachers in the evaluation of students' work. The paper is divided into four parts, each of which concerns different approaches to architectural composition teaching. In the first part the historical background of architectural composition teaching is presented. In the second part traditional teaching methods is described, the third concerns teaching of digital architectural composition, and the fourth - digital architectural composition in virtual space. At the end of each section, the advantages and disadvantages of the discussed methods are presented. These disadvantages were a stimulus for changes in the teaching process, which was enabled thanks to the development of digital technologies (software and hardware) during the last 20 years. The last part of the paper will be devoted to the presentation of potential directions of development of architectural composition teaching methods.

Keywords: Architectural Composition, digital modelling, Virtual Reality

HISTORICAL BACKGROUND
The main problem at the first stage of architectural education is activation of the students' creative abilities. At this stage the lack of empiric experience should be compensated by the knowledge of composition principles of spatial forms. This knowledge creates the basis for all future architectural professionals’ activities. This teaching method was introduced for the first time about 90 years ago in two great architectural schools - Bauhaus and VKhUTEMAS (Vysshiye Khudozhestvenno-Tekhnicheskiye Masterskiye (Higher Art and Technical Studios)). The main goal of both schools was an integration of all kinds of art and industry, and a break from old design tradition. Searching for a new kind of art meant a destruction of the old, formed new types of problems, and therefore required a new theory of creation. Kandinsky has written: "Creating abstract space forms will be very important therefore in result the tradition will be destroy. We will see the new tendencies in architecture. [...] Searching should start from elementary spatial forms as pyra-
The new idea of composition teaching belonged to N. F. Ladovsky, who claimed that teaching should concentrate on abstract composition themes, without indicating a concrete function. Models were to be used at all stages of the search for composition and in the final representation of the task. Thus, the foundation of a new method of teaching architectural design, which had not been known to the academic schools previously, was laid out. The principles of this method of teaching were formulated as follows: study of composition means and rules of creating spatial three-dimensional forms for solving architectural compositional design tasks; development of spatial thinking and compositional skills; mastering the skill of masking models as one of means used during the process of architectural designing. The entire theoretical and methodological material was presented in 1934 by V.F. Krinsky, I.V. Lamtsov and M.A. Turkus in the book "Elements of architectural and spatial compositions".

The teaching structure at the Bauhaus was developed by Walter Gropius in 1922. The central part of it was the Building. At the start of the studies, students attended what was called a "preliminary course", in which they were experimenting with colour, shape and materials with no specific goals. This approach was developed by Gropius, who also chose the teachers which was the most influential for the development of the Bauhaus's viewpoints. Johannes Itten was the first person to run the preliminary course in which he had broken the academic tradition by asking the students to create spatial forms based on their own subjective perceptions instead of copying from models. [1]

**TRADITIONAL ARCHITECTURAL COMPOSITION**

"Elements of spatial forms under appropriate combinations, relationships, proportions and rhythms are a means of expression of the content of the architectural object, including its artistic qualities. In the analysis of architectural forms, the use of the method of abstraction is quite justified." (Krinsky et al. 1968, 5)

Eighty years later P.D. Plowright in his book "Revealing Architectural Design. Methods, Frameworks and Tools" has written: "The manipulation of form is, then, a primary aspect of architecture, and one of the main ways in which discipline is engaged. It is not the goal, however, but a means to an end." (Plowright 2014, 18.)

Our course of architectural composition was introduced to the curriculum in 1987. It elaborated on the basis of Bauhaus and VKHUTEMAS. In this traditional approach to the architectural compositions teaching cardboard models were used. At the beginning our course of architectural composition consisted of three abstract composition exercises (façade, solid form, linear composition (walk-through the space)). According to the VKHUTEMAS rules, a composition does not have to be similar to anything that exists in the real world, but it should be approached as an individual singular action that completes itself. For each exercise we have elaborated a short description including general remarks on the activity and its goal.

**Façade**

The goal is to create a relief composition - a façade of an object of unspecified purpose. This façade will only be viewed from the front. The composition should be arranged on a 30x30 cm field. The viewer is on horizontal 30x30 cm surface. Perception point should be marked with a human shape, as its position determines the size of the façade. The façade may be built of different types of cuboids. Their size and number depends on the conception. The elements may be arranged within the plane in any way. The only limit concerns the depth of the composition, i.e. the distance from the furthest element to the composition plane, which cannot exceed 5 cm. The model should be monochromatic.

**Solid form with specific formal value**

The aim of the design is an exploration of a 3-dimensional space and 3-dimensional volumes in space, which is one of the most basic and funda-
Figure 1
mental architectural activities. Students should design a solid composition with a specific emotional value (dynamic, light, massive, monumental). The composition size should not exceed 30x30x30 cm. The composition will be viewed from different perception points located around the object. A point from which, according to the designer, the composition appears most effective should be specified. Any cuboid solid can be used to build the form. Their size and number depend on the conception. To make the evaluation of the object scale, a human $1,7 \text{ cm}$ figure should be placed on horizontal plane. The model should be monochromatic.

