Architectural education and digital tools: the challenges and opportunities

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ABSTRACT: Enriching architectural education with digital tools is the subject of this article. Such tools can create, support and visualise architecture. The focus in this article is on an interdisciplinary approach to media architecture (allowing variable visual content of architectural objects) and interactivity (user-space communication), revealing new possibilities in terms of human perception. The results of a survey on media architecture among 110 students are also presented. Described in the article are two courses related to new technologies that are conducted in the Faculty of Architecture at Gdańsk University of Technology (GUT), Gdańsk, Poland, including co-operation with the Faculty of Electronics, Telecommunications and Informatics. Presented also are the challenges of the visualisation of student-designed structures (example: the Coal Market), comparing traditional tools with innovative 1:1 visualisation methods in the Immersive 3D Visualisation Laboratory at GUT, and stressing the potential of this environment for new ways of media and interactive solution visualisation.

INTRODUCTION

Lighting technologies have played an important role in the night images of architectural objects since the beginning of the 20th Century. Next to historic buildings' illuminations, these days, dynamic media installations for newly designed buildings are becoming important elements of a post-modern city [1]. Light creates many opportunities to bring interesting effects into a space, enriching the perception of a city with a number of fleeting, variable sensations. As a result, lighting technologies supported by information technologies allow architectural objects to emit changeable visual messages, or even to offer interactive artistic scenarios. Media architecture created in this way can, on the one hand, become a carrier of unique content, but on the other hand, it also poses a threat to the uniformity of objects or of light pollution [1]. It is therefore important to include this subject in architectural education.

Whereas new media and interactive technologies are being inevitably developed, they are also applied and integrated into diverse art projects and frequently integrated into the buildings' interiors, façades or open public spaces [2]. Such artistic interventions clearly have the potential of improving the quality of the space and its multi-sensory perception. Moreover, numerous studies prove the positive influence of interactive art installations and responsive environments on people's feelings and behaviour, often involving them in interaction with the art work, and even with one another [3]. New media and interactive technologies have the potential to become a powerful architectural tool in creating sensory rich architecture and lively public spaces in future cities [4][5]. That is why it is crucial to introduce them appropriately to future architects in the early stage of their education; when they are open to discovering new methods, materials and tools, and experimenting with them to create better spaces in the future.

INTERDISCIPLINARY APPROACH TO ARCHITECTURAL EDUCATION

The undiscovered potential of the perpetually evolving new media and interactive technologies has aroused the interest of specialists and researchers from various disciplines, i.e. computer scientists and software engineers, but also artists, architects, sociologists, and others. Interdisciplinary collaborations allow them to explore the possibilities of the application of such technologies. Partnerships among different disciplines are mostly highly valuable and fruitful, especially in art and architecture, which is found to pull together quite a wide range of aspects from many other fields [6].

Such co-operation happens among practitioners, as well as scientists and researchers, but also for the students within their education. In 1946, Dean W.W. Wurster from MIT, invited artist György Kepes …*to introduce visual design as a discipline for architects and city planners* [7]. During this co-operation Kepes realised how uninformed he was on the topic of technological achievements and, at the same time, found how uninitiated some of his engineering and scientist colleagues were …*when it came to the most basic values of artistic sensibility* [7]. Since then, the concept of design education, including interdisciplinary approaches, has been practised at various institutions across the globe [8]. As far

as interactive art installations are concerned, the collaboration of architects and artists with scientists and engineers [9] and, most importantly, software developers seems indispensable, as interactive artworks are heavily dependent on software [10]. At MIT in the 1980s, within the Faculty of Architecture and Spatial Planning, a MediaLab research community began to study innovative implementation of technologies for social and human benefit [11].

It is crucial to follow the innovations and imply them both to the education curriculum, as well as to the teaching methods. It has been reported that academics in general …*may not be fully convinced of the value of a new or refreshed pedagogical approach or educational technology within their own field of discipline* [12]. It is crucial not only to teach traditional and trustworthy constructions, rules, spatial solutions and design methods, but also to acquaint the students with new technologies and up-to date materials, as well as to open their minds to non-standard ways of thinking. It is the best moment to open fresh minds to search for new, even futuristic, solutions and innovative approaches in their projects, to keep them developing their skills and knowledge and stay open-minded in their future practice. It is the case of a wide range of topics, from sustainable monument preservation [13], through architectural and environmental engineering in the context of climate change [14], progressive technologies, such as renewable energy sources [15], up to new media and interactive technologies in public art installations and architecture.

