

Universidades Lusíada

Silva, Fátima, 1963-
Negas, Elsa Inês Silva do Rosário, 1968-
Seco, Rui, 1971-

**Technology, mathematics and architecture :
order and structure in the formulation of space**

<http://hdl.handle.net/11067/7610>
<https://doi.org/10.34628/K1RY-8Z37>

Metadados

Data de Publicação	2024
Editor	Universidade Lusíada Editora
Palavras Chave	Arquitectura e matemática, Arquitectura - Inovações tecnológicas, Cidades e vilas - Inovações tecnológicas, Construção sustentável - Países da União Europeia, Desenvolvimento urbano - Portugal - Almada, Cerâmica, Artes do espectáculo
Tipo	article
Revisão de Pares	Não
Coleções	[ILID-CITAD] Contribuições em livros

Esta página foi gerada automaticamente em 2026-10-30T02:05:44Z com
informação proveniente do Repositório

TECHNOLOGY, MATHEMATICS AND ARCHITECTURE

ORDER AND STRUCTURE IN THE FORMULATION OF SAPCE

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DOI: <https://doi.org/10.34628/K1RY-8Z37>

Technologies, in their multiple dimensions, were the key focus of the 5th International Seminar on Architecture and Mathematics 'Formulas in Architecture'.

Intricately connected to mathematics and science, technologies are also articulated in the field of construction with architecture, a framework that enables the transformation of our environment, giving shape to it and physically defining the world we inhabit.

In this seminar, the concepts of structure and order intertwined with arts and other creative areas, from graphic representation to music and to performing arts, as well as to new technological developments. In this sense, the extended horizons brought by the digital developments currently broaden the scope of transformative action, from architectural conservation and rehabilitation to energy performance improvement.

Technologies help us in the understanding and interpretation of the habitat, better preparing transformative intervention, recognizing traditional values and the required balance between man and nature.

At a time when housing is once again becoming a pressing social issue, the examples of collective dwelling construction based on innovative and thoughtful prefabrication systems presented by Alberto Reaes Pinto in his keynote presentation provided an opportunity for further consideration and learning.

It is of the utmost importance that the most fruitful experiences of dwelling provision in Portugal may inspire the current debate on housing and the city, facing contemporary scarcity and need to intervene. The cases of Santo António dos Cavaleiros and Quinta do Morgado, two major developments conducted by the architect half a century ago in the outskirts of Lisbon, presented the use of a total heavy prefabrication system as a viable means to produce dwelling in a standardized and cost-effective way, integrating the full process of design and construction, from the first sketches to the finishing of the construction.

Following the assertion by the 'father' of rehabilitation Viollet-le-Duc that renovation and preservation are both modern ideas, Nora Lombardini made her keynote address on this theme. Heritage conveys the background and cultural inheritance of a people, making worth the efforts to conserve, faithfully preserving the original.

Rehabilitation allows new generations to enjoy their heritage and value their culture and history. The difficulties in obtaining and processing all the information about each building, such as durability, structural resistance and materials, were elaborated by the professor, highlighting the benefits of virtual models as effective tools in the study of existing buildings and their rehabilitation projects. Building Information Modeling (BIM) was pointed as capable of guaranteeing the necessary interoperability between the different players and, at the same time, being an effective interpretative tool of the constructive reality it represents.

Melik Ziya Yakut reflected on a very important topic nowadays, sustainable and clean energy. His keynote speech related current energy targets with architecture in cities, for which buildings must achieve better sustainability capabilities. Energy saving is critical to this goal, through its efficient use, and the use of technological advances in the construction industry is key in that regard, developing and employing environmentally friendly and sustainable forms and materials, using innovative energy-oriented technologies.

The production of energy from clean and renewable sources is another key aspect towards the reduction of this energy problem, amidst the strong population growth. If energy consumption in industrially developed countries has remained stable, in poor and developing countries the situation has increased greatly, using highly polluting energies. However, technology has evolved, and it is possible to enable progress towards a sustainable future.