**Linear composition - Passing through an open space**
The goal is to create a Passage through something important, something that has no beginning or end. A passage 'Through' and not a way 'From-To'. Students should anticipate the interlinks between present, past and future impressions; produce a space in which things happen and different moods are created. When applying architectural forms, a linear composition should be designed within a 0,3-0,6 km space. The composition will have different emotional impact. Any geometric forms and various materials (cardboard, glass, mirrors or metal) can be used. It is advisable to apply colour. The scale of the model should be 1:100 on a 30x60 cm board.

The starting point of designing was searching for the inspiration and preparing the sketches of the idea. Sketches were discussed and on their basis the model of the composition was realized. Also, 'no-function' (the traditional meaning) spaces were created. The only function of space was evoking emotions. Forms became more poetic and metaphoric. (Figure 1)

**Issues**
The design process of the façade was started by searching for inspirations, which may help the students understand the design problem. As a medium for searching all students used a sketch. After consultation with teacher they started preparing cardboard mock-ups. At this stage we observed that their manual skills were totally insufficient. Mock-ups were inaccurate and many students claimed that results looked different than they expected. Due to a lack of skills students did not want to develop design variants as they were too time consuming. In the case of the next exercise (Solid form) the beginning of the design process was the same, but the mock-up quality has improved significantly. However, because the compositions were more complex (they included emotional values), the students had trouble to imagine the real emotional impact of the composition. This aspect also evoked a biggest discussion between teachers during the assessment of the works. Often, it was difficult to assess whether the designs presented by students using scale mock-ups would actually be, for example, monumental or massive. In the last project - Go through - the evaluation has become even more difficult, as it was required to imagine the appearance of the space, which cannot will be viewed.

**DIGITAL ARCHITECTURAL COMPOSITION**
In 1987 R. Schijf (1987) has written that the design studio took up the central place in architectural teaching and it should be determined to introduce CAAD into the design studio. It demands that design teachers should know of the potential and the limitations of available computer facilities. At our school, we introduced digital media to the Architectural Composition course for the first time in 1997, after many years of experience with teaching traditional architectural composition. When we decided to use the new digital media for modelling architectural forms, we wanted to investigate the new possibilities of form creation. The digital course was based on the same exercises as the traditional course. After five years of experiments, in 2002, thanks to the intensive usage of computer modelling techniques the entire course was elaborated. This course included five groups of exercises: bas-relief (division, rhythm, façade); solid composition with specific formal; transformation - from a cube to a parallelepiped; walk
Figure 2
through (desert, valley, and tunnel); walk through an internal space (space of celebration, contemplation and dynamic space). We have added information about required skills and software to the exercise descriptions. In this course we permitted using any possible geometrical elements and surfaces with different colour and light. Practically in all exercises an animation was the obvious element. (Asanowicz 2003.)

The process of designing in both Traditional and Digital Course proceeded in the same way. The starting point was searching for the inspiration. Each student presented photos of existing architectural objects and a text, which explained the reasons of the choice. Next obvious stage was preparing the sketches of the idea. Sketches were discussed and on their basis the model of the composition was realized. As a result, forms designed by students in digital environment were similar to traditional carton models. The similarity concerned the degree of façade complexity. At the same time, we observed that students liked to design variants of the form. In these variants they tried to use different sources of light for achieving different emotions during process of perception.

We observed larger differences in the process of creating a solid form. Forms became more complicated: curvilinear planes, surprising transitions among particular elements appeared, and light was used in more conscious way. A simple computer animation allowed for a dynamic search of the best perception points and a better understanding of the visual frame. At the same time, we observed that better knowledge of the software allowed students to create more and more complex compositions and many students preferred to design directly in the digital space without the use of a pencil. They claimed that they were only able to present their project verbally. It made the teacher and student co-operation much more difficult, since the idea traditionally accepted in the graphic design convention was broken. (Figure 2)

**Issues**

Analysis of the possibilities of using computers for architectural compositions teaching has shown that using new digital media for modelling architectural forms gives new possibilities but at the same time creates new issues. The first is that little knowledge of software capabilities at the beginning of the learning process made it difficult for students to achieve the design goal. The problem that teachers faced were the difficulties in the evaluation of complex space compositions as it was really tough to imagine how the form will look in reality, especially in the case of the last exercise - walk through linear space.

