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PHILOSOPHY OF URBAN DESIGN TEACHING WITH THE USE OF INTERACTIVE AND PARAMETRIC DIGITAL TOOLS

Krystyna Januszkiewicz*, Anna Pazdur-Czarnowska**

* West Pomeranian University of Technology in Szczecin, Faculty of Architecture, uL.Żołnierska 50, 71-210, Szczecin, Poland
E-mail: Krystyna.Januszkiewicz@zut.edu.pl, ORCID: 0000-0001-6880-0862
** West Pomeranian University of Technology in Szczecin, Faculty of Architecture, uL.Żołnierska 50, 71-210, Szczecin, Poland
E-mail: Anna.Pazdur-Czarnowska@zut.edu.pl, nr ORCID: 0000-0002-7479-5665

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Abstract
Learn, experiment and enjoy it – the joy of understanding should translate into the joy of creation, then the joy of creation fits itself spontaneously into the creative process. Learning means sharing knowledge and joy of leading others into the unknown areas they have not discovered yet. Teaching is a constant interaction and exchange on the intellectual and emotional levels, as well as mental and cultural levels – it is also establishing role models and social attitudes.
Young designers are faced with challenge of translating the virtual world into the physical world in the current era of digital technologies. The use of parametric design programs allows them to create a versatile, functional, but artistic interactive environment, capable of shaping the urban interior within the city. This paper aims to present a design process and effect of an experimental, innovative academic program of semester course "Immersive environments and interactivity in designing architectural interiors and their surroundings". The final projects demonstrate the versatility of understanding and implementing the program and the plasticity of shaping public spaces – valuable skills in a student's path of design self-development.

Keywords: architecture; urban design; interactivity; philosophy of teaching; parametric design

INTRODUCTION

The boundaries between the physical and the digital are increasingly becoming blurred for the past three decades, which affects the a maturing vision of architecture that actively participates in our lives. In the era of rapid development of 21st century information technologies, significant changes are noticeable in many areas involving the design process. The community of architectural professionals is undergoing processes of interdisciplinarity, bringing together experts in space design, programming and artificial intelligence, as well as the sociological and philosophical aspects of human-machine interaction. Innovative realizations coupling virtual reality with physical reality and visionary research projects have become a response to attempts to redefine the concept of architecture and its environment. These processes respond to the dynamically changing needs of individual and collective users of urban spaces, while at the same time being part of the current trend of smart and sustainable city. The world of digital technologies, built from a network of connections and dependencies, has become an active participant in everyday life. The interdependence of the built environment and technological systems has triggered their mutual response and constant redefinition. Ubiquitous data capability has become an integral part of our lives and has begun to permeate all spaces, from devices to buildings and environments. The process of integrating architecture and digital systems in the modern era of their mutual cooperation becomes, therefore, a dominant issue in the design progress. Architectural art is being transformed and is no longer seen as the result of the fully predictable, limited ac-

tions of its creators, and giving it interactive qualities implies its reconfiguration and ability to respond, in real time, to the demands and needs of its users and to environmental conditions. As a result, architectural realizations are personalized and become much more unpredictable and animated. In this situation, it is the user of a given architectural space who becomes the center of development and operational processes, in opposition to traditional architecture, where designers, engineers, developers, etc. determine its quality and spatial organization.

1. INTERACTIVE BUILT ENVIRONMENT AND PARAMETRIC DESIGN

By definition, interactive built environments are built on the convergence of embedded computing and a physical counterpart that meets the requirements of adaptation through interaction. It includes both buildings and environments that are designed to respond, adapt, change and come to life. In addition, the use of interactive tools within architecture and its environment influences human experience by creating immersive environments.

The challenge becomes the realization of human interaction processes with the architectural environment through the tool of interactivity. Interaction, understood as the interaction of people, objects or phenomena with each other, is considered a property of interactivity as a technological process. The term "interactive architecture" (iA) means an architecture capable of continuous internal adaptation to the constantly changing conditions of its content and context. In other words, it exhibits characteristics of independent behavior that develops through its interaction with users and the environment. The didactic intention of the conducted course was to expand thinking about architecture based on modern technologies that foster the creation of experience in space. This activity combines a number of issues from scientific disciplines such as psychological perception of space, philosophy, new media, sociology of space and architecture of urban public interiors. Hence, the design process was preceded by an in-depth analysis of world cases, building a mind map and searching for deficits of the selected urban interior. This leads to the formation of a holistic view of the space and the needs of its users - city residents and tourists.

The Interactive Built Environment Studio managed by Krystyna Januszkiewicz and Anna Pazdur-Czarnowska started in 2018. The subject of this Studio includes a contemporary design actions undertaken in urban spaces that are based on an interactive dialogue between the artifact and the viewer while significantly increasing the place's attractiveness and aesthetic qualities. The studio deal with responsive environments which are defined as those, which engage interaction with the users of these environments through systems that respond to the audience's behaviour. Technologies used include detection and tracking motion through sensor systems, video cameras and/or body-worn sensors. Audio and video effects are generated according to the actual time of the event by software tailored to the accepted choreography of time and media type. The media choreography software is used to read and process the stimuli sensory input and generate responses in images and sound in real time. Moreover, such environments may contain interactive tactile devices. Myron W. Krueger is considered the precursor, who, from 1969, worked on "sensitive environments" to create spaces responsive to user's gestures and movement, using a system of sensors and video cameras. As early as 1970, he created installations such as Glowflow, Metaplay and Physic Space using video projections which the viewer could modify, considered a cornerstone of interactive art. Nowadays, Krueger's concepts are developed and increasingly often become attractive public spaces in the city, organizing the public zone. As a result, these types of installations have become a permanent part of the means of contemporary art's expression. The presented cases of responsive environments demonstrate a new artistic medium based on a commitment to real-time interaction between humans and machines. This medium consists of sensors, display and control systems. It receives input from or about the participant and then generates output in a way, which can be recognized as a response to its behaviour. The relationship between what constructs an input and an output is arbitrary and variable, allowing the designer to intervene in the participant's action and the results obtained. For example, physical movement may results in sounds or voices used to navigate in a visual space defined by a computer. It is the relationship between the action and response that is important. Visual beauty and auditory response are secondary. The response is the medium!

Within almost four months of the overall designing period, students presented a variety of concepts. The chosen urban interiors differed in function and the type of space limitation. Some were confined by a square net of trees, while others presented a clear border of building's facades surrounding the chosen interior [Fig.1 and 2].

The design concept EcoAr [Fig.1] was located in the city centre, at Pawel Adamowicz Square in Szczecin. It is an elongated type of urban interior bounded on two

sides by a roadway strip and a green line. The project aims to diversify the current appearance of the urban space by using elements based on pro-environmental solutions. Moreover, it offers a wide range of interactive attractions for passers-by and tourists. The central axis of the floor is formed by a strip of pavement tiles with a built-in kinetic effect sensing the weight of a passer-by. The mechanical energy of the tiles is accumulated and transformed into electrical energy which powers the illuminating effect of the gates in the square. In addition, the edges of the cycle path have been fitted with sensors to detect the movement of cyclists and to emit illumination in the outline of their edges. The openwork gates form a partial canopy over the square, offering lighting attractions activated by two systems, which are a part of an ecological, sustainable design trend. The energy from photovoltaic panels on the upper surface of the forms and spiral wind turbines, so-called Vertical axis wind turbines, power the light sources hidden in the lower layer of the gates' lintels. When the system detects human presence, the lighting intensity increases. The square is surrounded by lush low and medium-high greenery, which purifies the air, dampens noise, diffuses street sounds and has an aesthetic function.

The design concept is based on the use of renewable energy sources, kinetic energy, wind energy and electricity. The designed form is therefore self-sufficient and at the same time based on HCI (Human-Computer Interaction) technology, creating a new aesthetic and behavioural experience for the users of the square.