STUDENTS VERSUS MEDIA ARCHITECTURE

A survey was conducted among students of the sixth semester (first degree studies) to examine future architects' attitudes on media architecture. There were 110 respondents. A total of 81% of the respondents said the way the building looks after darkness (through its lighting), is an important architectural feature. Of the respondents, 19% claimed it depended on the rank and location of the building. That no-one in the group of respondents considered this feature insignificant or expressed any hesitation in the statement …*it is hard to say*, *proves interest in the night image of the city among future architects*.

What is more, according to 89%, newly designed public buildings should be illuminated after darkness because of their importance. Just 11% of students said, it was difficult for them to answer this question. The majority (67% of respondents) also confirmed that displaying variable, abstract images on the façade (as part of media architecture) is an interesting and desirable phenomenon in urban space, stressing at the same time that it depended on the function and location of the building. Moreover, 17% of respondents expressed unequivocal acceptance of media architecture.

Media architecture issues were considered significant by 32% of those surveyed, and by 65% as …*worth considering in architectural design*. Just 3% of respondents found it rather insignificant. No-one considers media architecture to be unnecessary despite the fact 13% of respondents indicated media architecture was an undesirable phenomenon that introduces chaos in public space. This slight divergence of views may indicate a lack of sufficient understanding by the surveyed students about media architecture, which confirms the need for education in media architecture. However, it can be seen that the majority of the respondents expressed interest in this phenomenon.

Students asked if interactive installations with variable lighting are an asset of the public space, answered *yes* (51%) and *yes, but only within the framework of temporary events* (41%), which again indicates a high approval of such initiatives in the public space. Once again, no-one recognised the phenomenon of interactive installations as unnecessary, and just 8% of respondents abstained. When asked if they would like to apply media architecture solutions to some of their projects, most respondents (74%) showed interest. A total of 35% of this group concluded they would like to enrich their project through media solutions. In this area, they listed the functions of buildings, such as: public facilities (16%), which included cultural centres, galleries and media libraries, as well as a kindergarten or court; collective housing facilities (14%), including hotels and dormitories, with one person pointing out cohousing projects (1%).

These proposals confirmed the accurate pairing between the possibilities of media architecture and functions of architectural objects. What is more, 39% of respondents said they would consider applying media architecture solutions to their future projects. Importantly, from the group of people who participated in the lecture in the field of media architecture, 89% opined that they would think about how the buildings they design would look after darkness.

DIDACTIC EXPERIMENTS IN THE FACULTY OF ARCHITECTURE AT GUT

Openness to new technologies among students of the Faculty of Architecture at Gdańsk University of Technology (FA-GUT) and their interest in media architecture and interactive installations is an incentive to conduct experimental didactic subjects in this field. Until now, at GUT, the course, Media and Interactive Technologies in Architecture has been initiated and led by Dr Bogusława Konarzewska and Dr Karolina Życzkowska. An elective seminar, Interactive Art Installation at GUT campus was initiated and is conducted by Katarzyna Urbanowicz and supervised by Professor Lucyna Nyka, Dean of the FA-GUT.

In the course, Media and Interactive Technologies in Architecture, students were acquainted with the technological possibilities within the scope of media architecture, and with representative examples of media and interactive solutions. Both solutions, integrated within the architectural structure, were discussed during the classes. The students' task was to use the knowledge presented and choose a place within the city of Gdańsk with the potential for media or interactive solutions. They were required to justify the intervention and to illustrate the developed concept.

Among the topics were underground spaces, animated by artistic light installations, landscaping elements dedicated to children, the media installations altering key architectural objects of the city or installations restoring lustre to underrated and forgotten spaces. So far, students' projects were developed based on traditional visualisation methods: posters and multimedia presentations. The topics related to changeability raise the need for new methods of visualisation and interactive media installation, which will be discussed below.

The second of the above-mentioned courses, the elective seminar, Interactive Art Installation at GUT, assumed an experimental co-operation between the Faculty of Architecture and the Faculty of Electronics, Telecommunications and Informatics. The idea was to create teams mixed with participants from both specialisations, to work together on proposals for arranging and improving spaces around the university campus by artistic installations involving new media and interactive technologies.

The exact location was to be chosen by the students according to the activity, function and established impact on the users of the space, including interactive screens on walls and façades, digital pavements or separate artworks and responsive environments in the open space. The first edition of the seminar was initiated in the summer semester of the academic year 2017/2018. There was an open call for the students from the Faculty of Electronics, Telecommunications and Informatics (FETI), to team with architectural students, who chose to participate in this course. Then, the mixed groups would co-operate on a common concept and continue working on a prototype during the next semester. Eventually, one of the first-year FETI students, Robert Krauze, participated in several meetings, consulting for a few groups within his range of knowledge. All in all, it was highly valuable input for the architectural students for the development of their concepts, as well as a chance for them to challenge their clear explanations of ideas to someone not only from a different discipline, but also who has to understand and support them in the interactive system of their proposal.