The other keynote speech, by Nikos Salingaros, addressed the beneficial connection between traditional design and human health issues. A new understanding of the living structure in relation with urban space is sought in this study as a way to engage users with architecture using a special healing geometry.

Ornament, nested symmetries and inverse-power distribution of sizes, such as fractal-based geometries, are factors that Salingaros highlighted as part of an subliminal reality that shapes unconscious human responses to architecture, from neuroscience observations using software analysis. Christopher Alexander's studies, among others, and traditional and vernacular architectures concur to this revolutionary revision proposition on architectural design, aiming at the development of a special healing geometry that links to our natural evolution, to generate emotional nourishment and boost immune responses.

Besides this broad spectrum of keynote addresses, a set of scientific papers has been presented to the seminar, being subject to a peer review process towards publication.

Luís Moreira Pinto and Emilian Gwiazdziński presented a study on the development of a digital perception tool for architectural atmosphere measuring. This instrument takes the form of a mobile app, named LikePlace, based on the development of an algorithm that evaluates the emotions that a specific place causes to most people. This evaluation is the result of collecting and processing information, creating a classification based on the dominant colors, the geometric shapes and volumes. LikePlace thus consists of a social network, interconnecting places wherever it is used, and allowing digital dissemination for tourism and real estate promotion.

The role of Building Information Modeling in the progress of sustainability in the Architecture, Engineering, and Construction industry sector was the subject of a presentation by Rita Ferreira. This study bases on a literature review on the strengths of applying BIM, emphasizing the possibilities of this methodology in the implementation of better practices. Easier communication between the various teams developing a project and more reliable sharing of information, minimizing errors, are pointed benefits of this methodology, building up a database that can be stored and assessed afterwards.

A technological instrument to assess urban space was presented by José Nuno Beirão and João Paulouro Neves. Convex and Solid Void (CSV) analysis through an algorithm created in this work is used to assist areas such as public management, city design, the real estate and retail sectors, the telecommunications and transport sectors and urban planning. A thorough and operative analysis of open urban spaces is performed by the model, which generates the Convex Void by associating the scanned points with a range of 3D information, such as elevation, slope, elevations of boundaries and neighboring spaces, as well as pre-existing GIS information.

The analysis of the territory is the subject of the study presented by Rui Seco and Elsa Negas, assessing the level of infrastructure on a given area. From the interpretation of the setting of infrastructure in the estuarine territory of the Tagus through history is molded a contextualization to the testing of the urban infrastructure index, an evaluation tool that comprises a set of infrastructure and basic urban services created by the authors. The area of Almada, on the left bank of the Tagus, is assessed to evaluate the infrastructure levels in a series of spots, registering and interpreting the differences, while also fine-tuning the index itself.

Miguel Brito presented a study on the theme of scale definition for patterns in architecture. The presentation emphasizes the importance of scale in the message to be conveyed in architectural design, as well as in the identified patterns. From the analysis of several examples that convey different ranges of information, depending on the scale, the author points out the appropriate scale as a key requirement for analyzing patterns. The prominence given by the observer to a single element in comparison to whilst associated with others with different scales is also considered in the study.

From the present-day importance of buildings' energy efficiency, António Afonso presented a study on the technical measures necessary to acquire a sustainable rehabilitation of existent residential buildings, exposing the case study of Bairro de Alvalade neighborhood, in Lisbon. Identifying frequent anomalies and the most likely causes for their appearance, the author considered that sustainable rehabilitation should primarily focus on the building's exterior envelope and thermal elements, and focused on specific advantages and disadvantages in the opaque building envelope, window intervention and ventilation.

