Impact of Digital Design Methods on Physical Performance

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Abstract. *This paper deals with relationship between the digital and the physical on the basis of retrospective of previous eCAADe conferences and the author's didactic experience. In order to show a scope of issues, different methods and tools are described and analyzed. Author believes that described approach may contribute to the ongoing discussion on recommendations for CAAD teaching. Reflecting the conference theme, author poses the question whether digitality can be identified as intangible physicality.*
Keywords. *Digital design theory and methods; digital architecture; integrated design; teaching strategies.*

INTRODUCTION

This year we are celebrating the 30th eCAADe Conference. The conference title *Digital Physicality/ Physical Digitality* clearly defines the current stage achieved in the information and communication technology and CAAD. It might be considered as a significant milestone on a "long and winding road" we have been passing over these years. What is more, the themes of last four conferences: from the *architecture in 'computro'* in Antwerp (2008), through *Computation: The New Realm of Architectural Design* (2009 Istanbul) and *Future Cities* in 2010 in Zurich to *Respecting Fragile Places* (2011 Ljubljana) seem to support this statement. Digitality is not a tool anymore, on the contrary, it has fluctuated towards "intangible physicality".

A BRIEF RETROSPECTIVE OF CAAD

Celebrating the 30th anniversary is a good opportunity for a retrospective overview of ideas development, concepts evolution, and technological progress. Through these years some schools have become leaders followed by the others. Some schools have specialised in particular domains while other offered general introduction to the vast variety of CAAD aspects. Despite these developments, "*the field has changed little in the course: ambitions, goals and means remain largely unchanged since the early years. What has been changing is the position of the area relative to architecture and building in general, both in academia and in practice. This has led to changes in the internal priorities of CAAD, especially in teaching. A critical examination of the strengths and*

weaknesses of the area leads back to the fundamentals of computational design. These are more important than ever, despite, even because, of the broad adoption of computer-aided tools because they determine not only the true character of the area but also possible scenarios for new directions for CAAD research and development" (Martens, Koutamanis, Brown, 2007).

This brief retrospective recollects the time when introducing CAAD started with teaching how to use a mouse and click left or right button intuitively. The digital aids to architectural design process seemed to be more an obstacle than facilitation. There is a famous cartoon by Roger Penwill, illustrating early use of computers in architectural practice: it presents a designer working at a large drawing table using a pencil and a drawing rule, and the computer is used as a chair... [1]

In this context it seems crucial to look back at some of the previous conferences themes which, starting from 1982 in Delft, have been reflecting advancements in digital technology and, what is more, its stronger and stronger influence on education, research and practice. Moreover, the technology has been forcing us to lifelong learning in order to keep up with brand new discoveries, research and applications. In the 1990s CAD curriculum and computer craftsmanship in architectural education were settled. The conference in 1994, entitled *The Virtual Studio,* introduced the concept of "virtual" for the first time in a way that the main lecture hall hosted the "real" presentations while an identical lecture hall located directly below, hosted the "virtual" presentations relayed simultaneously in sound and video from "above". Then, in Palermo (1995) multimedia potential power was broadly explored and discussed. In 1997 (eCAADe conference in Vienna) another shift was observed through focusing on *Challenges of the Future*. In consequence, topics such as a digital design process, spatial modelling and collaborative teamwork evoked in the context of new directions for computation in design profession. Two years later, during the eCAADe conference *Architectural Computing: From Turing to 2000* hosted by the University of Liverpool, the evidence of a radical change in the nature and goals of CAAD education and research was emphasized. At the beginning of 21st century the terms Building Information Modelling (BIM) and Architectural Information Management were already adopted and applied in practice (eCAADe conference in Helsinki in 2001). It has passed exactly ten years since the conference in Warsaw took place. Its main theme *Connecting the Real and the Virtual* underlined duality of physical and digital design worlds. The question provoked a discussion how these worlds could be effectively and creatively inter-related. Only a year later, the eCAADe conference in Graz, became a forum focusing on virtual and augmented reality as well as spatially immersive real-time environment as a tool for designing, communicating and collaboration. A further search for the place and role of digital technology in a design process became a focus of the eCAADe conference *Digital Design: the quest for new paradigms* which took place in Lisbon in 2005. Two years later, editors of the *Predicting the Future* conference proceedings stressed that the virtual environments had become quite enough close to reality that it was possible to predict the performance of a project prior to its execution. At the same time, authors emphasized that it was difficult to predict which direction the technology would develop in the future. Principally, because "*the future does not »just happen«. It needs shaping by people with ideas, people with visions and people working hard in research*" (Kieferle, Ehlers, 2007).