A lighting structure was a core form of Kaskada Project. Located within the pedestrian walk closed from the shorter side with the facade of Kaskada shopping mall entrance, this project was an activity point for the visitors and their children. The labyrinth consisted of colorful elements, which were successively activated when crossing its parts. In the final phase, the entire maze was illuminated, as well as the facade of the shopping gallery. It was designed as a futuristic playground for children, who can pass it while the adults are engaged in shopping. The colourful lights were building another layer of immersive xperience after dark. Additional attractions of the maze were water and reflective curtains, activated by the movement of users. The ecological function was fulfilled by the use of TiO2 surfaces –the sunlight activates TiO2 and allows it to clean the air from harmful NOX particles contaminating the air of every largely populated city [Munafo, Goffredo, Quagliarini, 2015].

A similar curriculum structure was also applied to the subject of parametric design. The Parametric Design is treated here as a catalyst for social innovation by exploration of the role of interactivity in the public space. The digital design space is defined by computer, mathematical and algorithmic logic. Implications of digital formats by functions and polynomials have yielded applications with expanded spatial capabilities. For example, NURBS parametric fluid geometry allows accurate modeling, without analytical approximations, of arbitrary curves and surfaces, with a single set of commands [Januszkiewicz, 2012]. Digital space, having introduced an interactively and dynamically organized base time, can trigger such spatial operations as evolution, transformation, hybridization and mutation. The extension of animation takes advantage of the properties of compound time, which can be viewed as nonlinear, differently understood from the time of the fourth dimension of architecture animation. The nonlinear time reading system is the opposite of kinematic modulation. It is being used increasingly in the formation and representation of architecture and in technology. Digital tools, therefore, are also changing the previous relationship of space and time in architectural design [von Weizsäcker, 1979].

2. THE LEARNING AND TEACHING STRATEGIES

The **principal learning and teaching strategies** of the subject was the creation of design projects, from which students gained experience, knowledge and skills required for shaping design projects using digital tools based on NURBS. Moreover, the understanding and applying the principles underlying the theory of digital and parametric design in architecture and the interactive environment and the city.

The teaching strategy associated with the researching process was regular, tutor-led, based on research tutorials in which small teams presented ongoing research work, discussed and evaluated these results. Teaching also included discussion and evaluation of research experimentation and research presentations. During design tutorials assessments were made in comparison to each student's individual progress and development, relative to his or her own past performance and participation. This allowed an absolute measure of progress made by individual students and teams.

The Educational Aim of the following Subject was that students learnt architectural design and the use of digital tools based on NURBS in the design process. This was the start to the digital design thinking, the way in which the digital designer is beginning to think, employing digital tools and interacting with representational media. The subject also aimed to develop the learner's interest, knowledge and skill of contem-

Fig.1. EcoAr project at Adamowicz Square. Students: Julia Franecka, Ernest Białous; source: author's didactic materials

Fig. 2. Firefly Project – concept of a public space design. Students: Julia Klein, Laura Koperska, Anna Hardziej; source: Author's didactic materials

porary architectural and urban design, including the relationship of contemporary architectural projects and spaces to urbanism and urban settings. Emphasis was placed upon learning advanced design concepts, skills and knowledge related to the making of architectural design proposals. Participants in the subject were beginners in using advanced design tools such as: Rhino and Grasshopper, 3D max or Maya. They used to prepare projects traditionally and design the project's representation by the use of popular design tools such as: AutoCAD, ArchiCad, Sketchpad and Photoshop or Corel Draw. Therefore, students have learned to understand not only the logic of the advanced software, but also the logic of its use in the design process.

The subject included a series of examples of contemporary design actions undertaken in urban spaces that are based on an interactive dialogue between the artifact and the viewer while significantly increasing the place's attractiveness and aesthetic qualities. The student's case study includes the history of interactive designs of kinetic facades; from a primal Institute of the Arab World from 1987 (by Jean Nouvel), through the sensorial spatial forms as main design components of a dutch group Studio Roosegaarde, to uniquely innovative attempts on use of the artificial intelligence conducted by such architects as the Turkish group Ouchhh (urban sculpture Monolith). The use of AI is a new trend combining architecture and art. The

gathering and analysis of data as well as its further processing works on both the internal level of architectural forms located in urban interiors, and the external level of complicated sensorial systems that gather data from the environment [Chaillou, 2019]. The author examines the examples of interactive architectural structures in urban space while recognizing the innovative direction of their development - the direction based on the pioneer solutions for the technological systems based on artificial intelligence. The definition of interactivity as a coupled effect between the human and the machine is still being developed based on new models of intelligent behavior in architecture.

3. DESIGN PROCESS

The design process consists of several stages during which a given design task is solved.

Stage 1: Project Analysis (Weeks 1–2). Work on the project begins with a detailed analysis of the project brief and formation of initial concept. The design team prepares initial project statements summarising design goals, objectives such as: initial design analysis of the project programming, site, clients etc. These initial analyses are based on an outline the student prepares, individually and with subject tutors;

Stage 2: Programme Analysis (Weeks 3-4). Preliminary strategies outlined in stage 1 are used as the basis for establishing the criteria used to undertake detailed site and brief analysis for the proposed project. The student undertakes various forms of investigation into the physical, social and material features of the project site and situation, studying how relevant existing architectural spaces and urban surroundings are used; how the site relates to existing and proposed infrastructures. Initial design concepts in handmade sketches and models also in Rhino are explored and presented in Power Point files.

Stage 3: Diagrammatic Exploration and sources of shipping forms inspiration (Weeks 5-6). As the main project constraints become better understood through initial site and programme analysis, initial design ideas and alternative design strategies are developed for potential solutions to the design problem outlined in the project brief. Design Students undertake a series of studies, in traditional design media, (handmade sketches, handmade modelling), which begin to visualise spatial strategies, structural ideas and their potential effect on the social life of the proposed project. Alternative building programming strategies are explored, showing how the project can adapt itself to proposed activities and the usage. Summary: Individual presentation.

Stage 4: Initial Design & Modelling (Rhino-Grasshopper) (Weeks 7-11). Alternative designs are digitally visualised and modelled in relation to their urban surroundings, showing how the project will affect existing circulation patterns, uses, and future development. More specific details are studied regarding the various systems that need to be accommodated in the project, including building structure, enclosure, openings, entrance, internal divisions, different uses, and potential for future growth and change. Choices are made for specific designs and systems to be further developed. Selected systems are developed in a step–by–step process leading to more detailed designs.

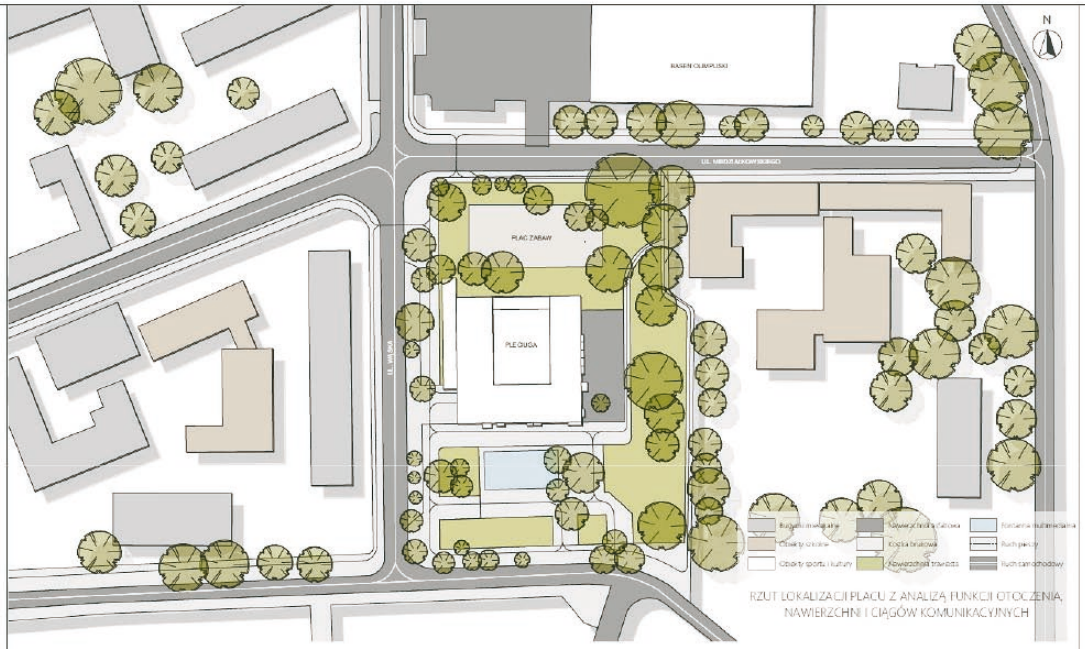
Stage 5: Design Development and Integration (Rhino-Grasshopper, 3D max, Maya, Autocad) (Weeks 11-15) During this stage different strategies for solving the problems related to specific features of the project, including overall building structure, enclosure, growth, internal prehensive, design proposal, are being clarified. As the project becomes more clearly modelled, drawn and visualised, its performance is then tested, repeatedly, in relation to the design team's initial design objectives. A combination of physical and digital modelling processes is used to create a detailed project design, which is fully visualised in terms of the project's brief, site, and proposed uses. The final project is presented at the end–of–semester.