A more comprehensive theme was tackled by Joaquim Marcelino, presenting a study on constants of nature, constants of architecture and mathematical interface, reflecting on quantities, order and geometry. This research studies the practical means required by architecture and art, such as materials, techniques,

and technologies, bound by natural laws. 'Is mimesis a natural instinct?' is a question the study aims at responding, stating the author that the expression of mathematics in architecture, through geometry or geometric-mathematization, is rooted on intellection, and not in a sensory experience or the direct need of shelter.

The connections between mathematics, geometry and architecture were also addressed by Luísa Paiva Sequeira in her presentation on the illusory games of anamorphosis. Different techniques of controlling and influencing an observer's perception of a surrounding space are analyzed and explained in this study, showing how the understanding of the observer's view as he wanders through a space enables the creation of the intended optical illusion effects. The study also tackles the evolution of anamorphosis assisted by technology, as illusory games can be both real or virtual, executed using traditional methods or new technologies.

This 5th Seminar involved a more practical hands-on dimension with the participation of architecture students. This consisted in a ceramic tile creation workshop, from the creation of the geometric concept to its experimental production by direct manufacture by the participants, tutored by the ceramicist Alice Dinis.

This workshop was framed by a conference by the architect and ceramicist Maria Ana Vasco Costa, presenting her design on a range of architecture work, in many cases collaborating with other prominent architects. Innovative geometrical tile-based façades were exhibited by the architect, that referred her study of dimension, light, framing in the street, square and city as basis of her design.

Maria Ana Vasco Costa's work provided the frameset that inspired the work that the students themselves then developed and was afterwards presented at an exhibition associated to the seminar, that the participants had the opportunity to attend, appreciating both the representations of the patterns created by the students and the experimental tiles they also produced.

There were also three invited speakers in the seminar.

Adelaide Carreira and Suzana Metello de Nápoles introduced a video presentation on the evolution of tiles through history, namely on the Portuguese case. Developed at the time of the pandemic as part of the Intuitive and Interactive Geometry Project, this video, named *The Geometry of Architecture*, showed in depth the associations between formulas, the geometry of shapes and their implementation.

This presentation enabled the visualization of complex shapes and the intuitive perception of their generation, using emblematic works of architecture to acknowledge the embedded geometric figures.

The notion of purity associated to geometry, as a materialization system of rectitude in reasoning is the starting point of the presentation made by Mário Chaves on topology. The Cartesian system of thought that conducted western civilization over the last 30 centuries is asserted by the author as a legitimization of an architecture founded and legitimized itself as the splendour of built form in sedentary society, distancing itself from natural topological forms and towards a

possible simplification, through the form of Platonic ideal multiplication, which came to suit the systematization of industry, in its immense power to standardize, systematize, trivialize and repeat.

By combining distinctive artistic disciplines Vasco Mendonça related architecture to music and theatrical performance, presenting a lecture on the handling of spatial issues in musical creation. From this vast and complex field, comprising various sub-fields of research, the author focused on his own work as musical composer to reflect on concrete examples of the connection between scenic space and musical narrative. Four musical plays – two musical theater pieces and two chamber operas – were analyzed by the composer, focusing on the different spatial approaches in the stage work and their intertwining with the musical narrative.

The broad field of presentations and studies of the 5th International Seminar on Architecture and Mathematics 'Formulas in Architecture' explored, once more, the interconnection between these disciplines. The always evolving nature of technology fostered this edition, in which technical expertise and new digital developments contributed to a comprehensive address of the relation between Mathematics, Architecture, and also further artistic and knowledge areas.

From the evolution of construction techniques to newcoming design assistance, this set of research work explored many innovative developments. But it also focused on the preservation and rehabilitation of ancestral, cultural and artistic values, as also highlighted nature as the main asset that humanity needs to preserve and has to reach for ideas and solutions for the future.

Order and structure are defining features, or cornerstones, of both architecture and mathematics. Human perception of these values is key in the beneficial transformation of our habitat, in the quest for a sustainable future that we all can aspire for. This seminar focused on technology to grind towards these objectives.