sciendo RIGA TECHNICAL UNIVERSITY
Architecture and Urban Planning
10.2478/aup-2019-0013
2019 / 15

Parametric Design Concept in Architectural Studies

Vytautas Baltus, Tadas Žebrauskas, *Kaunas University of Technology*, *Kaunas*, *Lithuania*

***Abstract* – Architectural studies in Kaunas University of Technology shift towards implementation of BIM concept-based approach in design modules, which suggests the use of related software (Revit, ArchiCAD). Implementation of parametric design (3ds Max, Cinema4D) related subjects in the study process is in alarming situation because of the University's and even national policy. Nevertheless, its wide usage, at least in the visual presentation of architectural projects, strongly suggests that graduates need to have knowledge of these technologies as it is often required in the general practice. However, the different concepts of BIM and parametric design modelling practice makes the study load too heavy for the students. Thus, it is vital to find a balanced solution for both of these subjects to be presented equally during architectural studies at the University. The aim of this paper is to analyse the opportunities and challenges of introducing parallel learning of both software.**

***Keywords* – Architectural studies, BIM modelling, parametric design.**

Introduction

Architectural studies at Kaunas University of Technology are gradually moving towards very practical approach: developing BIM technology skills, solving problematic tasks, bringing them closer to real-life situations. Very often the tasks are provided by social partners, thus they tend to be very pragmatic. That, on the one hand, brings students closer to real practical experience, but on the other hand − is limiting sovereign creativity. Moreover, when taking a quick overview of Lithuania's architectural context, it becomes clear that there are still not many (if any at all) examples of pioneering parametric architecture, and the architectural studios still find themselves working in a traditional way, reluctant even to accept BIM usage. Nevertheless, a new generation of so-called digital architects are exploiting the potential of parametric form-generating software to design buildings, or at least "pet architecture" objects, that could not even have been conceived without CAD systems [1, *185*]. And Parametric modelling skills, if developed during the studies, might help not only in stimulating architectural creativity, but also enhance students' visualization and representation techniques, which are an important aspect of any visual design-based discipline, which encourages ways of representing ideas that are both exciting and challenging [2, *5*]. Visualizing skills are valued by architectural studios and help graduates to negotiate better position in the market. Thus, implementing study modules which focus or at least obliquely pay attention to parametric design, modelling and visualization techniques is an important choice for University's Architectural studies program to keep it up-to-date.

I. Description of experiment

BIM and parametric design based software is very different in its approach and logics of modelling [9], [10]. Thus, while students at the University are prepared for real-life practice, it is generally understood that it is more important for them to learn BIM related programs. These, to name most relevant and popular, would be Revit or ArchiCAD. Meanwhile, most common professional visualization or animation software, which ground their modelling as parametric, used in the field are either 3ds Max or Cinema4D. They still do not carry all the parametric load making it necessary to add supplementary plug-ins such as Forest Pack, RailClone and FloorGenerator, not to name final editors of materials and lighting − rendering engines as V-ray or Corona. Thus, mastering all of these different instruments is something similar of mastering performing music on different instruments and it is definitely very hard to achieve affirmative results at once. Parametric design takes even a step further from the conventional generation of form (if we take a traditional imagination when the author conceives an idea in his mind and puts it on paper with the help of pencil and ruler) − it operates with the help of algorithms, connected nodes, etc., which is very different from sketching, visualizing, conceiving a form by traditional means.

Thus, it is standard perception that there should be a logical system of teaching how to gradually master software during architectural studies. It is commonly accepted that at the beginning it should be concentrated on mastering "simpler" BIM software such as Revit or ArchiCAD, later moving on to 3ds Max or Cinema4D with all of their vital plug-ins. However, this leads students to certain problems. Revit and ArchiCAD allow one operate with ready-made objects: walls, windows, doors, etc. They are predesigned, put into libraries and ready to use. That kind of very practical approach aimed at professional work makes it much easier, but for the beginners (1st semester students) it often results in a contrary outcome − it simplifies their creative designs to the software suggested elements composition (Figs. 1, 2, 3). On the other hand, 3ds Max lets one operate with simple geometrical forms (boxes, planes, lines, etc.) and has no prefabricated elements. It takes much more time to design a window or a wall itself, than to use a pre-made one, but it also forces to think about its design, its materials and construction more deeply (Fig. 4).