Usually, architects use sketches at the conceptual design stage. In our work the architect's traditional tools such as a pencil, a sketch block and physical models are effectively replaced by a computer, which creates a new way of doing things. For example, students applied various materials of different transparency and many projects concentrated on playing with light and not form. As mentioned above, students created animation which required preparing some kind of a scenario, determining points of perception, and defining which places and spaces were important. Thereby, the perception process becomes dynamic and the onlooker's emotional engagement increases. It is possible now to convey the emotional message of the designed spaces more precisely. This helps to better understand the relations between composition elements as well as their influence on emotions. At the same time, in early design stages, when formal value is sought, computer modelling which can be done almost intuitively. Simple operations with basic forms enable students to design architectural sculptures, forms with specific formal value. The level of freedom in designing space by computer methods differed substantially from traditional models. Most of the students claimed that the process of decision making was much more flexible and as a result more effective.
Figure 3
From traditional mock-up to Virtual Reality presentation.
DIGITAL ARCHITECTURAL COMPOSITION IN VIRTUAL SPACE

Perception of a traditional composition was limited by the insufficiency of our imagination. It is extremely difficult to imagine the space inside a mock-up, and then evaluate the correctness of the solutions. Even great architects such as K. Melnikov considered that even the author of the project cannot predict all. He claimed that what the author of a project sees and feels cannot be transferred into traditional means of presentation. The author’s idea can be understood up to a point, only to be perceived completely in the completed building. His dream was to see how people will perceive the unusual form of internal space created by him in his design of a Columbus monument. It was a trimmed cone, into which another similar but rotated cone was immersed at the top. K. Melnikov admitted that even he could not have had imagined what impression this interior would have on others (Khan-Magomedov 1990).

In our Digital Architectural Composition Course we decided to use the Oculus as an evaluation tool. As D. Gann has written in the preface to the J. Whyte book "Virtual Reality and the Built Environment": "They make it possible to create virtual prototypes, to model attributes and to simulate performance characteristics without having to build full-scale mock-ups. By adding another dimension to the ways in which space can be configured over time, they complement and enhance the value of using face-to-face communications and physical models." (Whyte 2002, 7.)

Oculus allows one to enter through the monitor screen into “the computer world”, where an interaction with the forms present there is taking place. It turns out that apart from these virtual forms, nothing else exists. Designers and users of this virtual world receive new experiences of space and new means of interaction. Virtual Reality eliminated the boundaries between the spectator and the space. This creates the conditions for the perception of the metamorphosis of forms, non-physical objects, paradoxical images, the reality of the illusion, and above all the perception of the invisible aspects of our world. The development of a virtual reality in which interacting with representations of virtual objects can take place, allows the use of new perceptual, cognitive and interactive capabilities of man.

Students may check the design solutions and decide whether the planned emotional values were reflected in the created space. The same also applies to the teacher who does not have to visualise what the student imagined designing a space. The evaluation process becomes more objective, insofar as we can objectively assess the emotional values. (Figure 3)

Issues

This approach demands additional time for teaching new software, which is fortunately not difficult. The problem is rather in hardware part, as this way of presentation requires powerful computers. The system requirements were published on the Oculus website. The recommended settings for using the Rift are as follows: NVIDIA GTX 970 / AMD 290 equivalent or greater, Intel i5-4590 equivalent or greater, 8GB+ RAM, Compatible HDMI 1.3 video output, 2x USB 3.0 ports, Windows 7 SP1 or newer. Atman Binstock, the technical director for the Rift, explained why the requirements are as high and has written: "On the raw rendering costs: a traditional 1080p game at 60Hz requires 124 million shaded pixels per second. In contrast, the Rift runs at 2160×1200 at 90Hz split over dual displays, consuming 233 million pixels per second. At the default eye-target scale, the Rift’s rendering requirements go much higher: around 400 million shaded pixels per second. This means that by raw rendering costs alone, a Virtual Reality game will require approximately 3x the GPU power of 1080p rendering." [2]

DIRECT DESIGN

Over the last years, there was a discussion about the possibility of using Virtual Reality technology as a design environment where design actions would be possible. This idea was based on a full immersion of
the architect in the environment projected by them. Creation and visualization of design solutions follows directly in virtual space. The architect is within the projected space, defines a direction of changes and in an interactive mode realizes these changes, moving forms in virtual space. Unfortunately, so far no software offers real-time interaction. Preparing models for CAVE or virtual goggles requires a lot of time and this Virtual Reality model can be used for evaluation only.

CONCLUSION
Correct learning by students of compositional categories, formation of creative skills, and in general mastering basic methods and ways of architectural design process is of crucial importance for the development of their creative abilities.

Our experience showed that the implementation of the new computer technologies is very promising. What is more, students prefer to work in a digital environment. When designing a façade, 17 out of 30 students began work from a sketch, in Solid form design 5 students. In the final exercise, only 2 students were using a pencil as a tool, while 28 designed directly using a computer. In Virtual Reality students experienced a better understanding of the scale of the composition than in traditional manual or digital modelling. Even a simple model without texture and shadows provides more information about the designed space. The only obstacle to the effective perception seems to be a problem with navigation in virtual space.

This does not mean that traditional models are useless. Mock-up is one of the primary ways of developing spatial imagination, avoiding mistakes when adjusting the scale of the proposed forms to the size of the environment and avoiding mistakes or illogical/impossible to construct spatial forms. Based on our 20 years of experience, we can conclude that the best pedagogical effect is achieved by the parallel use of both techniques.

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