Three-dimensional and synchronous resolution of functional and spatial aspects in architectural design

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ABSTRACT: Methods for teaching architectural design at Polish universities is the focus of this article. The authors review common methods based on conceptual drawings solving design problems in only two dimensions. After completing the sketching of floor plans in 2D, 3D virtual models are made, but seldom as cardboard mockups, to illustrate the final spatial form of the designed object. At the Faculty of Architecture of Gdańsk University of Technology (FA-GUT) the method of building an architectural concept is based on the analysis of spatial structure, functional connections and utility assumptions in three dimensions, by testing first all the ideas in the mockup structures to find adequate solutions. As the second stage of the design process, the traditional methods of 2D design are implemented to conclude the architectural task. This process of building an architectural concept first as a 3D mockup shapes students' spatial imagination: a desired ability in the architect's profession.

INTRODUCTION

The architect requires many skills in art and technical sciences, as well as knowledge of the history of culture, humanities, social and economic sciences. Academics at architectural schools are tasked with preparing the student for their future profession. The programmes in the education of architecture students are diverse and handle issues through various teaching methods [1].

There is no one leading line. Teachers experiment by searching for the optimal way to educate future architects. For example, at the University of Stuttgart, Germany, students have experimented with unusual materials to create initial concepts, such as eggs, balloons or shaving foam. This method of creating the concept was the beginning of such projects as the German pavilion at Expo'67 in Montreal or the roof over the Olympic stadium in Munich in 1972.

In Poland, architect Oskar Hansen created the teaching method called the Open Form, based on creative co-operation of the student group in a visual dialogue. Students in groups conducted visual activities through cameras specially constructed for this purpose. This method was supposed to contribute to understanding the rules of the visual language and stimulate students' imagination, as well as their intellectual abilities [1].

Experimental methods emphasising the importance of selected aspects crucial in future architectural activities, such as understanding and creating social behaviours or rules of inter-branch co-operation, are used in teaching architecture. However, in schools of architecture, the method of graphically building a preliminary concept in two dimensions by making hand sketches or using computer-aided techniques is most common.

BUILDING AN ARCHITECTURAL CONCEPT IN 2D

In teaching architectural design, two-dimensional concepts are created through commonly used methods, and then with computer-aided techniques the final models of the design objects are built in virtual space. Maria Żychowska notes that although computers expedite the design work they do not replace the creative process of shaping architectural space. The drawing helps to develop spatial imagination [2].

Andrzej Białkiewicz underlines the role of drawing in stimulating and developing space awareness [3]. This method is based on activities, applied practice and the experience of well-known architects in creating the initial assumptions of the design concept. *All of Le Corbusier's design were preceded by a* wave of drawings, *which then served as the formal foundation – not necessarily as an exact and direct reproduction* [4]; for example, the initial sketches of the Roman Catholic chapel, Notre Dame du Haut, in Ronchamp, France, became the keystones for the final project realised in France in 1955 [4] or the Composition diagram by Toyo Ito provided the design guidelines for the Bruges Pavilion in

Belgium, completed in 2002 [5]. Rough conceptual sketches were revised and modified by building a number of fragmentary paper models.

The models illustrating the final design solution adopted for the entire facility, a part of it or details were created only at the implementation stage (see Figure 1). A variation of this method is a design based on a *logo*, which is a graphical symbol expressing the compositional concept of the designed object: *Capturing them is made possible thanks to their graphic notation - an indispensable element in communicating an architectural concept* [4]. A graphical recording is not preceded by site or urban context analysis, it is a record of the creator's individual intellectual idea, characteristic for the concept being created.