So, through these years we have come up to the stage where distinction between real and digital has become pointless since information and communication technology has embedded in the physical world and sunk into it deeply (Brown, Winchester and Knight, 2008). It is observed in everyday life since development of multimedia influenced the perception methods of contemporary generations, who absorb knowledge in a different way than their predecessors. Linking various media and digital imaging forms a modern source of information broadcasted to people, whose imagination is being shaped by mass media, including television,

Internet, computer games and mobile applications. There is no doubt the impact of technology also affects the performance of professional practice. Nowadays architects and designers are challenged by constantly evolving technology and, in consequence, are provoked to explore undiscovered domains. Moreover, the best known masterpieces of contemporary architects would not be possible without advanced digital technology. As a result, on the one hand, it stimulates constant challenges and, on the other hand, it evokes requirements of the education process.

"DIGITALITY" - A SCOPE, METHODS AND TEACHING PROCESS

The eCAADe conferences have become not only an established forum for exchanging the leaders' experiences in the cutting edge research but also a place of inspiration for the followers. They have enabled discussions of primary ideas and supported methodological thinking. What is more, teaching or educating has always been a predominant factor. The history of CAAD teaching at the Institute of Architecture and Urban Planning at Lodz University of Technology goes back to 1993 - next year we will celebrate 20th anniversary of establishing the CAAD Unit. Over the period education and research in the field pursued, similarly to other schools of architecture, the "long and winding road" from the basic CAAD, through BIM, advanced 3D modelling and GIS, towards integrated design methods. It is, however, not only a question of deploying a particular software, but also of teaching strategies. The latter issue will be revealed in the following sections.

At present, we teach undergraduate students of four different course studies, namely: Architecture and Urban Planning, Interior Design, Architecture Engineering and Spatial Economy. First and second year students are given fundamental courses in CAD, BIM and basic GIS applications while third and fourth year students learn advanced 3D modelling, visualisation techniques and multimedia presentations. What is more, they are introduced to more complex topics such as computer aided spatial planning and management tools, parametric design, generative architecture and algorithmic methods of design among many others. Some of those courses are elective, so students can choose a subject to study. The overall didactic goals have been defined as follow:

1. to provide an introduction to CAD and BIM applications;
2. to develop practical skills by creating information models of architectural objects and project documentation based on the models;
3. to develop practical skills of advanced three dimensional modelling, visualisation and animation;
4. to introduce latest tendencies and technologies of computer aided design (e.g.: parametric design, generative architecture, algorithmic methods of design, 3D scanning, point clouds, photogrammetric, rapid prototyping, reverse engineering, VR, GIS);
5. to amplify knowledge of computer aided spatial planning and management;
6. to provide methods and techniques of post-production in architecture, and multimedia presentations;
7. to extend computing skills in terms of creation of parametric and generative objects.

To sum up, the general mission is to open students' minds to the new technology and develop skills of appropriate software selection in terms of acquiring projected objectives and satisfying final results. In order to show a scope of issues to be dealt with a variety of tasks, different methods and tools are described and analyzed in the following paragraphs.

Individual work

The aim of the project was to provide a realistic three-dimensional visualization of buildings along the main street of the historic city centre of Lodz. Therefore, it was necessary to acquire archival materials, then to digitise them and to verify through the comparison with photographic documentation of the current stage of buildings. On this basis, three-dimensional modelling of buildings was done with

the use of the CAD and 3D modelling software. The accuracy of modelling often required the elaboration of architectural details. Then the visuals were done deploying dedicated software for photo-presentation. The accomplished virtual reconstructions were visualised and presented to the public during an open-air exhibition arranged along modelled street, so everybody could compare the results achieved by students with the real appearance of heritage buildings. This is an example of the traditional, instructive teaching method, supplemented by individual task summarising achieved skills.