The suggestion to start with BIM courses is based not only on the fact that there are differences between software logics. It is also due to the position of the official study course of the school and even nationwide politics. There is a Regulation that from 1 July 2020 all architectural projects in Lithuania should be BIM prepared [13]. Though it is not clear whether it will apply to all projects or just the public segment, the trend towards digitalization of civil engineering and architecture is obvious. For architecture schools to be ready for this challenge, BIM based design courses and related software takes a privileged position rather than parametric design.

Decent BIM modelling of the building this way requires a lot of knowledge about construction and building practice, materials

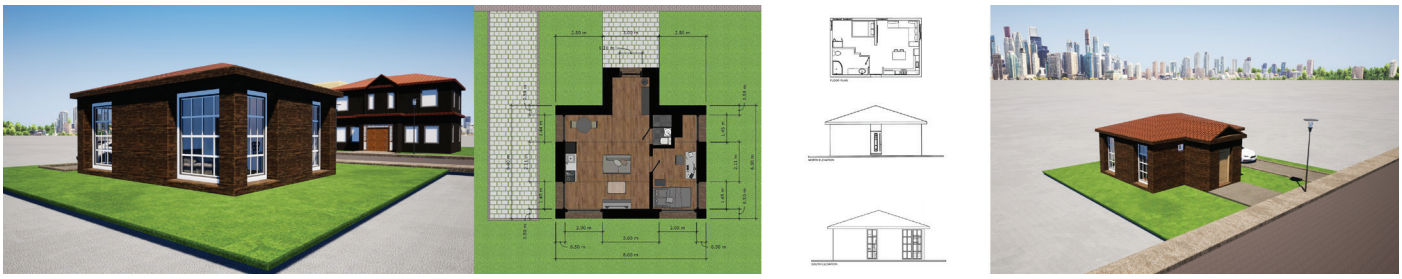

Fig. 1. Student E. Ogulcan's first design proposal made with Revit illustrates use of software suggested simple graphical representation and use of standard library elements [Figure: V. Baltus].

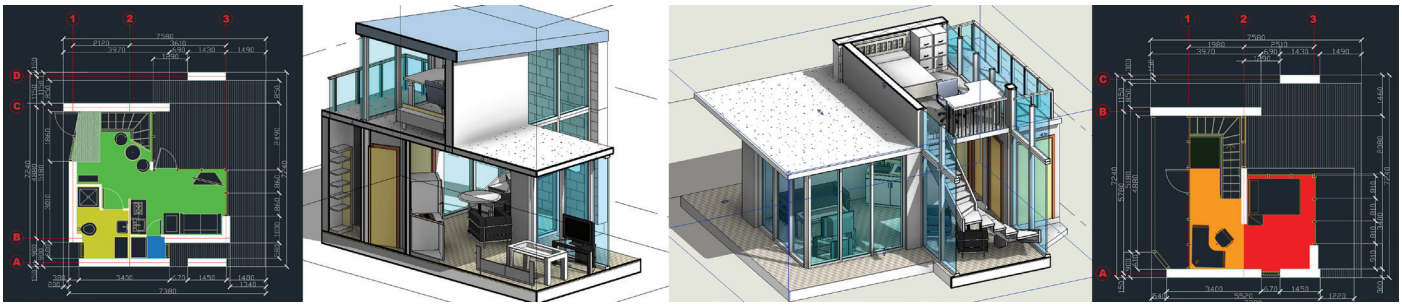

Fig. 2. Student T. Zykevicius' first design proposal made with Revit and AutoCAD searching for more artistic graphical representation, still based on software suggested solutions [Figure: V. Baltus].

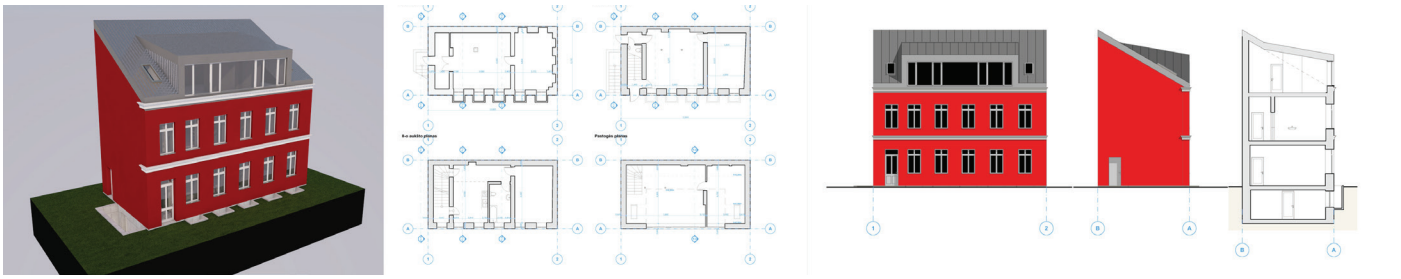

Fig. 3. Student T. Zykevicius' second design proposal made with ArciCAD indicates positive effect of BIM technologies, allowing even a 1st semester student to present project in decent architectural graphics. Still, architectural design is very simple, and obvious lack of materiality is noticeable [Figure: V. Baltus].