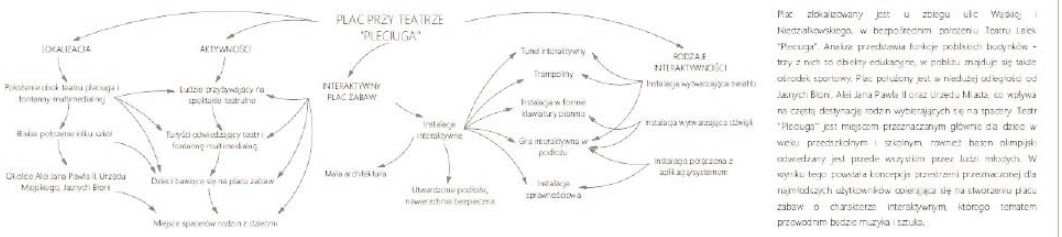
4. DESIGN PROJECT SUBMISSION

The printed format consists of an A2 cardboards project documenting key project images, graphics, models, diagrams, quantitative data and an accompanying text [Figure 3 and 4]. Project presentations, including verbal description and discussion of project development, results, media, documents and models are being prepared.

At the end of the course students are expected to:

1. Have acquired a range of technical skills and knowledge related to the making of conceptual architectural interactive design projects and have gained understanding, knowledge and abilities related to establishing design goals, objects, and project results.
2. Have learned how to make digital and physical architectural models that show the detailed organisation, assembly and design of an interactive design project in relation to its urban setting and surroundings.
3. Have learned how to record and describe patterns of use, operation and performance of a design project described dynamically, in re-





Plac zlokalizowany jest u zbiegu ulic Wąskiej i Niedziałkowskiego, w bezpośrednim położeniu Teatru Lalek "Plecuga". Analiza przedstawia funkcje pobliskich budynków - trzy z nich to obiekty edukacyjne, w pobliżu znajduje się także ośrodek sportowy. Plac położony jest w niedużej odległości od Jaroych Błoni, Alei Jana Pawła II oraz Urzędu Miasta, co wpływa na czestą destynację rodzin wybierających się na spacery. Teatr "Plecuga" jest miejscem przeznaczonym głównie dla dzieci w wieku przedszkolnym i szkolnym, również basen olimpijski odwiedzany jest przede wszystkim przez ludzi młodych. W wyniku tego powstała koncepcja przestrzeni przeznaczonej dla najmłodszych użytkowników opierająca się na stworzeniu placu zabaw o charakterze interaktywnym, którego tematem przewodnim będzie muzyka i sztuka.

Koncepcja zagospodarowania terenu przy teatrze "Plecuga" zakłada stworzenie placu zabaw o cechach interaktywnych. Na terenie parku zaprojektowane zostały instalacje sprawnościowe, most w formie fortepianu, huśtawki, kopuły ze ścianką wspinaczkową i rozdłem, gra interaktywna w podłożu, podświetlane trampoliny, tunel interaktywny oraz fontanny kaskadowe w powierzchni, dzięki czemu podczas ciepłych dni możliwa jest zabawa z wodą. W samym rozplanowaniu przestrzeni dominuje linia swobodna i ścinne nawiązanie do okręgów. Kolorystyka opiera się na żółtych i pomarańczach z dodatkiem bieli i szarości. Na placu wykorzystano drewno, metal i tworzywo sztuczne. Całość uzupełniono kwiatami i krzewami odpowiednimi dla miejsc przeznaczonych dla dzieci.

Fig. 3. Pleciuga's interactive playground – final design boards. Students: Adrianna Orłowska, Katarzyna Stojałowska; source: author's didactic materials

lation to time and how to conceptually create, test and modify design assumptions in relation to a specific, detailed design proposal.

4. Have gained experience in relations to the initial design objectives, project briefs, including key project constraints, as well as in relation to specific design processes, tools and concepts.
5. Have learned skills related to the making and refining of a design project in relation to contemporary architectural interactive design discourses and urbanism.
6. Have gained understanding and knowledge of how to document, present, and communicate design results.

The approach adopted in this is based on the school of research-by-design, a type of academic investigation of the architecture field (in particular, urban design and landscape design), through which design is developed as a method of inquiry. The didactic process, proposed here as a process of shared knowledge, represents a precious opportunity to undertake an experimental research path [Frankel 2010, Roggema 2017] In

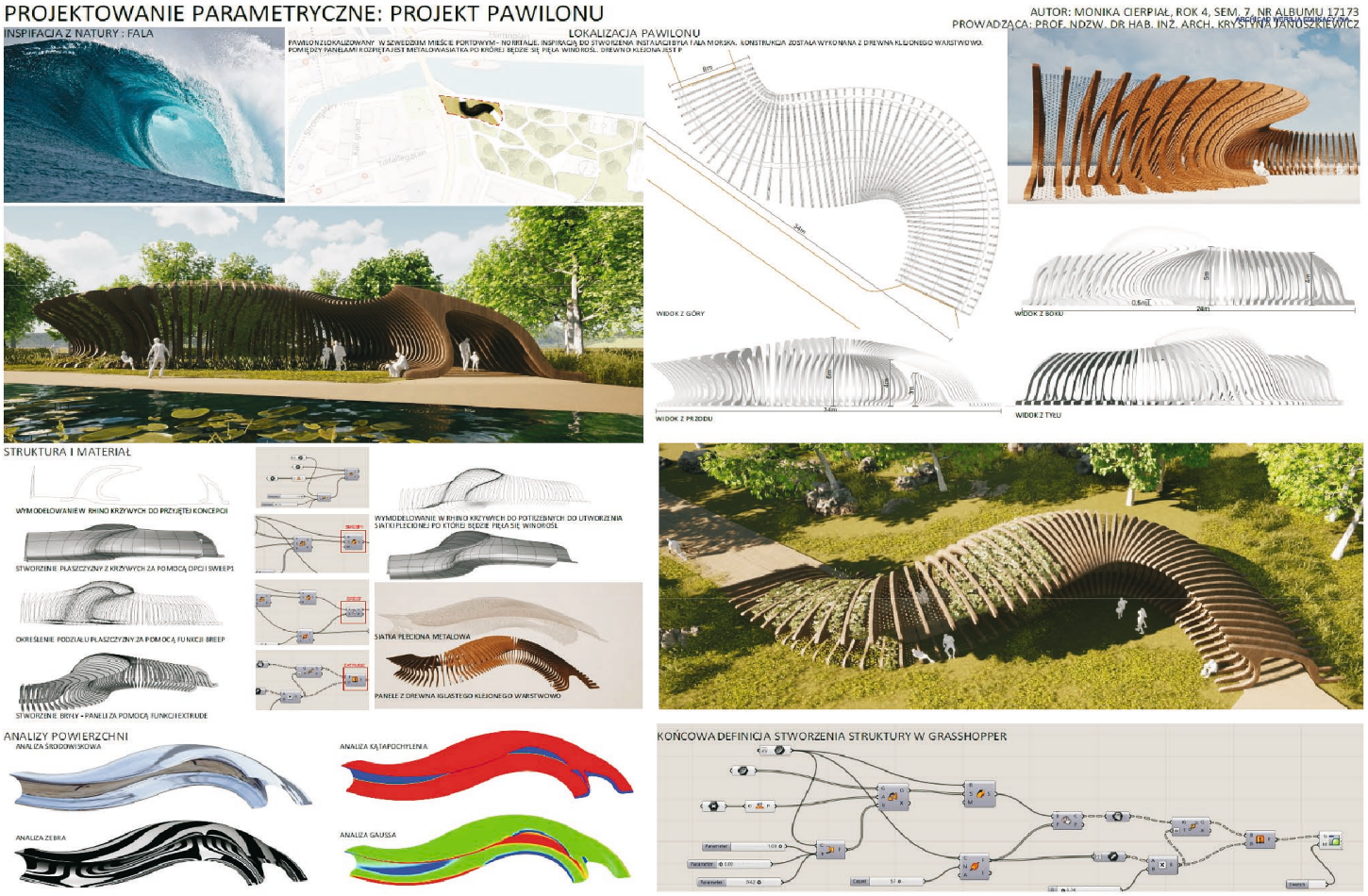


Fig. 4. Parametric Design Studio – Wave Pavillion Project. Student: Monika Cierpiał; source: Author's didactic materials

