METHODS OF TEACHING PARAMETRIC DESIGN
FOR ARCHITECTURAL STUDENTS

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Abstract
The aim of this paper is to introduce the teaching method utilized in teaching architectural students to parametric design at the University of Pécs in Hungary. This is a special subject for various reasons. First of all, this is a special kind of architecture, and although it is not commonly used in architectural practice, the students show increasing interest in the topic. On the other hand, using parametric design requires skills and capabilities, which are not commonly necessary for architects, that is why the preliminary subjects do not cover them.

The aim of the research was to develop a course which would help students understand and utilize the way of parametric thinking and discover the possibilities given by parametric architecture, while they also acquire the necessary digital and logical skills, and learn to use a parametric software. During the years this course have been taught, different teaching methods were tested with different success. It was studied, which solution is the most useful to provide the theoretical knowledge of programming, data management and mathematics to architecture students, who are not familiar with the first two topics. The teaching of parametric thinking is the most crucial part of the curriculum, and the success of the actual method is clearly visible, when the students have to solve problems on their own, or they have to define a task which requires parametric tools to solve.

The current curriculum of the parametric design course covers the basic theoretical and practical knowledge that is necessary for students to use parametric tools through the architectural design process and helps their engrossment in this field of architecture. This gives the students a unique knowledge on the labor market and a different point of view compared to what they used to see during their education, and also helps the spread of parametric architecture.

Introduction
Parametric design is a new field of architecture, it requires new capabilities from architects, and teaching parametric design constitutes new challenges for teachers.

The subject which covers parametric architectural design was called at the University of Pécs “Parametric constructional design”, “Parametric design” or “Constructional skills (parametric design)” in the different semesters. It is obligatory for students on Architecture MSc and Architectural Art MA majors and optional for bachelor students. Master students learn parametric design in the first semester of their master studies. The applied softwares are Rhino 3D and Grasshopper, which is a plugin for Rhino.
Fields of knowledge

The knowledge what this subject should cover and deliver to students can be divided into three main fields. The first of them is the application of parametric design softwares. The second main field of knowledge is parametric design thinking, which is the cognitive model of the design process [1, 2]. Finally, there are some theoretical knowledge from different scientific fields, mostly from mathematics and computer science, which is necessary for students to be able to apply and understand parametric design, but the architectural curriculum does not cover them. The education method is based on the combined teaching of this three main fields, and the parallel teaching of practical and theoretical knowledge.

Parametric design thinking and using parametric design tools

Architects, engineers and designers still keep changing the definition of “Parametric design thinking”. According to Oxman, this change is fundamentally based on the changing and evolving parametric design tools, and on the ways how designers use them. [1] This means that how the tools and abilities of designers change it changes their definition of Parametric design thinking. The same process is noticeable by the students, who start to learn parametric design. As they use parametric design tools and practice the application of parametric softwares their ability to understand and apply parametric design thinking evolves. Because it lays out the basics, it is of extreme importance for students to be able to apply parametric design thinking, but it is impossible without using parametric design tools. Teaching the application of parametric design tools without the theory of parametric design thinking is possible but pointless, and it results that students can use the tools themselves but they cannot exploit the opportunities of this design tool. This demonstrates clearly the close connection and inseparability of using parametric design tools and parametric design thinking, and shows that the teaching of the application of parametric design softwares and the theory of parametric design thinking have to be parallel, continuous and related.