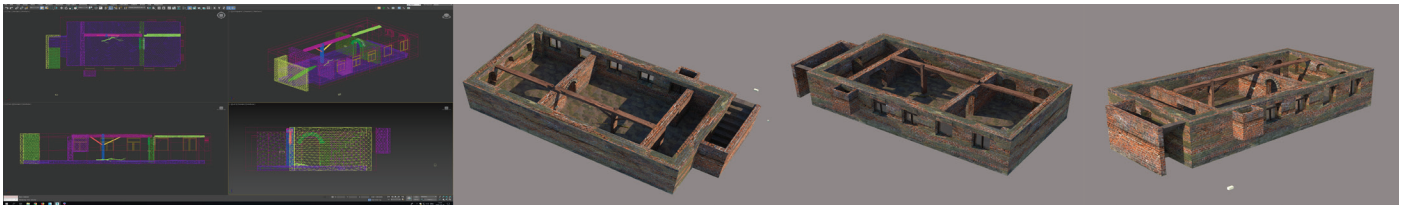

Fig. 4. Student T. Zykevicius' second design proposal (only basement floor) remodelled with 3ds Max simple geometry allows much more artistic understanding of building construction, its materials and, its materials and structural elements [Figure: V. Baltus].

and even legal technical requirements, which, for the first year students are still unknown. As indicated in Fig. 5, Architectural Materials course is taken at the same time as CAD Design 1 and Architectural Experiment 1 when studies in the first semester begin, and Structures of Dwelling Houses are studied in the second semester. Thus, a lot of possibilities of ArchiCAD are left behind if not forgotten during the years and full software employment capabilities are limited just to create a simple 3D model in the best case, or in the worst – just to prepare technical 2D drawings.

The first decent use of the whole BIM technology is taking place only in the 3rd year of studies during Joint Project module, when students from different study programs, such as Architecture, Civil Engineering, Building Services, Engineering and Electrical Engineering, work on the same, very down-to-earth, and very practical project straight from the beginning to the end and exchange information by the help of BIM file formats (as .ifc). This course is the supreme goal of BIM technique deployment during Architectural studies at Kaunas University of Technology.

Subjects

	Year 1				Year 2				Year 3				Year 4				Year 5			
Obligatory	Architectural Experiment 1	12	Architectonic Development 1	12	Architectural Experiment 2	12	Architectonic Development 2	12	Architectural Experiment 3	12	Critical Analysis of Architecture	6	Urban Planning 1	12	Urban Planning 2	12	Research Project	18	Master Final Degree Project	30
	CAD Design 1	3	CAD Design 2	3	Innovative Materials	3	Engineering Systems of Buildings	3	Joint Project	6	Economics of Spatial Decisions	3	Space Syntax	6	Urban Theory	6	Sociology of Spaces	6		
	Architectural Materials	3	History of Architecture	6	Stuctural Solutions of Public Buildings	6	Theory of Architecture	6	Sustainable Architecture	6	Practice of Architectural Design	18	History of Urbanism	6	Sustainable Urbanism	6	Optional	6		
	Introduction to Architecture	6	Structures of Dwelling Houses	3	Typology of Occupants	3	Typology of Spaces	3			Spatial Legislation	3								
Optional	Media Philosophy	6	Academic and Technical Communication in English	6	Building Physics	6	Cultural Heritage	6	Construction Technology and Organization	6			Territorial systems	6	GIS for Territory Planning	6				
	Sustainable Development	6	Languages	6	Interactive website Systems	6	Parametric Animation	6	Parametric Installation	6			Virtual Reality Generation	6	Virtual Reality Activation	6				

BIM related subjects

Parametric design related subjects

Fig. 5. BIM related and parametric design related study subjects in KTU Architectural study program. Author V. Baltus.