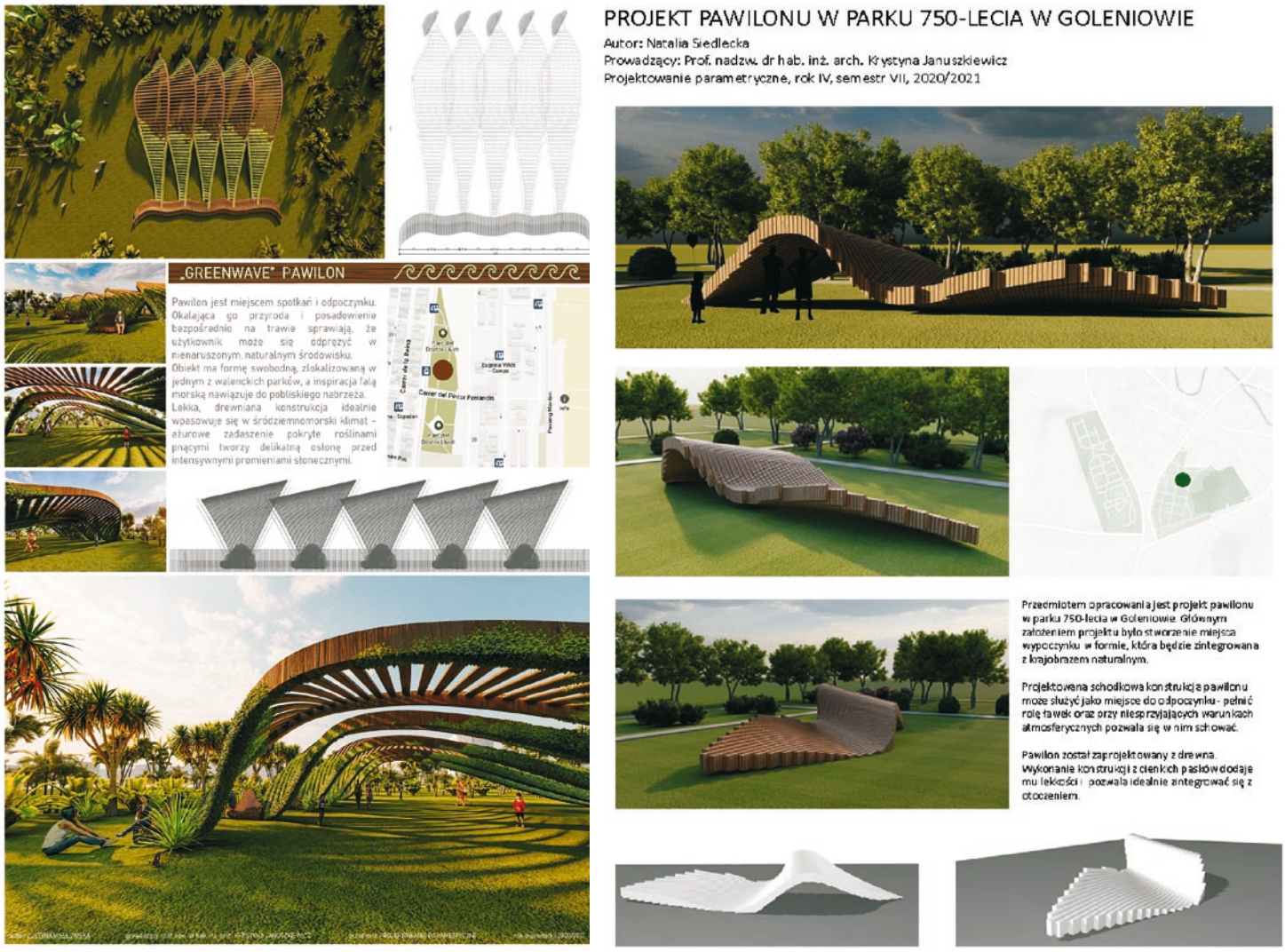


Fig. 4. Parametric Design Studio - Greenware Pavilion (left), student: Justyna Masłowska, Wooden Pavilion (right), student: Natalia Siedlecka.

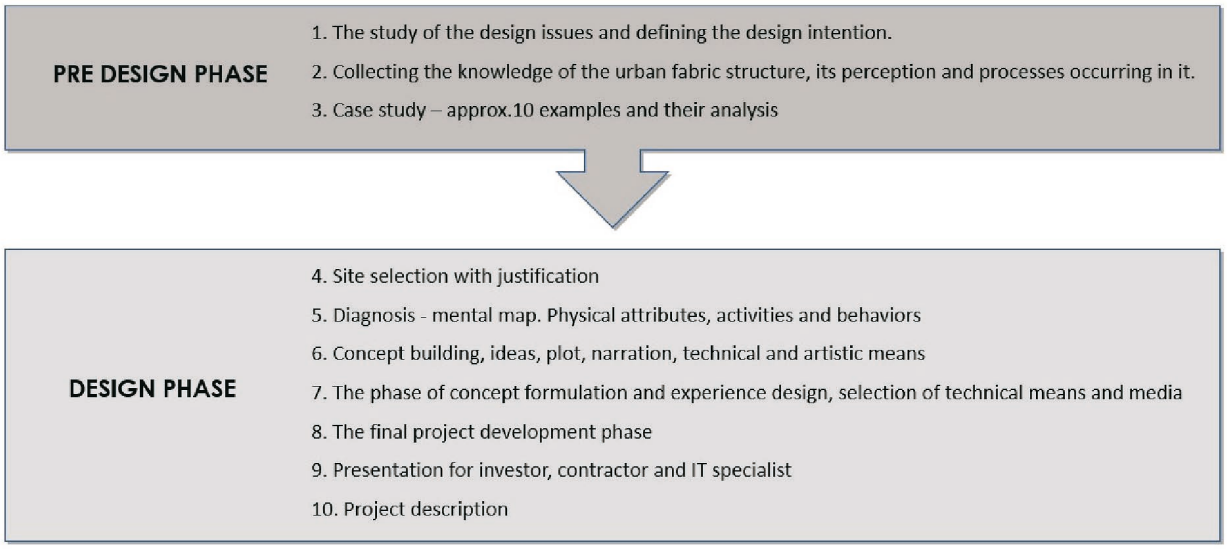


Fig. 5. Research-by-design method adopted to didactic program. Design steps creating the Pre Design and Design Phase; source: author's didactic material

this case, there is the opportunity to build a structured and conscious methodology, in which each step is explained and understood building an awareness of the diachronic and spatial implications.

The didactic program has been mainly inspired by Michael Brawne's analogy between design and a sketch of scientific research as a problem-solving sequence. The process has been divided into two main parts, which were then followed by a sequence of steps [Figure 5]. The Pre Design phase allowed the students to firstly collect a certain amount of basic theoretical knowledge focused around a chosen urban interior of Szczecin. The Design Phase presented a practical part of the program, where the aforementioned objectives have been considered in an individual project of interactive environment. The same sequence of steps has been used according to the parametric design program.

The aforementioned design process is presented below, based on two projects from the Interactive Environment Subject.