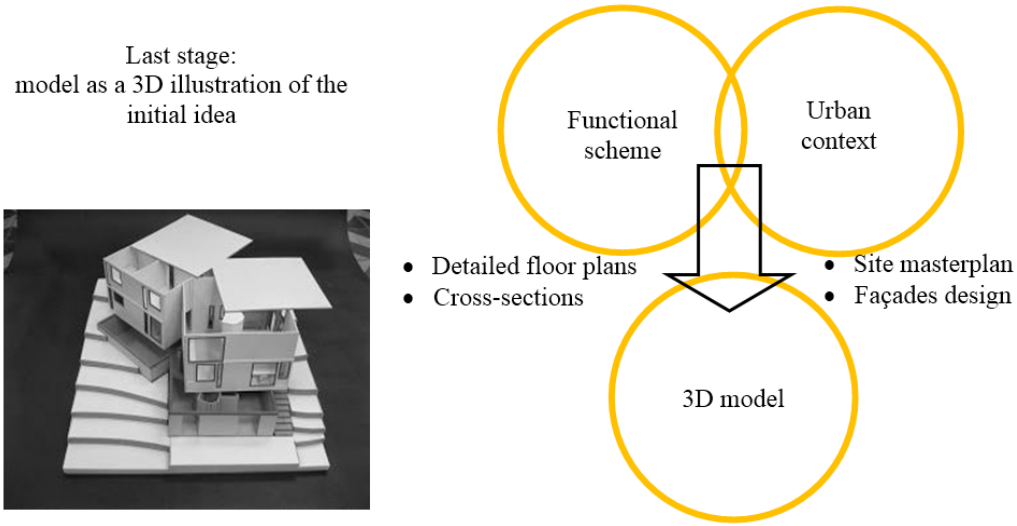

Figure 1: The order of the stages, in the traditional method of teaching architectural design: a 3D mockup is the last stage in the design process.

The graphic ideogram determines building the final spatial and functional concept of the object. Another variant of the method of graphically building the initial architectural concept is to solve individual design problems after accomplishing the programme-, urban- or historical- and landscape analysis. In practice, the basis for building an architectural concept are a detailed functional programme, including specified rooms with a specific surface and purpose, the current legal regulations, definition of the area that can be built upon, the height of the designed object and the analysis of urban composition patterns illustrated on the map, as well as the graphical ideogram if needed.

All urban, function and usage analyses, environmental and landscaping connections are studied in 2D, applying freehand drawings or computer drawings. The following stage of developing the semester project concept of the design is based on forming the functional segments of particular building floors in accordance with the assumptive functional programme and the lawful regulations.

After defining all floor plans, they *are raised* by drawing characteristic cross-sections and by designing the shape and façades, which become the result of predefined projections of individual levels and an elaborated function scheme. It is a two-dimensional design, where students solve the following stages: the urban design, floor plans, cross-sections and façades with a minimal correction of design decisions taken in the primary stages of the project. On the basis of predefined plans and sections students create a model of the final designed architectural object in virtual space using computer techniques.

BUILDING THE INITIAL ARCHITECTURAL CONCEPT OF DESIGN IN 3D

Walter Gropius believed that *Traditional training involving only drawing is inadequate preparation. Drawing and painting are undoubtedly valuable means of self-expression, but paper, pencil, brush and watercolour are not useful in developing a spatial sense, indispensable in unhampered expression. Therefore, the student should first be introduced into three-dimensional experiments ... that is, spatial composition* [6].

He justified this by saying that …*the task guiding such a training is not the improvement of professional skills, but the development of personality* [6]. He also believed that *Architect's training should take place in a concentric rather than a segmental course; its essence is the complexity and gradually increasing accuracy of the approach, the increasing clarity of thoughts and the practical information on implementation* [6].

On the principle defined by Gropius: *Three-dimensional imagery is the basic field of architecture* [6] and that the study of architecture requires teachers [who] …*Must first teach looking, perceiving distance and entering* [the] *human scale* [6]. In the Faculty of Architecture at Gdańsk University of Technology (FA-GUT), in the Department of Housing

and Public Buildings Architecture, a method of teaching architectural design was developed that consisted of the simultaneous analysis of spatial structure, functional connections and utility assumptions in three dimensions using cardboard mockups as a basic tool to recognise and understand the potential of the reshaped space. Students employ computer programs, after defining a spatial and functional concept, as a tool to illustrate their final design.