Joint Project course tasks would be impossible to accomplish with the parametric design designated software 3ds Max or Cinema4D, because they have a completely different purpose, not only graphical but also algorithmic logics of designing, are not meant for this task, and are even not relevant to architecture. They are still more design-oriented programs. Thus, though deepening skills of BIM software during all the study years is a vital factor, parametric design software right at the beginning of the architectural studies might lead to a different level of creativity and whole development of ideas [9]. For example, leaving aside all the technical data information about thermal conductivity and concentrating only on design, not specifying whether it is a wall, slab, roof or anything else, but working on geometry with the help of such 3ds Max tools as Line, Box, Circle or Sphere is comparable to hand drawing design. Moreover, many architects are facing problems when switching to 3ds Max after they have mastered any BIM software, as there is no opportunity to determine precise measurements, intersection points, etc. Limitation to evaluate the drawing by visual form is quite an obstacle to overcome for an architect-shaped mind attached to the idea of being able to place objects exactly down to the level of millimeters with the dimensioning system and coordinates. For the creative thinking, not having that attachment might be an advantage.

The other obstacle of single usage of 3ds Max in the studies is its incapability to produce technical drawings. The software anticipates users to be satisfied with the final result provided as pictures or animations. Thus, while being a powerful tool to boost students' creative potential, conceptual (synthetic) and refined sketching [3, *463*], it suggests that technical skills of drawing making must be developed elsewhere (ArchiCAD, Revit or even AutoCAD). And while it can export to .dwg, it would need a clean-up. On the other hand, creating, for example, a window, door or roof form in 3ds Max from simple geometrical tools (Lines, Boxes etc.), later individually assigning materials to them, is way more liberating than choosing a prefabricated (even if it is possible to exhaustively modify them through settings) door, window or stair object in ArchiCAD. Analysis of Architectural Design course projects during more than ten years at Kaunas University of Technology shows that use of 3ds Max logics leads to much more freedom and creativity in design. While students, who are using BIM software tend to limit their designs to the building objects and materials database resulting in a standard solution, and simple designs, which are easily manageable and composed of ready-made software proposed components. Due to this BIM approach, any sophisticated design ideas are left behind. In other words, software often influences final design too much, leaving creativity of the author only the minor role or suggesting prefabricated solution. Here parametric design might liberate students and help them to develop more intriguing results and artistic architectural design solutions.

So, if nowadays, sketching by hand at the idea development level sometimes is seen by students as an obsolete and archaic way to work (while this point of view is not supported by the majority of teachers, but due to extinction of hand drawing courses there is no way to counter that argument), other tools are used to improve how architecture is represented visually [4, *7*], e.g. 3ds Max software might succeed in this case. If imagined as a tool, as a three dimensional "pencil" free from limitations of BIM prefabricated library can help to "sculpt" very intriguing and free form that is unrestrained by the conventions [5, *140*]. The abundance of possible parameters (so called "Modifiers") to be used for that kind of sculpting a building in 3ds Max is vast. Any geometry can be modelled, animated and presented visually. Going further, almost all of this geometry can be further modified with even more complex parametric plug-ins such as RailClone, which, due to algorithms, is possible to be changed by few simple alterations of nodes and can bring in non-repetitive, individual and unlimited in scale design results, which would otherwise require a tremendous amount of reiterating technical work in BIM software.

Solving the question of the organization of studies, it was always considered problematic that both BIM and parametric modelling can be fully comprehended and understood by the students if taught at the same time, leaving an open question, which should be taught at first with appropriate attachment of it to relevant design tasks. On the other hand, researchers consider that integration of both approaches in the design process will allow to benefit from both [11]. Experience in various architecture study programs indicates, that previously study process concentrated on starting with learning BIM related software, so called, basics of architectural graphics and representation and only later, just as an Optional subject, moving to parametric modelling. Students usually learned it on their own. As an experiment, this academic year (2019), undergraduates of Kaunas University of Technology Architectural studies, besides typical curriculum subjects (including Revit and ArchiCAD) are also supplementary taught to master 3ds Max software from the beginning in their Architectural Experiment 1 course. It is anticipated that such a diversity of spatial practice would encourage and assist in rediscovering architecture itself [6, *5*].

Standard and reliable tasks during this subject traditionally were:

1. an analysis and redrawing of famous contemporary architectural building;
2. analysis and redrawing of inter-war period modernism architecture house in Kaunas;
3. design and presentation of small-scale object near the previously analysed inter-war period house.