Cognitive models: architectural design vs. parametric schema

Students learn the way of design thinking in each and every semester of the university, for years before they know parametric architecture. They learn how to use their creativity to solve architectural problems and create spaces and buildings. They learn the method of evolution, reflection and re-editing and they identify it as a creative and impressive process. At the University of Pécs students are not allowed to use computer softwares for architectural design in the first two years, because teachers want to avoid, that the rules and boundaries of these softwares limit the creativity of the students. They solve every task with the modification and adaptation of their typological knowledge [1]. By using parametric design and making the parametric scheme of a building they have to design a rule structure [1], and for the first sight it seems to be the complete opposite of what they learned for years. Students have to think in rules, formulas and schemes, and it looks like that this design process neglects creativity. However, the creative process of parametric design is the creation of the rule system, the parametric scheme itself. The first step of teaching parametric design thinking is the demonstration, that the design effects the rules and not the rules effect the design. During this course the students have to learn how to design a rule-based system instead of an experiment-based design, what they learned to create in the previous semesters [1].

Education method

The setup of the schedule of this subject is separated into two segments or half-semesters. In the first one students learn the theoretical and practical basics of parametric design. They build a parametric model together at every class, and every one of these models is destined to demonstrate specific problems and solutions. In the second part of the semester students solve an individual task on their own
or in pairs. It helps them engrossment in parametric design, tests and evolves their ability of parametric design thinking.

Exercise models

The education method is based on the combined teaching of practical and theoretical knowledge. Students attention is usually reduced, if they have to learn a bigger amount of theoretical knowledge at the same time, especially, if they think, it is not necessary for their practical work. Moreover, architectural students are often afraid of mathematics. Because of these it is not effective to teach the theoretical knowledge first, and practice later. For this reason, during every class the students make a model, they learn how to use the software and meanwhile they learn, how to solve a specific type of problem, and what theories are behind them. The exercises are selected from the book of Arthuro Tadeshi [3] and from various internet resources.

![Figure 1. Class tasks. Rotating tower and freeform truss-grid structure.](image)

Every exercise is started with the determination of the goal. It is a very important step in the education process, because it helps students to think on the solution and improve their skills of parametric design thinking. During the presentation of the exercises the exhibition of parametric design thinking is continuous. Before the start of the exercise solution it is necessary to define the bigger logical steps of the solution. Making this together with the students helps them to acquire this type of solution searching method. Without the targeted teaching of parametric design thinking students often just copy the exercise, and they cannot develop an overall image about the current problem and solution.

After defining the tasks, the production of the actual solution is the next step. This is the part of the exercise, where students learn the practical knowledge, how to use the software and its particular commands. On most classes there is a part of the exercise, where theoretical knowledge is necessary, which students never learned before or they already forget it. This theoretical knowledge can be come from the fields of graphs, intervals or data management. In this case the theoretical education appears like a part of the practical problem solving. Students learn the new knowledge and they immediately learn, how to use it.

Some of the class tasks are architectural examples, like the rotating tower and a freeform truss-grid structure (see in fig. 1.). During making the rotating tower students learn how to use series, domains, graphs and the data management, and to design the truss-grid structure they have to use meshes and understand how the surfaces’ UV-coordinates are used. Other exercises introduce useful design solutions, which are specific to parametric design, like force field and Voronoi diagram (see in fig. 2.).
Individual tasks

After the sample exercises the students have to accomplish an individual design task, which helps them to learn the creative process of creating a parametric schema. Choosing the task itself is a challenge for students. The selection of a right exercise indicates clearly if the students understand parametric design thinking and if they can recognize in which tasks can it be helpful for them. During the design process the students can experiment and evolve their ability of parametric design thinking, they learn to use the right tools, and utilize their possibilities. As their individual task students can create complex building designs, using their previously learned architectural design knowledge and the newly acquired parametric design thinking together (see in fig. 3. and 4.).
Summary and conclusions
The introduced teaching method leads students into the world of parametric design. They learn the basics of software application and parametric design thinking through the class exercises. During the creation of an individual design task students can dive in the parametric design. Students are interested in this new field of architecture and they see the new possibilities of this evolving design tool. After the course the students are able to create a simpler parametric schema and they possess the knowledge to be able to improve their parametric capabilities.

Acknowledgment
This research is supported by the ÚNKP-17-3-IV New National Excellence Program of the Ministry of Human Capacities.

References