This method is applied at the FA-GUT in architectural design classes conducted at a second level, Master's degree studies. In the first stage of building the initial architectural concept, according to the theory of Professor Emeritus Francis D.K. Ching, contained in his book *Architecture, Form, Space and Order*: *…when space begins to be closed, surrounded, modelled and organized by the element of forms, architecture begins to exist* [7]. Thus students learn about the space that will be the subject of their architectural activities.

The result of this study is to build a mater-model (matrix) of the existing spatial context in which students will design a particular object (see Figure 2). Then, to start creating the initial architectural concept, they base their approach on principles defined by the architect, theoretist and professor, Juliusz Żórawski, who said architectural design is based on subsequent tasks and *…these tasks will always consist in adding new parts to the already existing unity* [unified whole] [8].

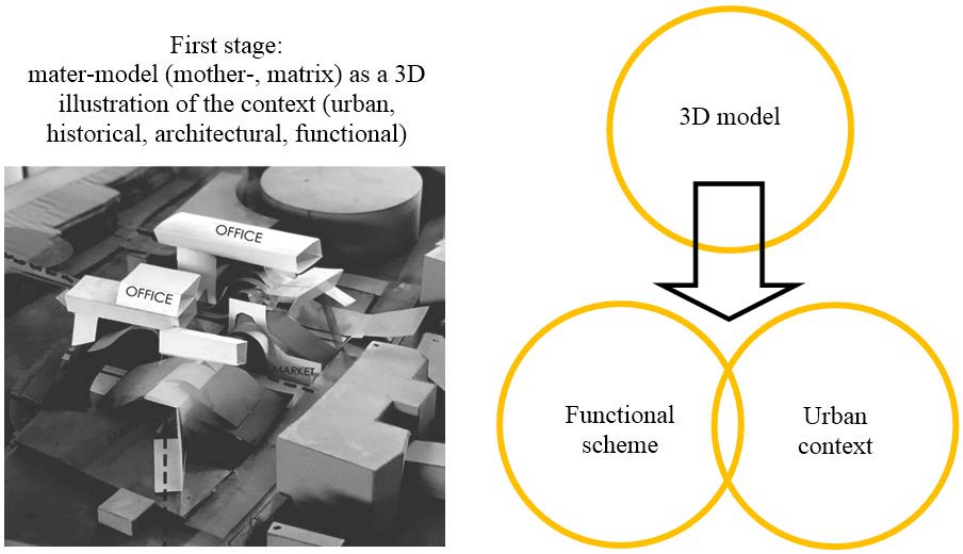

Figure 2: The stages in the synchronous method of teaching architectural design: 3D mockup as the initial stage in the design process.

At this stage students look for an answer to the question: *what spatial form suits the existing spatial and functional context of the selected location which is the subject of the semester project?* According to Żórawski: *The form depends on the unity, in which it should appear* [8].

In searching for the answer to this question, students insert further spatial proposals into the previously made mockup. These are synthetic models that illustrate the compositional idea as the reaction to the particular space. Thereafter, from the several proposals presented by the students one of the concepts - that best suits the existing spatial and functional context - is chosen for further elaboration, while, as Żórawski claimed: *…form depends on the relations of the parts with respect to the unity* [8].

The selected mockup contains compositional assumptions not only regarding the form of the designed object, but also façades and urban context connections. Simultaneously students continue functional and usage analysis of the existing environment, searching for a reasonable response to the question: *what usage would be the most appropriate for the designed object?*

While making a decision on the function of the designed object, which may become a public building, administration, hotel, and so on, and following the records included in local development plans and current building law, students determine the number of storeys, as well as their height dependent on the purpose of the storeys. A cross-section sketch is created to illustrate the number of possible usable levels contained in the adopted spatial concept considering the spatial law indicators.