5. PRE DESIGN PHASE

The students Angelika Bajko and Paulina Ossolińska started their design journey by focusing on the current environmental issue – a threat of bee extinction. A preliminary analysis of the problem revealed a wide range of threats, most of them provoked by human activity. The aspect of the disappearance of the pollination process of flowers and the depiction of man as an intruder in the animal world became particularly interesting to them.

This idea was then developed by a sketching process. The creation of the form, structural elements and basic shapes have been instantly enriched by technological solutions [Figure 6]. For instance, the idea of a honeycomb shape evolved into the shape of paving tile. The over scaled shape of a flower has been enhanced with the sensor mode of opening its petals by the touch – responsive reaction.

The two, next steps of Pre Design Phase were based on a thorough research of worldwide examples of urban interiors and public spaces. a detailed analysis of the designers' past achievements provided further creative inspiration, but also helped to gain knowledge and guard against copying existing ideas. The collected examples had to be analyzed by the students and presented to the group. During this step, students learned about the design path and its intricacies. In this case the authors of the project have described the idea as follows: the idea behind the immersion plant development project is to get closer to the problem of air pollution and engage with the topic of environmental protection. The role of humans is to symbolically transform into a pollinating bee. Thanks to the interactive installation, we have the opportunity to contribute to the development of buds by touching the flower stems.

6. DESIGN PHASE

The Design Phase was started by the choice of location and further development of the concept idea. The BEES Project was located on the Lotników Square in Szczecin – open public space surrounded by a two lane street [Figure 7]. The students immediately recognized main characteristics of the place by seeing it as a busy area, with good capacity of the main traffic route and an open, free space with catering and public facilities.

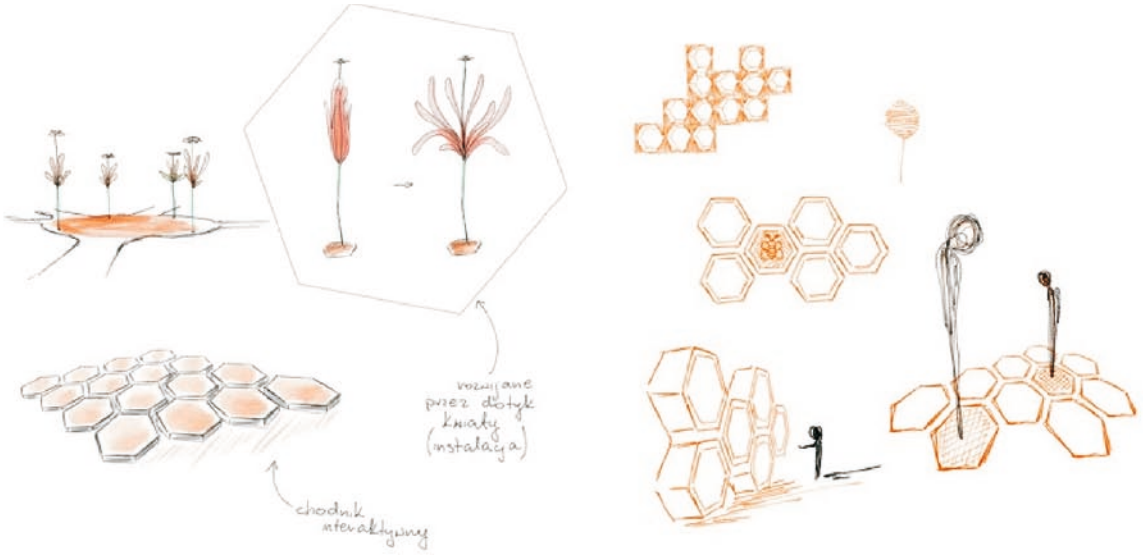


Fig. 6. Basic ideas of the Pre Design Phase. Searching for a form and its use. Flowers opening by the influence of touch and a pedestrian walk built out of honeycomb tiles; source: students: A. Bojko, P. Ossolińska

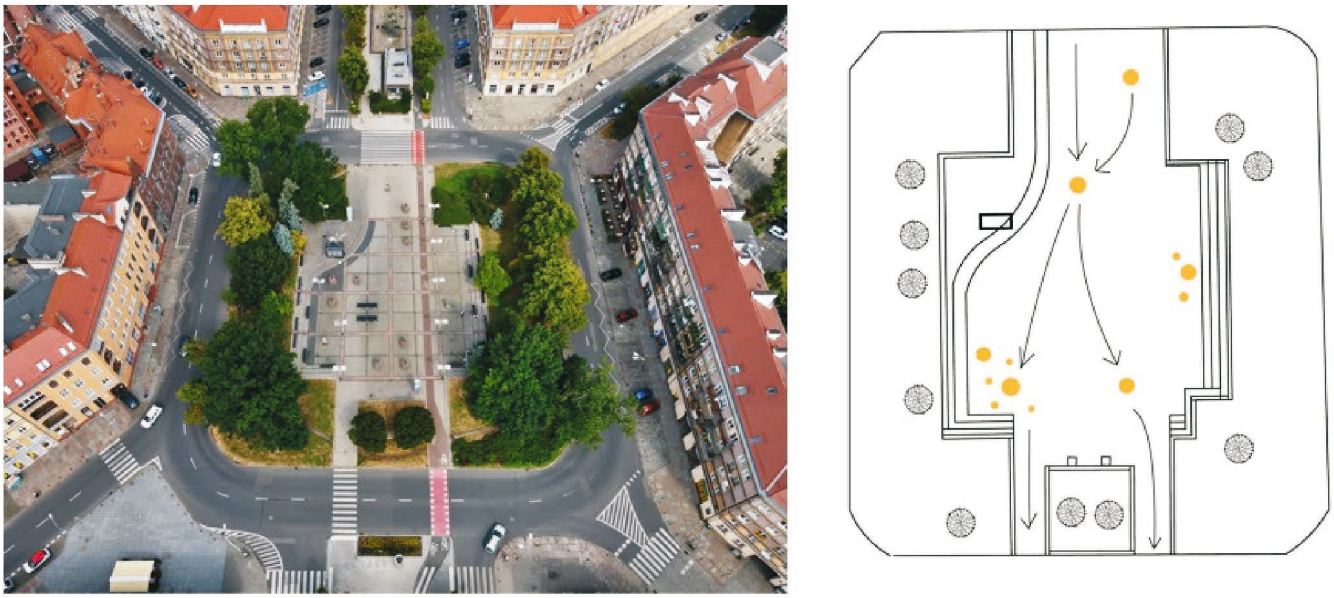


Fig. 7. Lotników Square in Szczecin. The aerial view and the analysis of main people meeting spots; source: students: A. Bojko, P. Ossolińska

The square is urbanized by a touristic trail with a bike path. It serves as a kind of stop on the road of historic sights and points of interest in Szczecin. The surrounding steps and the Colleoni monument allow stopping and generate gathering points for users. The next design step has evolved around the concept itself and its core parts: Idea, Environment, Interaction and Solutions [Figure 8]. The created Mind Map has organized the chaos of ideas and allowed the students to focused step-by-step on the design process.

The students identified the components for the four groups building the design concept. The environment group responded to ecological problems and their technological solutions. They looked for ways to enrich the form with nature-friendly elements. The idea group was built around the theme of bees and the pollination process and their salutary effects on the environment. It also emphasized the smallness of man in the face of the power of nature. The interaction aspect was defined by specific new media art solutions based on the human-computer interaction system, or sensor-response sensory interaction. In the solutions group, the students proposed forms inspired by the theme of bees, which was a summary of the previous three groups.