Teamwork

The aim of the project was to create three-dimensional models of roof structures based on measured drawings of old wooden churches, done earlier by students during a summer training. There were four principal goals of the project. First, to recognise historical timber roof structures, secondly, to attain three-dimensional models of trusses comprised of elements suitable for virtual assembling and disassembling as well as for animation, thirdly, to accomplish models capable to store and visualise various types of information such as nature and level of damages, structural characteristics and force distribution analysis, and finally, to increase knowledge and skills in the three-dimensional modelling.

The organisation of work required that the group of fourteen students had to create the list of individual tasks, to determine the order of their implementation and to select a coordinator to supervise the proper conduct of the subsequent stages of action. The coordinator was responsible for the division of work and submission of the entire model, while the preparation of the components was the responsibility of other participants.

Problem Based Learning

Ksiezy Mlyn is an important part of the former paternalistic industrial complex, built in Lodz in the late nineteenth century. The site is one of the best examples of this kind in Europe. A good state of preservation and authenticity of most buildings mean that the complex has outstanding historic and heritage value and is of great importance for the local community. This latter issue was the fundamental assumption of the project, which objective was to find the best method of commemoration this city area. The result was a comprehensive study devoted to Ksiezy Mlyn in a form of a website. First, three-dimensional models of the whole complex and its most important components (including a director's villa, a factory hospital, a school for workers' children) were done with the use of the CAD and 3D modelling software. On this basis, cardboard mock-ups for self-assembly were prepared. Furthermore, an interactive map of Ksiezy Mlyn was created providing historical description of each object and photographic documentation illustrating its past and present condition. Particularly interesting results were achieved through a series of views, recreating daily life in Ksiezy Mlyn, in the style of old postcards from the late nineteenth and early twentieth century.

What is interesting, the PBL method facilitated a broader exploration of the possibilities prior to deciding on problem-solution, and moreover, it gave opportunities to learn a variety of digital tools within one project. Work started with the "brainstorming" allowing active involvement of participants and their commitment to the subject.

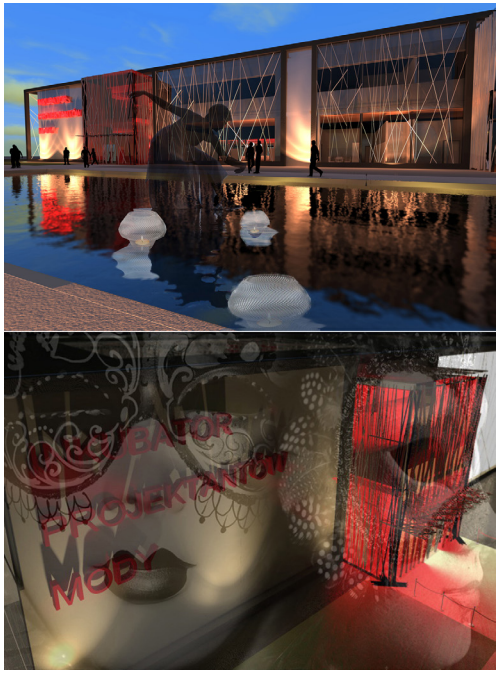
Then, students jointly defined a problem, its solution, and created an implementation plan. The progress of the project was being evaluated throughout the semester, which helped to overcome the greatest difficulties instantly. The final outcome reflected the workload of various participants.

Workshop

The main task of two workshops for the fourth and fifth year students of architecture and urban planning was to introduce students to algorithmic design techniques. It is necessary to stress that students did not have any experience in programming before (Kepczynska-Walczak, 2008).

During the first workshop students were familiarised with the possibilities of Maya software and

Figure 1
Digital physicality - an example of student's design.

