Interdisciplinary Courses: a Personal Experience
Math, Art, Architecture

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The paper elaborates on my experience with interdisciplinary courses between mathematics and a number of subjects (including art, architecture,...) over a number of years. These academic activities started as a personal experience more than 30 years ago. For many years I was (and I still am) officially a full professor in Math and non-officially I worked on the relationships between mathematics, art, architecture, biology, physics, literature, cinema. At a certain point of my activity my work on art and math was recognized as official work in mathematics.

Introduction

“Changes in education are not going to produce miracles. The division of our culture is making us more obtuse than we need be: … we are not going to turn out men and women who understand as much of our world as Piero della Francesca did of his, or Pascal, or Goethe. With good fortune, however, we can educate a large proportion of our better minds so that they are not ignorant of imaginative experience, both in the arts and in science.”

On October 6th 1956 an article by Charles Percy Snow was published on the New Statesman that discussed a problem that would have been developed in a lecture and a book three years later. The book, entitled The Two Cultures [1] compared the scientific and humanistic culture. The book sparked a long polemic that moved Snow a few years later, in 1963, to publish an appendix to the book that concluded with the words quoted at the beginning.

In the introduction to the 1993 edition Stefan Collini, professor of English literature at the University in Cambridge wrote: “We need to encourage the growth of the intellectual equivalent of bilingualism, a capacity not only to exercise the language of our respective specialism, but also to attend to, to learn from, and eventually contribute to, wider cultural conversations.” [2], [3]

My personal experience with interdisciplinary courses between mathematics and a number of subjects (including art, architecture,...) started more than 30 years ago. For many years I was (and I still am) officially a full professor in Math and non-officially I worked on the relationships between mathematics, art, architecture, biology, physics, literature, cinema. At a certain point my work on art and math was recognized as official work in mathematics. I was very proud when I received as national coordinator two grants in 2007 and 2009 for research on mathematics and modern art and architecture. These grants were assigned by the Italian Committee for National Funds (PRIN) for mathematics. Due to the economic crisis in Italy and in the funds for the Universities a choice like this means that other researches, strictly math researches, did not receive a grant. Due to the change in the attitude of the Math community it was possible to undertake several projects:

Conferences and books


Exhibitions


Films

20 films of the series Art and Mathematics produced in several languages, shown in the Italian State Television and other TV channels, including the film on Soap Bubbles, featuring mathematicians at Princeton University, Fred Almgren and Jean Taylor. A film on Escher with Roger Penrose and Donald Coxeter, a film based on the book Flatland all in animation, original music by Ennio Morricone. All films were produced in French for the Cité des Sciences de la Villette in Paris. Most of the films produced also in English and Spanish versions.

Courses at the University

In 2004 I launched a completely new course, essentially visual, existing only at the University of Rome, called Space and Form, an interdisciplinary insight of the relationships between mathematics, art, architecture, biology, literature, theatre, cinema with a myriad of applications in all these fields during the XIX and XX century. It involves students of the last years in math, design and architecture, including a small group of ERASMUS students from several European Countries. Architects, like Massimiliano Fuksas, artists, writers, film makers like Gustavo Mosquera, came to present their works to the students for the course. One important result of this activity was:

- The Literary Viareggio Award 2010 (Best Italian essay 2010) for the book on Soap Bubbles (in Italian). From the motivation of the Jury: “Emmer wrote an extraordinary book in which mathematics and science, analytical rigor and artistic sensibility is a perfect match, ...a real adventure of intelligence, which he reconstructs in masterly fashion by giving us a book not only interesting, but rare.” The same book also received the Premio Capalbio Scienza 2010 (Best science book)

Interdisciplinarity: One interesting example of math and architecture

One of the main topics of my courses on Space and Form is the relationship between math and contemporary architecture. The main reasons for considering this topic for the students of math and architecture (it is indeed an interesting experience to have math students together with architecture students) are:

- the idea of metamorphosis
- the idea of transformations
- the idea of topology.