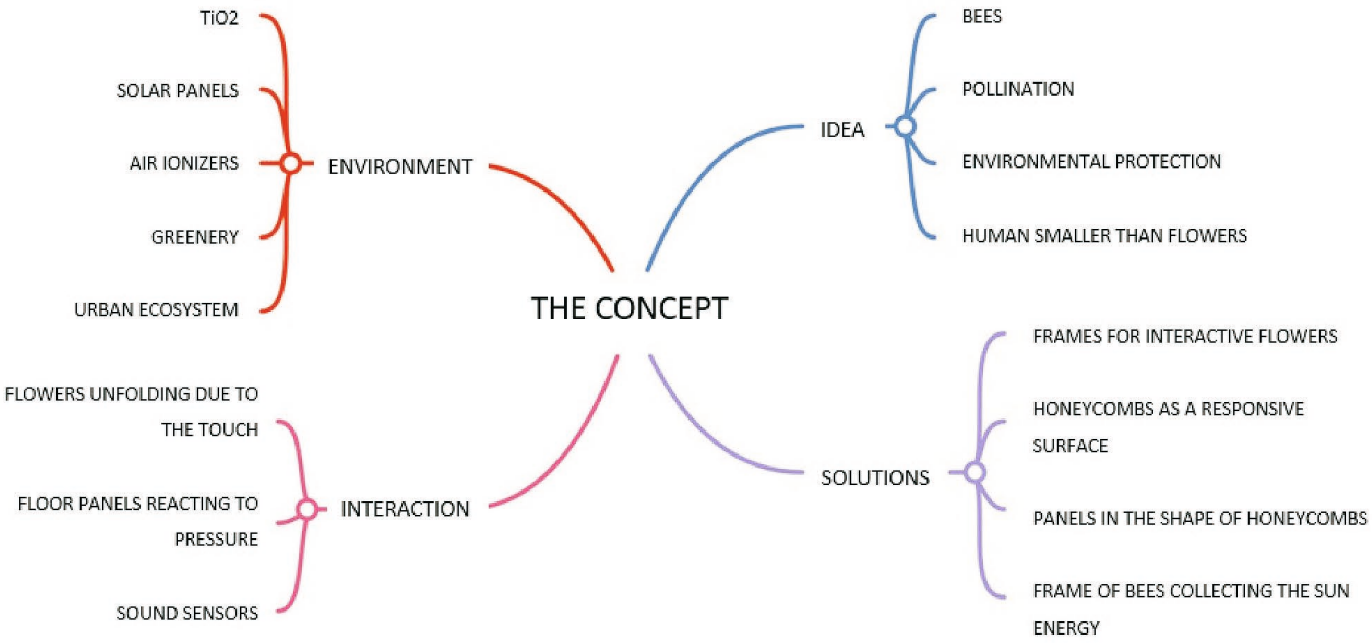


Fig. 8. Mind Map around the core concept. The main groups of issues: Idea, Environment, Interaction, Solutions; source: students: A. Bojko, P. Ossolińska

The overall form and its night and day view has been presented in the set of 3D renders [Figure 9 and 10].

One of the chosen projects has been presented below and designed by a student's duo – Natalia Rzepka and Aleksandra Moroz. The form has been located within a courtyard of the Szczecin's city hall [Figure 11]. The central facade is permanently illuminated in green. Two mirrored spatial forms and a red ball in the center invite passers-by to approach and participate in the fun. At the human touch, sensors in the floor activate an open-circuit lighting system that shines on the ground. The purpose of the lighting is to encourage people on the square to come closer and gather around the mirrors. This allows making new acquaintances and fostering interpersonal contacts. When a sufficient number of people gather, soft music begins to sound. Another highlight is the animation of the façade using the 3D mapping technology, showing the stages of vegetation. In a few minutes the green wall changes from a solid wall into a green, moving structure. This shows the beauty and value of greenery in the city and its symbolic tree – Magnolia. The rose ball in the center displays a gently moving foggy animation that reacts to the touch of a human being [Figure 11]. The task is to find the map of the city underneath, which further emphasizes the location of the object, and it is also a great attraction to open up to another human being and start working together with a common goal.

7. PARAMETRIC MODELLING – BASIC COURSE

The Parametric Design Studio leaded by Januszkiewicz started in 2012 as one of the first events in Poland for digital modelling, parametric design and digital fabrication in architecture. The focus of this Design Studio is on how to use Rhino3D with Grasshopper efficiently when modeling basic and more organic and fluid geometries, how to start using Grasshopper from scratch with a beginner-friendly learning approach, and how to understand the logic behind parametric modeling. This basic course provides an introduction to parajetric thinking and complex 3d modelling and algorithmic design methodologies. Rhinoceros3D is a powerful 3D Nurbs-based modelling program with incredible precision and customisability that is increasingly become industry standard in many design fields. Participants will gain a practical understanding of parametric geometry and more complex topological surfaces [Tedeschi, 2014].

This course provides an introduction to complex 3d modelling and algorithmic design methodologies. During the parametric design classes [Figure 12] the tutors and students also discussed and critically evaluated to identify appropriate materials and manufacturing techniques as well as the assembly process and connections. Considering the budget, manufacturing capability and process of construction it was decided to use plywood and CNC milling for manufacturing of

Fig. 9. The day view on the BEES Project form (by students: Angelika Bojko and Paulina Ossolińska)

Fig. 10. The night view on the BEES Project form (students: Angelika Bojko and Paulina Ossolińska)

Fig. 11. Magnolia Project on the semi-opened courtyard of Szczecin's City Hall by students: Natalia Rzepka and Aleksandra Moroz

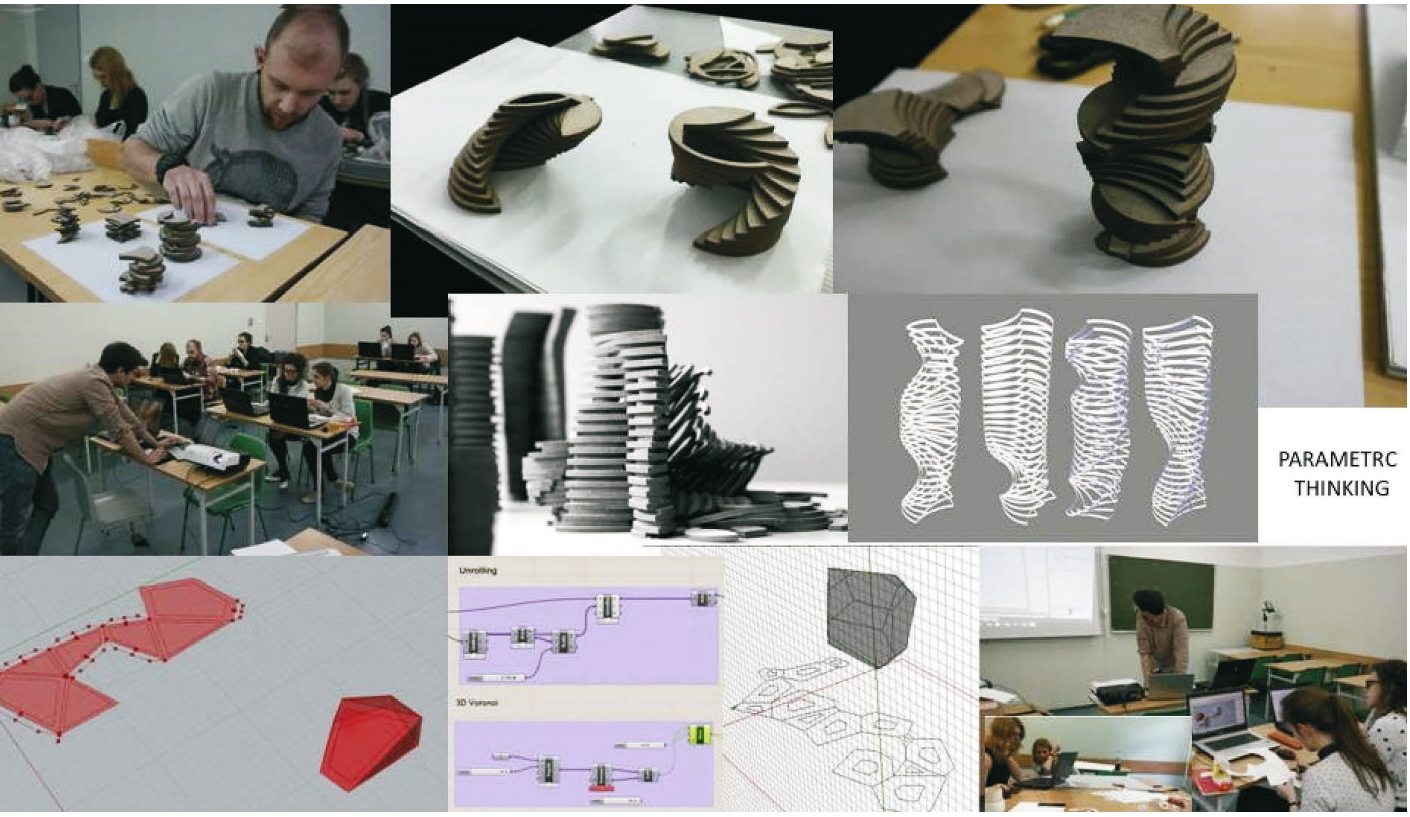


Fig. 12. Parametric Design Studio, Parametric Thinking Workshop; source: author's didactic material