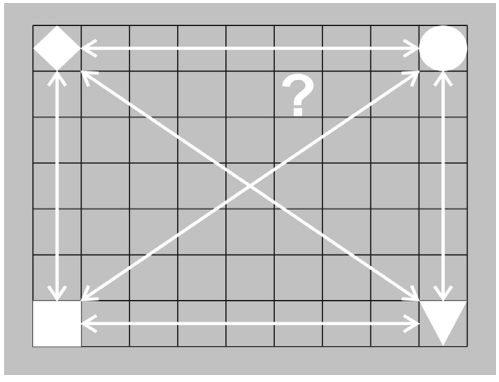


MEL script language. They experimented with simple programming and checking effects in the virtual space. Later, they tried to write a script in order to achieve a spatial form in a controlled way. The involvement of students was impressive, although the visual solutions depended mainly on cognition of algorithmic design and programming skills.

During the second workshop, the participants had an opportunity to experience a real designing process – from an initial concept, through its development, to the realisation of designed structure. The main task of the workshop was to create a component, as a starting point for a complex structure by experimenting with various transformations of this basic element. Students explored and tested different tools and functions of the software, such as: duplicate, grid, field force, deformers, blend shapes and lattice.

The results of the above-described workshops depended primarily on the skills in using a new tool and to a lesser extent on spatial imagination as well as a designer's concept.

Figure 2
Matrix illustrating the problem of designer's imagination limits. The arrows indicate transformation of figures. With appropriate software it is possible to obtain the shape which ought to be in the square with the question mark. But is it possible to imagine it before the results appear on the screen?



SUMMARY AND CONCLUSIONS

Various modes of teaching applied in the projects have been presented. Author believes in aided value of the approach described above so that it may contribute to the ongoing discussion on recommendations for CAAD teaching (Kolarevic, 2008; Matejovska and Achten, 2008).

What is more, some of presented projects acknowledge the synergetic qualities of the physical and the digital. This issue might be also illustrated with a diploma design of a building, flexible by changing its appearance due to digitally simulated modes of performance. As a result an observer receives digital responses in a physical way. The building communicates with an observer through the changeable performance. In other words, digital physicality, though intangible, can be perceived or experienced with physical senses (fig. 1).

The Interactive Panorama of Liverpool is another interesting case of relationship between the real and the virtual. The loop of technology which occurred during the panorama creation might be also considered as a symbol of transition process blurring boundaries between the digital and the physical - "*merging real and virtual worlds somewhere along the virtuality continuum which connects completely real environments to completely virtual ones*"

(Brown, A., Winchester, M. and Knight, M.: 2008).

There is, however, another important lesson, which might be drawn from the described projects: the impact of digital tools and methods on a final design performance is immense. Though, it strongly depends not only on students' creativity but, what is observed as predominant, on scripting skills (fig. 2).

We are now witnessing unprecedented transformation of work of an architect. This implies a smooth transition from design to implementation, carried out entirely within a digital platform. According to Mitchell (2005) "buildings were once materialized drawings, but now, increasingly, they are materialized digital information - designed and documented on computer-aided design systems, fabricated with digitally controlled machinery, and assembled on site with the assistance of digital positioning and placement equipment".

In consequence, algorithmic and procedural thinking as well as programming skills are becoming a commonplace for contemporary designers. This poses new challenges for architects to acquire skills that until now were the domain of IT engineers (Kepczynska-Walczak, 2008). With generative methods architects no longer model forms directly. Instead, the form is generated by the computer, and the architect controls it with a code or script. The designer's work starts to resemble that of a programmer. What is more, such a design process requires a high level of mathematical knowledge, rather unusual for graduates of schools of architecture.

Similar situation was experienced in the early years of CAAD, when imagination was constrained by variable tools and computer literacy. In other words, if there is no direct link between a designer's mind and designing tool, a designer becomes rather a reviewer than a creator (fig. 3.). This conclusion resembles the thought of Aart Bijl (1983), who considered the ease of use as a single most important criterion of judging the importance of new developments in digital technology.

This may be considered as a main obstacle challenging architects on the "long and winding road" towards the synergy of the physical and the digital.

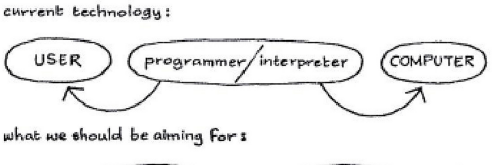


Figure 3
Relationship between a designer and a digital tool (after Bijl, 1983).

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[1] http://www.cadcartoons.com/