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*Nexus 2000:
Relationships Between
Architecture and Mathematics*

4-7 June 2000, Ferrara, Italy

The Nexus 2000 conference

"Mathematics and Architecture" was the theme of the international conference Nexus 2000 (the proceedings of which, *Nexus III: Architecture and Mathematics*, are already published [Williams 2000]), held in Ferrara at the MusArc, the National Museum of Architecture. This was the third edition of the conference, organized by Kim Williams, and by now an established biennial appointment for international scholars to discuss papers that refer to relationships between mathematics and architecture.

The presentations were inspired by diverse ideas, but were in any case linked by a certainty: it is above all the intentions (which then lead to certain decisions) that need to be made explicit, especially when the research takes its point of departure from an area that is apparently very far afield but which is then brought to bear on themes related to the disciplines at hand. It is in this context that, in the course of the conference, discussions went from the analysis of the proportions of a Palladian villa (in the presentation by Rachel Fletcher) to the study of harmonic relations in the Cappella dei Pazzi in Florence (presented by Mark Reynolds). Further presentations went from interesting presentations of eastern architecture, where the leading motive is the search for the mathematic underpinnings of every kind of endeavor, to the fascinating presentation of David Speiser on Raphael's painting, *Lo Sposalizio della Vergine*, in which mathematics, architecture and theology have various points of intersection and where the geometry of significant elements in the painting is united to symbolism with extreme effortlessness.

Among the various presentations it is appropriate to mention those in which the link between architecture and mathematics lends itself to the teaching of mathematics. For example, Franca Calì and Elena Marchetti presented a very valid experiment based on the creation of a virtual model through the use of a generative mathematical technique. The operative procedure consisted in observing the architectural object, extrapolating the geometric form that describes it, determining the mathematical equations of that form and then constructing the virtual model. Using a generative technique, the presenters explained, means singling out a base form to which is then applied a transformation, generally a linear transformation, through the use of matrices. It is clear that, in the description of an architectural object, the models can be many and various; that which was presented was a model that, given the simplicity with which the curves were described, could easily be used in teaching an introductory course in mathematics in a faculty of architecture. The analysis of the model, and of the type of model in combination with the forms being considered, is a notable stimulus for the design process, both from an expressive-communicative point of view and from a critical-operative point of view. These are two extremely relevant aspects for the acquisition of content and of methods of investigation, which obviously should be part of a didactic strategy at the university level.

The Nexus conference closed with the presentation of Alessandra Capanna, who recalled the emotions, sounds and history of the project for the Philips Pavilion of Le Corbusier. In 1956 the architect was commissioned by the Philips Corporation to design a structure in which it was not necessary to exhibit any of Philips's products, but which would be a demonstration of the boldest effects of light and sound to illustrate what Philips's technical progress might carry us in the future. This was in effect a request for a symbol, a perennial image! The architect accepted the commission, but his intention was to create a *poème électronique*. It was for this reason that he asked the musician Iannis Xenakis to translate his ideas through the use of mathematics. Xenakis, using numbers and notes, determined the geometric forms for the pavilion, made of hyperbolic paraboloids with splendid cusps, put there as though to underline the force of the message and to indicate the thrust towards an innovative and progressive future. The point of departure was a problem of minimums. Xenakis was convinced that the architect should frame the problems differently from how this had been done in the past, asking himself, "what geometric form should the enclosure have so that the quantity of material used in its construction is minimum?" It is mainly engineers and experts in statistics who are occupied with the problem of minimum forces in enclosing materials. Through the use of computers the projection of particular solutions led architecture to a period of great originality, permeated by revolutionary thought, and certainly innovative: "the architect, abandoning the right angle, must be daring with forms that draw upon curved spaces."

It is in this context that the Philips Pavilion lies, with its futuristic form and its message communicated through sound, color and imagery. In the interior is the *objet mathématique*, which justly recalls a polytope, the 24-cell, projected into three-dimensional space. The introduction of the fourth dimension – spatial and not temporal – not only into the imaginary space but into the constructed space as well, is a bold and difficult undertaking. The designed space is united with the abstract space of mathematics, but "the variables of the constructed n-dimensional space depend as well on the reflections and the discoveries of scientific and philosophic thought, and consequently, are tied to the evolution of the concept of beauty".

The wealth of emotions raised by each of the presentations, in a setting of great sympathy and amity, make Nexus a much-anticipated appointment. It is a moment in which to reflect profoundly on one's own daily work and an invaluable occasion both for comparing one's own ideas with those of scholars from other countries as well as transmitting the passion with which each individual research aims to come closer, and to bring us closer, to mathematics.

Experiences of a modeling laboratory

Contemporary with the conference, the Musarc hosted the didactic exhibit entitled, "Experiences of a Modelling Laboratory", designed and realized by the Istituto Statale d'Arte Sperimentale of Monza in collaboration with the Liceo Artistico of Busto Arsizio. In design culture and in the didactic tradition of an institution for experiments of an artistic nature, the model is not recognized as only a three-dimensional artifact but instead has a wider connotation: the model is tied to the concept, that is, to the design; to the language, that is, to its description; to the reality, and therefore to the interpretation and reproduction. It is obvious that the study of form – the primary research in the connection between architecture and mathematics – constitutes a primary field of enquiry that is indispensable for the research, analysis and design of models; still more evident is that, in this process, various didactic experiences belonging to different disciplines are brought to convergence.

At the MusArc were displayed various didactic itineraries, as for example that of the polyhedra that comprise two models of polytopes – the 24-cell and the 120-cell – and that of the tilings of the plane with models of beautiful Italian pavements inspired by the work of Kim Williams. The exhibit also presented some interesting results of reflections on and analysis of works of great artists who measured themselves against the aesthetic and rational values of geometry: from Ledoux to Le Corbusier, from Nervi to Calatrava, from Le Ricolais to Frei Otto and Fuller.

The imposing model of the tetrahelix, at the center of the upper room, is emblematic of the research described. The form consists in a column – which theoretically could be reproduced to infinity – of regular tetrahedra joined in such a way so that each polyhedron wholly shares with two others a surface and with three others a vertex. The potential growth to the infinite is one of the most fascinating aspects of the tetrahelix.

The search for beauty and harmony that permeates all the works exhibited is common to the history of all branches of knowledge, though with different canons and languages. Researchers of note have always been found in this field of enquiry. We recall only two, distant from each other in time but very close in terms of their aims. The first is Leon Battista Alberti, who held that beauty is the agreement and harmony of the parts in relation to a determined number, just as the fundamental and most exact laws of nature require. The other researcher, already amply cited, is Le Corbusier who, in the third chapter of his book *The Modulor* says, “Mathematics is the majestic structure conceived by man to grant him comprehension of the universe...Harmony reigning over all things, regulating all the things of our lives, is the spontaneous, indefatigable and tenacious quest of man ...pursuing one aim: to make a paradise on earth.”[Le Corbusier 2000: 71-74]

It is important to note that beauty and harmony are not the exclusive patrimony of a particular area, but are part of the culture and the research of all disciplines. Only by bringing all precepts, obviously each in its own specificity, to converge in the same direction, will it be possible to bring to light forms and typologies in a global consciousness that is truly innovative and lasting.

First published in the NNJ online Winter 2001

Acknowledgment

This report appeared for the first time in *Lettera Matematica Pristem* no. 37, pp. 62-64, and is reproduced with permission.

For further reading

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About the reporter

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