These are the motivations:

**a) Metamorphosis**

“Many of the great creative acts in art and science can be seen as fundamentally metamorphic, in the sense that they involve the conceptual re-shaping of ordering principles from one realm of human activity to another visual analogy. Seeing something as essentially similar to something else has served as a key tool in the fluid transformation of mental frameworks in every field of human endeavour. I used the expression *structural intuitions* to try to capture what I felt about the way in which such conceptual metamorphoses operate in the visual arts and the sciences...The expression *structural intuitions* attempts to capture what I tried to say in one phrase, namely that sculptors, architects, engineers, designers and scientists often share a deep involvement with the profound sense of involvement with the beguiling structures apparent in the configurations and processes of nature – both complex and simple. I think we gain a deep satisfaction from the perception of order within apparent chaos, a satisfaction that depends on the way that our brains have evolved mechanisms for the intuitive extraction of the underlying patterns, static and dynamic.”

Words by Martin Kemp, an art historian specialized in the relationship between art and science in his article for the catalogue of the 2004 Venice International Architecture Exhibition. [11] Kemp writes mainly about architecture. The image accompanying Kemp’s article is a project by Frank O. Gehry, an architect who obviously cannot be overlooked when discussing modern architecture, continuous transformation, unfinished architecture, and infinite architecture. These words, projects, and ideas at the 2004 Exhibition were visually closely connected to the ties between mathematics, architecture, topology, and transformation. Let’s backtrack a bit, to the early 1990s. In 1992 the architect Eisenmann (who won the Leone d’Oro for his architectures at the 2004 exhibition) and his collaborators projected a skyscraper in Berlin, the *Max Reinhardt Haus*. The structure of the enormous building is based on a topological surface, the Moebius strip. In 1993 Ben van Berkel planned and built the *Moebius House*. So these two projects held the place of honor in the large hall of the Corderie, as if a reminder of an important step in contemporary architecture, in the idea of transformation, of metamorphosis. An explicit reference to topology.

**b) The fascination of topology**

Jules Henri Poincaré held that “the geometrical axioms are neither synthetic a priori intuitions nor experimental facts. They are conventions. Our choice among all possible conventions is guided by experimental facts; but it remains free, and is only limited by the necessity of avoiding every contradiction, and thus it is that postulates may remain rigorously true even when the experimental laws which have determined their adoption are only approximate.

In other words the axioms of geometry are only definitions in disguise. What then are we to think of the question: Is Euclidean geometry true? It has no meaning. We might as well ask if the metric system is true and if the old weights and measures are false; if Cartesian coordinates are true and polar coordinates are false. One geometry cannot be more true than another; it can only be more convenient. Euclidean geometry is and will remain the most convenient.”

Poincaré, in *Analysis Situs* [12] (Latin translation of the Greek τόπος, luogo, e λόγος, studio), published in 1895, is responsible for the official birth of the sector of mathematics which today is called *Topology*:

Poincaré defined topology as the science that introduces us to the qualitative properties of geometric
figures not only in ordinary space but also in more than 3-D space. It is important to mention that the discovery (or invention) of non-Euclidean geometry, the higher dimensions (from the fourth on) and topology, the new idea of space to summarize, is one of the most interesting examples of the profound repercussions that mathematical ideas will have on humanistic culture, art and architecture. [13]

The key word is geometrical intuition. Some of the topological ideas were sensed by artists and architects in the past decades, first by artists, then much later by architects. [16] Mark Burry, who is in charge to complete the Sagrada Familia by Gaudi in Barcelona [17] dedicated a chapter on topology in his recent book [18] The New Mathematics in Architecture. He wrote:

“The freedom that topology affords in architecture as a more generalized framework that geometry has received greater appreciation in the post-digital age…The essence of architectural and urban planning is also captive in such non-geometrical diagrams, as are the relationships between component spaces or activities of building. This is regardless of how building itself may solidify through the process of design and construction into a static, unchanging form that is also subject to detailed geometrical description. It is possible that the organization of the early development world of our childhood is a similar network of connections between significant places and things, and it is only later and gradually that the absolute reference of metrical Cartesian space is superimposed on our established perception of proximities and relationships…

What is it about topology and its freedom of description that has seized modern architectural production, long after the underlying ideas were in common domain? It became possible to model surfaces that could change, stretch, adopt free from curvature, or conform to a geometrical rationale without loosening their integrity – wonderful surfaces that, plastically and geometrically at least, exceeded the behaviour of any known material and could be given visual material qualities at a whim…Topological description is being adopted as the means of mapping architectural intention, and with it arrives the progressive discovery of how to map this onto the frozen Euclidean moment in the physical world.”

c) Topological and Fluid Surfaces

In the chapter Topological Surfaces Alicia Imperiale writes: [19]

“Topology is the study of the behaviour of a structure of surfaces which undergo deformations. The surface registers the changes in the differential space time leaps in a continuous deformation. This entails further potential for architectural deformation. Continuous deformation of a surface can lead to the intersection of external and internal planes in a continuous morphological mutation, exactly like in the Moebius Strip. Architects use this topological form to design houses, inserting differential fields of space and time into an otherwise static structure.”