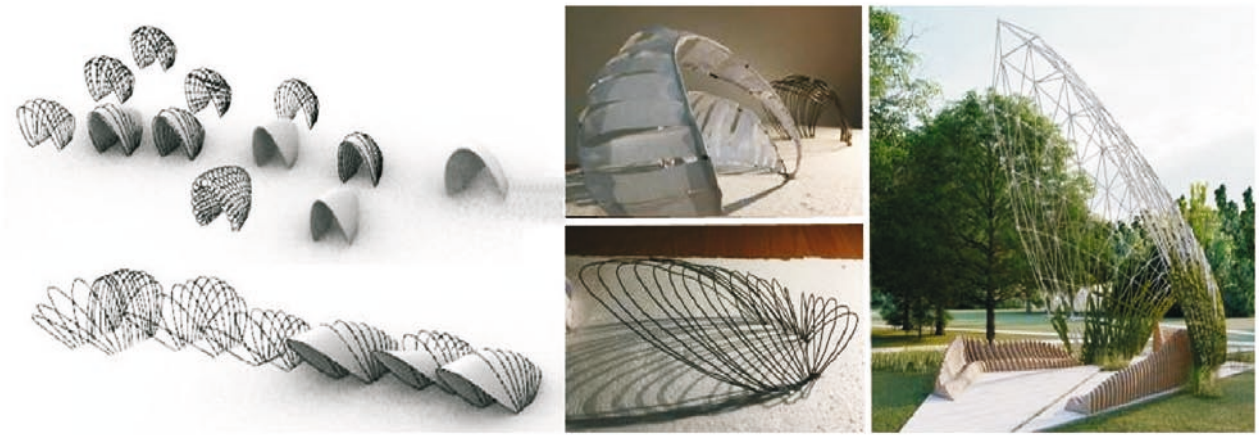


Fig. 13. Designing a parametric pavilion in the public space: digital and physical models by student Aleksandra Smal

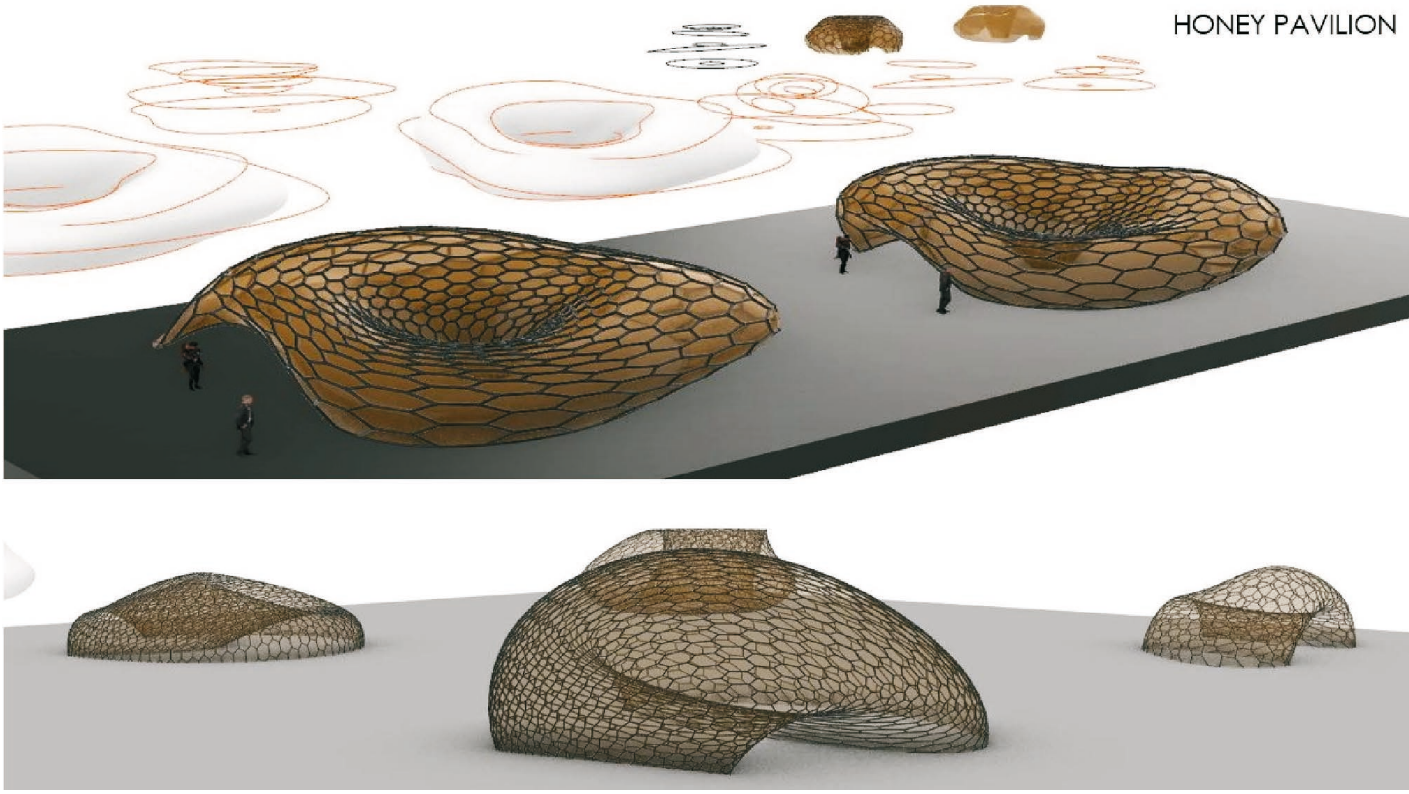


Fig. 14. In the search of form and surface (student Maciej Nestorowicz)

each piece in the frame. Through development of computation and prototyping a simplified way of assembly and fixing techniques, using notches, was identified. This also allowed the team to achieve flush edges at the joints, as the depth of each notch was half the width of a piece [Koralevic, Parlac, 2015].

This course provides an introduction to complex 3d modelling and algorithmic design methodologies. Rhinoceros3D is a powerful 3D Nurbs-based modelling program with incredible precision and customi-zability that is increasingly become industry standard in many design fields. Participants will gain a practical understanding of basic geometry and more complex topological surfaces.

Fig. 15. Honey Pavilion by student Maciej Nesterowicz. The final 3D render.

Following 3D renders present the effects of the teaching program based on the same research-by-design method as Interactive Design.

The focus of this Parametric Design Studio is on how to use Rhino3D with Grasshopper efficiently when modelling basic and more organic and fluid geometries, how to start using Grasshopper from scratch with a beginner-friendly learning approach, and how to understand the logic behind parametric modelling. The parametric designs present general knowledge about interactivity, NURBS programming and is followed by the explanation of design process [Figure 13-16]. The results introduce chosen projects prepared by the students from both, interactive and parametric design studios.