To advance the project, students must determine the most adequate location of the particular usage zones, according to the already evolved form of the building. The students sketchily arrange defined groups of specific function rooms, working on all levels, and controlling their relations in 3D space.

At this stage, students implement blocks of staircases and lifts in optimal locations for the designed usage, as well as the functional and spatial connections. The spatial composition of the form of the object, recorded as the synthetic mockup, is an overriding priority in all stages of the project. Since students define the general functional and communication

scheme for the paper model, they then detail a particular solution in floor plans, cross-sections, façades and site plan development (see Figure 3). Also, at this stage, students are allowed to support their designs with computer techniques for developing the aesthetic expression of the ultimate façades, visualisations illustrating the designed spatial solution in the existing context and the graphic design of the poster presentation (see Figure 4).

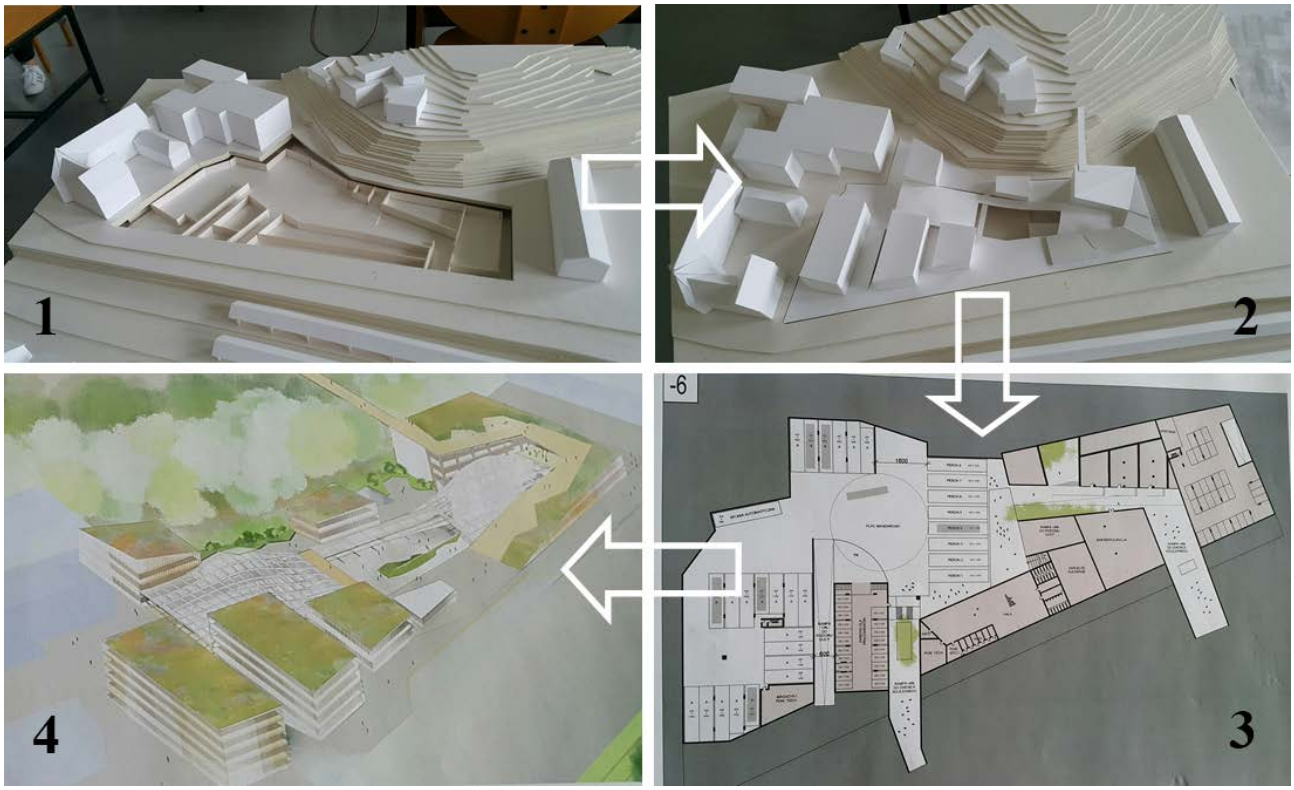

Figure 3: Results of the synchronous method of teaching architectural design: 1) matrix model of the site and its context. 2) mockup as the initial stage of the project development. 3) floor plans with details. 4) axonometric presentation with suggested façades and landscape solutions.

Figure 4: The final public presentation of the students' semester projects, with the 3D models of the designed buildings embedded in the matrix model.

METHOD LEADS TO LEARNING: WHAT STUDENTS MUST KNOW

Students learning how to design, and invoking Gropius, must understand the process *should be based on comprehensive solving of architectural problems in space;* in other words, it suggests the building of an initial spatial concept using a three-dimensional creation. Architectural design as taught through the methods applied at Gdańsk University of Technology is a process of three-dimensional and synchronous resolution of functional and spatial matters supported by constructing cardboard mockups. A list of relevant points for students is shown below.

The design process in architecture: summary	
a	The spatial concept of the designed object depends on the existing spatial and functional context.
b	The spatial concept of the designed object complements the existing spatial context.
c	In architectural design the prime value is the spatial composition that suits the existing built-up context and increases the value of the designed place.
d	The functional solutions and relations between them may be properly designed in multi-variant options adapted to the accepted spatial form of the designed object.
e	There are functional dependencies in the space of a specific solid/object.
f	In designed space there are places that are most adequate for particular functions.
g	The location of vertical communication and installation units depends on the adopted spatial concept included in the mockup.