It is the 3rd task that aims at introducing parametric modelling with 3ds Max. It is planned and anticipated that students will use parametric design and modelling solutions in their previously hand-drawn propositions. When still learning simple CAD tools for technical drawings and presentation, they will be urged, but not obliged to convert and update their traditionally designed small-scale objects using 3ds Max parametric modelling. Again, in order to present it as technically required they will shift to regular CAD technique. The outcome of this experiment is yet not clear, but high hopes are given to more contemporary nurture of students' architectural design skills. On the one hand, it might seem as double work and load, but it is also noticed that younger generation appreciates these technological challenges way easier than might be expected. Other important point to be verified is that design of imaginary, conceptual or radical buildings [7] with the help of parametric modelling is probably best to be carried out exactly in the first year of studies, later concentrating on much more technical BIM elements and solutions. In order to justify this hypothesis, the student survey was conducted. The readiness to start mastering both software during the 1st year of studies was affirmed by majority of students (from the 1st to 4th year of their studies, 20 respondees). 85.7 % of them are ready for the challenge of master both technologies and related software at the same time and think that it should be taught during the 1st and 2nd semester of their studies. None of the respondees found it worth to learn gradually more complicated software in later periods of their studies. Still, equal results (50 % / 50 %) were submitted regarding which technology (BIM or parametric modelling) seems more important for them to be taught during studies to better get ready for a real-life practice. But the fact, that the issue of troubles when designing unique objects with BIM related software was obvious for 100 % of respondees, and that 71.4 % agreed that BIM technology limits their creativity just proves the necessity of more creative technology implication during studies. This would likely imply concepts heretofore unsuspected in all that refers to the static nature of space; to the materialization of structures; to variation of shape [8, *166*]. In the visual world of architectural education, message (design) and language (graphics)
are so interrelated that they cannot be separated. The design process always includes graphic skills to clarify and communicate the issues in question. The primary type of communication in any kind of design work is drawing. To communicate design ideas to others, one must draw (render) with enough facility to make ideas clear. Furthermore, one needs to be able to communicate graphic ideas to ourselves because as working on any design, ideas are constantly changing and evolving. The language of graphics requires the use of all aspects of the brain − analytical, intuitive, synthetic, and even emotional [3, *ix*]. Continually striving to come up with new ways to represent and express design is not meant to dogmatically lead into a narrow path of particular software, instead the goal is to encourage students to start their own journey of discovery and exploration.

Conclusions

Students might well pass all their study subjects mastering on BIM software, and later on, even in professional practice to limit themselves to an artisanal fashion, but adding parametric modelling as another one, completely different in its approach, would escalate their creative potential and could result in more creative compositions. And this idea keeps its pace with a notion that the progression of architecture towards advanced one means that new construction way is information modelling.

Architectural studies previously had taken parametric design and modelling courses as advanced knowledge and thus to be implemented only in later study courses, in the first study years concentrating attention to BIM related tools. Contrary to this opinion, an experiment is carried out in Architectural study program at Kaunas University of Technology to introduce modelling practice with the help of 3ds Max software to undergraduates during their first Architectural Design course. Hypothesis that the work overload and simultaneous teaching of two different concepts and approaches to design will be a challenge were denied because enthusiasm of young students proved to cope with technological issues easily. Also, survey data proved that students are ready to paralelly master both software from the beginning of studies. Currently, the process shows that the decision to conduct an experiment was right and allows Architectural studies to keep pace with technologies.

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Vytautas Baltus (Kaunas, 1979) received the degree of Master of Architecture in 2003 from Kaunas University of Technology. He has been a lecturer with the Faculty of Civil Engineering since 2008.
His current research interests include BIM software, parametric modelling, and architectural design.

Tadas Žebrauskas (Kaunas, 1969) received the degree of Bachelor of Design in 1994 from Vilnius Art Academy. He has been a lecturer with the Faculty of Civil Engineering and Architecture since 1994. His current research interests include architectural design and composition, and drawing.

Contact Data

Vytautas Baltus
Faculty of Civil Engineering and Architecture
Kaunas University of Technology
Address: Kaunas University of Technology, Faculty of Civil Engineering and Architecture, 48–309 Studentu Str., LT-51367 Kaunas, Lithuania
Tel. +370 606 30306
E-mail: vytautas.baltus@ktu.lt; vytuko@gmail.com

Tadas Žebrauskas
Faculty of Civil Engineering and Architecture
Kaunas University of Technology
Address: Kaunas University of Technology, Faculty of Civil Engineering and Architecture, 48–309 Studentu Str., LT-51367 Kaunas, Lithuania
Tel. +370 618 32820
E-mail: tadas.zebrauskas@ktu.lt; ztadasz@gmail.com