8. DISCUSSION

The recent decades more than anything else have revealed the ambivalence not only of the articulated expectations about the digital public sphere but also of the 'real' development itself. This thematic issue of Media and Communication highlights some of the criticalities and specificities of the evolution of the public sphere during this period where digital communication ecosystems are becoming increasingly central. The different articles offer a polyphonic perspective and thus contribute significantly to the debate on the transformations of the public sphere, which—in the time of the Covid-19 pandemic – dramatically affect the very essence of our democracy. Today the range of the interactive and parametric studies and designs include the analysis of the new interactive design trends observed in public spaces. Urban interiors keep evolving both in definition and meaning. Early theoretical analysis of public urban spaces was based mainly on the research on a human visual perception and overall esthetics. They related to the need to combine art, architecture and city into one. However, it is Camillo Sitte first who brought up the aesthetics of public spaces and malleable approach to city design and is being considered the pioneer of the urban analysis. Following the development of this area of art it is worth mentioning that the early theories either ruled out or diminished the human factor and the role of consumers in a particular space. a rapid increase in this field can only be observed in the span of the recent decades, during which the urban manifestos started including concepts like "place-making" or social participation in creation of urban *genius loci*. The urban tissue undergoes changes through active actions of designers cooperating with local citizens as well as bypassers. The interaction between human and space which allows the former to manipulate the latter is becoming more significant. The examples of such a shift include passive interactions like 3D mapping or design means actively engaging person, which are a core of this paper. In 2004, columnist George Lawton, in an article titled "Machine-to-machine tech-

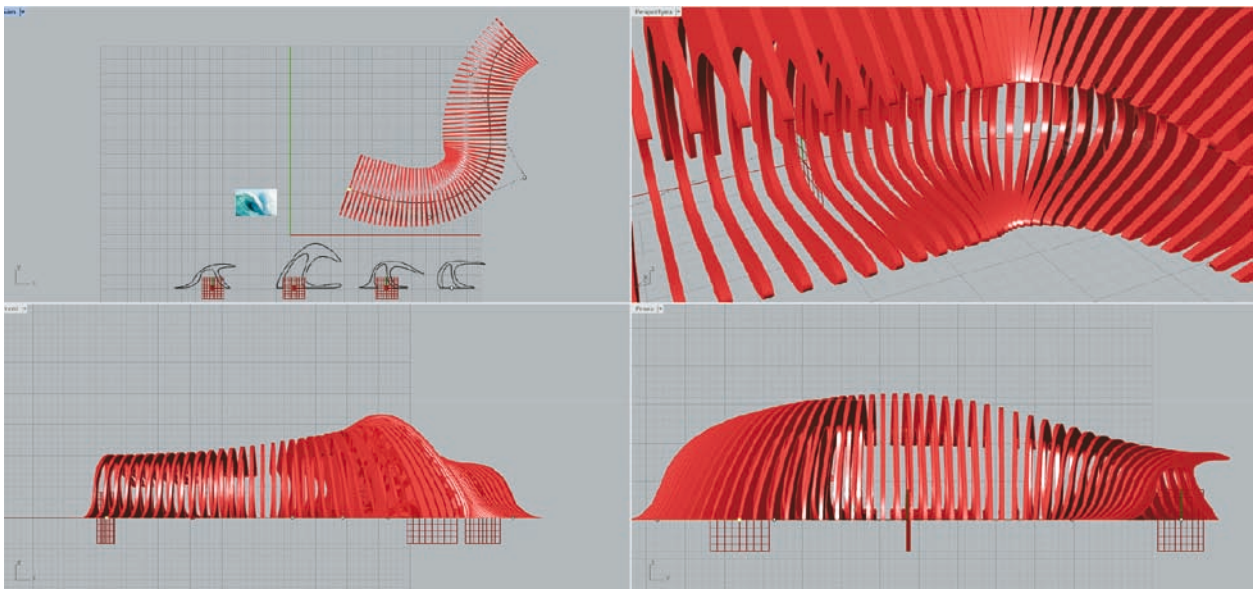


Fig. 16. Wave Pavilion by student Monika Cierpiał. Inspiration of shape modeling and surface contouring and the final design render

nology gears up for growth" for Computer "magazine, writes'' that there are already more mechanical, electrical or electronic machines in the world than people, and the number of those that are interconnected is growing. According to him, the idea of M2M is based on the premise that "machines are more valuable if they are networked, and a network is more valuable the more machines connected in it." In terms of sensing the place itself, quoting McCullough - interaction design must serve the basic human need for getting into place. Like architecture, and increasingly as a part of architecture, interaction design affects how each of us inhabits the physical world [McCullough, 2004]. Digital media expanding the scope of influence of visual arts has opened new research areas on the psychology of perception.

In digital design, virtual space appears as an inevitable medium for articulating the design space. Virtual architecture is defined by the digital environment in which the design is created. The database, corresponds to the digital space of design-support programs. The virtual potential of architecture should be considered together with the digital environment of the project. The digital design space is defined by computer, mathematical and algorithmic logic. Implications of digital formats by functions and polynomials have yielded applications with expanded spatial capabilities. For example, NURBS parametric curve geometry allows accurate modelling, without analytical approximations, of arbitrary curves and surfaces, with a single set of commands [Januszkiewicz, 2012]. Digital space, having introduced a base time organized interactively and dynamically, can trigger such spatial operations as evolution, transformation, hybridization and mutation. The extension of animation takes advantage of the properties of compound time, which can be viewed as nonlinear, differently understood from the time of the fourth dimension of architecture animation. The nonlinear time reading system is the opposite of kinematic modulation. It is being used increasingly in the formation and representation of architecture and in technology.

The rapid development of computerization after 1990, resulting from the creation of the Internet, allowed for the progressive implementation of interactive surfaces and structural elements into all architectural spaces. Simultaneous progress in the design of virtual spaces has led to the creation of computer-aided tools to support such environments as the creation of computer games, web applications or even special effects in films. Thus, designers brought about the inception of immersive surroundings, which lead to the perception of an artificially created, illusory environment as a real one through the use of technologies such as, for example, CAVE (Cave Automatic Virtual Environment) or HMD (Head-mounted display) [Pazdur-Czarnowska, Yatsiuk, 2021].

Currently available sensors can detect almost anything, from complex gestures to CO_2 emissions and hair color. The interconnected digital world means that, in addition to sensory perception, data sets ranging from Internet usage to traffic patterns and crowd behavior can be the drivers of interactive buildings or environments. The technologies required are simple enough to enable designers who are not computer experts to prototype their ideas in an accessible way and communicate design intent. New developments and ideas, driven by applications, will quickly support advanced thinking in the discipline; however, it is important to understand that their foundations have been in place for some time, going back almost thirty years. The growth and impact of digital technologies in the world of connected networks has led to an explosion of current exploration with the fundamentals of interaction design in architecture. The Internet of Things (IoT) has fairly quickly begun to define the technological context of interactive design as a holistic element of connected networks and environments that affects essentially everything from graphics to objects, buildings and cities. The term "Internet of Things" is first used in 1999 by Kevin Ashton, director of the Auto-ID Center, who, along with David Brock and Sanjay Sarma, applied RFID (Radio – Frequency Identification) technology to identify individual devices connected within a single network. A year later, LG launches the first Internet-connected refrigerator, which at the time was not received favorably by potential customers due to its price and, in their view, unnecessary features [Suresh, Daniel, Parthasarathy, Aswathy, 2014].

CONCLUSIONS

The emergence of digital media generated a whole array of euphoric expectations regarding the reconfiguration of the public sphere: one points to an emanating network society characterized by a dehierarchized structure [Castells, 2011], and by a new autonomy from the 'institutional' power [Castells, 2015]. Others emphasize the prospect of public debates being more inclusive, especially of those segments of the population that had been previously marginalized. The prospect of using innovative didactic programmes in research or teaching projects is currently one of the most desirable postulates of the academic world. Crossing disciplines' methodological and epistemological boundaries is a proven practice that yields

revolutionary results in the conducted research or didactic process. The students, coming from the Faculty of Architecture and Interior Design, are acquainted with the premise and the design processes of interactive environment in the public space and parametric modelling. It has become essential to indicate multimedia techniques currently used in the design of existing urban spaces, such as Lighting Control Engines used on facades, sensory systems reacting to human exposition, DMX control software, timer activated networks and others. Wide area of issues related to computer technologies and the brand-new tool in the form of AI required deep research during the early stages of the design process. Digital out-of-home media and pervasive new technologies are bringing the internet experience into public spaces and stepping up the pace with which brands and products, as well as their virtual representations, penetrate urban environments. This article explores the current phenomenon of pervasive advertising and its underlying perceptions and puts forward a typology for describing a range of applications for the emerging media infrastructure. It argues that the critical dimensions comprise the way in which pervasive advertising and creatives exploit both physical and social contexts by increasingly relying on the effects of illumination, temporality and spatiality [De Blasio *et al*, 2020].

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CONFLICTS OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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