h	The division of rooms in functional segments is multi-variant, ancillary to the adopted spatial concept embodied in the paper model.
i	It is necessary to find the interrelations between the floor plans and the concepts of the façades, at the stage of a synthetic paper mockup.
j	Project development and elaboration based on the mocked-up building allows the grasping of the proportions between the existing context and the planned spatial form.
k	Building a 3D computer model in the initial design phase impedes students properly grasping the scale of the designed object in relation to the existing urban and architectural context.
l	It is easier to adapt a designed spatial concept to the current law guidelines by using their correct interpretation in a 3D context.
m	In observing the 3D mockup relations and construction, it is pertinent to select the adequate structural and installation systems for the adapted spatial form of the designed object.

CONCLUSIONS

All methods of the architectural design teaching mentioned in this article are applied with varying intensity in Polish architectural schools. All of the teaching processes were conceived to prepare students for the future profession of architect, which is multi-faceted with high social responsibility [9].

In Poland, it is a profession of public trust. An architect to a great extent is responsible for the urban and rural spatial order, so the task for teachers is to teach a student to comprehend spatial issues and to learn and interiorise the principles of their formation, as the impact is large on a city's future image. Students regularly are invited by city authorities to present in urban or architectural competitions [10] their visions for future development of particular city districts, and they are expected to use 3D mockup methods.

As said above, students' learning of design, which echoes Gropius, should be based on the solving of architectural problems in space. That means the building of an initial spatial concept is first presented as a three-dimensional object. The methods of teaching architectural design at Gdańsk University of Technology include the three-dimensional and synchronous resolution of functional and spatial matters supported by the constructing of cardboard mockups. In the process, students learn a set of related rules that guide the achieving of a satisfactory outcome.

Students build an architectural concept by first analysing spatial structure, functional connections and utility assumptions in three dimensions. These are tested in mockup structures to find the best solutions for the design. The second stage of the design process is where traditional methods of 2D design are implemented so as to complete the architectural task. Thus, by building an architectural concept first as a 3D mockup, students' spatial imagination is shaped and this is most certainly a desired ability in any future architect.

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