During the following year, it was possible to formally arrange an experimental interdisciplinary common project for architectural students, again within the elective seminar, co-operating with the students of FETI. One group of students from ETI and architecture developed a concept for a portable device displaying with interactive illumination the current temperature and CO_2 pollution. Next semester a prototype of the device will be constructed.

The rest of the architectural students' groups in academic year 2018/19 were supported by Dr Łukasz Kulas and Mr Michał Tarkowski, teachers and researchers in FETI. Their assistance was professional, but since they were consulting with all the teacher-student groups, it was a different type of co-operation than intended at the beginning. Nonetheless, the presence and support of professionals from the IT field was definitely both enriching and empowering concerning the development of the design concepts.

The development of digital tools is both an inspiration for innovative architectural concepts and a challenge in terms of development, presentation and realisation. For the student proposals on new technologies, after the conceptual phase the next challenge was to build prototypes, which has not yet been implemented at GUT. This should be the aim for the future editions of the courses, as working on the prototypes could revise and support understanding between the teammates from the different disciplines. What is more, prototypes might stimulate evolution of the creative ideas, as well as the opportunity to evaluate the interactivity of the artwork [10].

The aspect of interactivity is one of the most challenging, because as far as people's response is concerned, there is always a dose of unpredictability. Prototyping allows development of required skills and for the expected audience to test the effect and operation of the designed device in different stages. Students take into account not only their good intentions and imaginary results, but they actually can revise the consequences of design decisions and improve projects through iteration. It is a crucial skill for the students to acquire, to be empathic and able to visualise the variety of modes of usage of their project by different kinds of user. That refers not only to the interactive artwork, but anything they design, from software to buildings and space arrangements.

An interesting area of didactics development would be experiments related to display elements applying renewable energy and building prototypes of such components. This is most important from the point of view of sustainable development because of the energy consumption of media solutions. Prototyping also could be conducted in new materials enabling variable visual effects or kinetic transformations, as well as sensory solutions supporting the functioning of disabled or elderly people.

VISUALISATION POSSIBILITIES IN IMMERSIVE 3D LABORATORY

Although the phase of media solutions prototyping has not yet been implemented at GUT, there are new possibilities of visualisation of architectural assumptions within the Immersive 3D Visualisation Laboratory (I3DVL) at the University. This laboratory has six screens, each 3.4 m by 3.4 m, forming the cave automatic virtual environment (CAVE): an environment enabling virtual simulation of designs at 1:1 scale. This allows for a virtual walk through the designed space, enabling verification of the designed concepts in motion, in real proportion. This is a highly innovative method of presenting architectural designs compared to traditional visualisations or animations; comparison of these methods is shown in Table 2.

The I3DVL provides an opportunity to test media solutions, taking into account not only the real distance perception of media installations and their scale, but also the rate of change of displayed content, colour and light intensity. This set of characteristics is most important in the assessment of media solutions. They should be represented in the content [1], in contrast to aggressive messages from digital billboards, causing discomfort to users of urban spaces, because of the rapid pace of change, distracting text messages and excessive brightness.

The I3DVL opens up the field for didactic experiments in designing various media solutions. Innovation in the range of I3DVL is also the ability to simulate the interaction between user and space, allowing the perception of generated changes in a real time context. In addition, the user can change the place of observation at any time they wish, as well as view the proposed media solution in motion, which is a great advantage over traditional visualisation techniques (see Table 1).

Table 1: Comparison of traditional and innovative visualisation methods (K. Życzkowska).

	Feature	Traditional visualisation	Animation	Visualisation in I3DVL
1	Ability to choose any frame	+- (only at the pre-rendering stage)	+- (only at the pre-rendering stage)	+ (at any time, in real time)
2	Ability to choose any frame by a recipient	-	-	+
3	Possibility to perceive the project in 1: 1 scale	-	-	+
4	Ability to view variable visual effects	+- (by comparison between renderings)	+ (in terms of scenes included in the scenario)	++ (in real time, from real distance)
5	Ability to receive the rate of change of visual effects	-	+	+
6	Ability to visualise interactive installations	-+ (selected scenes)	+- (selected scenes in the pre-programmed scenario)	++ (ability to interact with the recipient in real time)
7	Verification of design assumptions	+- (only in the fragment presented in the rendering)	+- (only within the selected sequence of scenes)	+ (from each side)
8	Verification of design assumptions in motion	-	+- (only within the selected sequence of scenes)	+
9	Viewing comfort	+	+	+- (possible problems with the labyrinth)
10	Possibility of a wide range of recipients	+ (depending on the type of presentation)	+ (depending on the type of presentation)	- (maximum 7 persons)

Media installations so far have not been visualised within the I3DVL. However, the first experiments on visualising students' architectural concepts already have been carried out with a group of students under the direction of Dr Karolina Życzkowska who had the opportunity to verify their design assumptions for a Gdańsk city quarter in the I3DVL. Visualised projects were developed during architectural design classes supervised by Professor Elżbieta Ratajczyk-Piątkowska in co-operation with Dr Karolina Życzkowska, as a reply to an architectural competition organised by the city of Gdańsk for the revitalisation of the Coal Market in Gdańsk (see Figure 1).

This area is a prestigious public space, constituting the foreground of the historic part of the city. In the I3DVL, through co-operation with Dr Mariusz Szwoch and Dr Jacek Lebiedź from FETI, the winning concept of this competition was visualised, as well as two other honourably mentioned concepts [16]. Students had the opportunity to immerse themselves in the new space of the Coal Market as designed by themselves. It is rare when students' projects are realised, but thanks to the I3DVL, such a scenario has become partly possible. City authorities - the organisers of the competition - also were invited to a virtual walk through the revitalised Coal Market. This innovative way of project visualisation was well received by them. Therefore, the I3DVL can be treated as a new co-operation platform between

investor and designer, as well as between student and teacher. However, a drawback of this visualisation method are the possible problems with labyrinth disorders inside the CAVE, which can lead to something similar to motion sickness.

Figure 1: Immersive 3D Visualisation Laboratory (I3DVL) at Gdańsk University of Technology (K. Życzkowska).

A certain limitation is also the failure to adapt I3DVL for a large number of users (see Table 1). Improving this environment is another challenge in light of co-operation between architects and IT specialists [17]. However, the big advantage of this method is the possibility of applying spatial models developed in a sketch-up (a program commonly used by architecture students) within I3DVL. Students greet with great interest this new approach to the visualisation of architectural designs. For example, from the group of 12 graduates of Dr Karolina Życzkowska, everyone declared their willingness to visualise their concepts developed as part of the engineering diploma at I3DVL. These activities are planned in October 2019, to allow for possible corrections in the students' project before the final defence in December 2019.

Digital Tools - Opportunities and Challenges

Digital tools provide both opportunities and challenges for the education of architects. Opportunities and challenges apply to the new technologies themselves and to the environment, where they are presented. By working with these technologiesthe future architect develops greater awareness, and it consolidates the I3DVL as a new platform for co-operation between the teacher and student (see Table 2).

Table 2: Opportunities and challenges in architectural education (K. Życzkowska).

Architectural education	
Opportunities	Challenges
Interest of students in media and interactive technologies	Building interdisciplinary, interfaculty courses
Searching for new solutions on the borders of architecture: art, information technologies and lighting technologies	Searching for media solutions in the context of sustainable development
Pursuit of the uniqueness and changeability of architectural objects	Construction of prototypes of new display elements and responsive structures
Interdisciplinary co-operation between students of the Faculty of Architecture and the Faculty of Electronics, Telecommunications and Informatics	Developing students' communication skills, such as focusing on interactivity and human perception from different users' perspectives
Visualise architectural designs on a 1:1 scale in the Immersive 3D Visualisation Laboratory (I3DVL) at Gdańsk University of Technology	Visualisation of media and interactive solutions in the I3DVL: a new platform for co-operation between the teacher and the student

CONCLUSIONS

The possibility of building concepts on the borders between architecture, art, information technologies and lighting technologies opens up new areas for architectural education. The interest of students in media and interactive technologies, and the pursuit of solutions leading to unique architectural objects, raises the challenge to develop

interdisciplinary and interfaculty subjects. This opens the door to more advanced projects, also taking into account the principles of sustainable development.

The possibility of interdisciplinary co-operation between students of the FA and FETI creates new experiences and enables the students to develop communication skills that will be indispensable to them in future. The interactivity aspect encourages students to focus on human perception to imagine scenarios that influence people and possible responses from the users.

Apart from applying digital tools in the conceptual phase, challenges arise as how to apply them in prototyping, simulation and testing of media and interactive solutions. These last steps are becoming more urgent in the context of the Immersive 3D Visualisation Laboratory at Gdańsk University of Technology. Digital tools are an opportunity and a challenge for architectural education, both in applying new technologies and the environment of their presentation. Experiments in this field allow the shaping of awareness of the future architect and consolidate the I3DVL as a new platform for co-operation between the teacher and the student (see Table 2).

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