Naturally some words and ideas are changed in switching from a strictly scientific field to an artistic and architectonic one. But this is not a problem, nor a criticism. Ideas move freely and each person has the right to interpret and attempt, as with topology, to capture the essence.

“Van Berkel’s house, inspired by the Moebius Strip (Moebius House), was designed as a programmatically continuous structure, that combines the continuous mutation of the dialectic sliding couples that flow into each other, from the interior to the exterior, from the activity of work to that of free time, from the fundamental to the non-fundamental structure.”

In the section on Installations of the Biennale of Architecture in Venice in 2008 was presented a Zaha Hadid and Patrick Schumacher’s project, Lotus, [20] was presented in a hall of the Arsenale and the Malcontenta Villa, one of the most famous buildings by Palladio on the Brenta River, far away from Venice. The Aura installation for the 2008 Venice Biennale represents a dialogue between the fluid contemporary language of the Zaha Hadid studio and the mathematical principles.
of harmonious architectural composition of Andrea Palladio, on the 500th anniversary of his birth. The work focuses on the piano nobile of Palladio’s Villa Foscarì La Malcontenta, which encapsulates his theory of perfect form. Accordingly, the proportions of the sequence of spaces provided the starting point for Zaha Hadid and Patrik Schumacher’s study.”

In November 2009, a new space for contemporary art and architecture in Rome, MAXXI was inaugurated. This how the project is presented at the site of the study of Zara Hadid: [21]

“MAXXI supercedes the notion of museum as object or fixed entity, presenting instead a field of buildings accessible to all, with no firm boundary between what is within and what without. Central to this new reality – its primary force – is a confluence of lines – walls that constantly intersect and separate to create indoor and outdoor spaces. MAXXI integrates itself with its surrounds, re-interpretation urban grids to generate its own geometric complexity. Through the flow of its walls it defines major streams – the galleries – and minor streams – interconnections and bridges, delighting in a peculiar L-shape footprint which in this context becomes ‘liberation’ – a freedom to bundle, twist and turn through existing buildings.”

At the inauguration of MAXXI Zaha Hadid said that first of all she had to decide whether or not to keep all existing buildings. Once the decision, she began to study the geometries that would replaced, them orthogonal, parallel or diagonal. “What appeared was a confluence of lines of different geometric present on the site. This way it started and a fluid interpretation of the space emerged.”

The fluidity is now one of the keywords of contemporary architecture. Among other things, Zaha Hadid has a degree in mathematics.

Conclusion

Throughout my ten years of experience teaching the interdisciplinary course Space and Form, math and architecture students have been exposed to information, tools and methodologies to understand how mathematics have had and continue to have a strong impact on culture in addition to applications to a variety of human activity including literature and humanities. In my opinion this kind of course are not only useful to provide new experiences to students, but also provide new stimulus and interest for mathematics, history of mathematics, teaching of mathematics. They widen the cultural knowledge of future mathematicians, whatever the work they will be engaged in the future. The hundreds of term papers that students have developed in all these years have made a valuable contribution including for didactics. This experience can be also useful for high school teaching.

References


Interdisciplinary studies are an approach to scholarship, teaching, and learning, that crosses disciplinary boundaries. For example, in American Studies, the focus would include history, literature, sociology, economics, political science, and such. Human and nature dynamics (HANDY): Modeling inequality and use of resources in the collapse or sustainability of societies. is my favorite interdisciplinary study. It uses a math model for the ecology of species survival to examine the future of the human race in the light of ancient history. Its principal author has a notably interdisciplinary resume. Dr. Safa Motesharrei is an Environmental Systems Scientist whose focus is on the integration of the Human System into the Earth System Models. Courses. Interdisciplinary Studies. A single course is often part of a certificate or degree program. It can be short and introductory or long and more in depth. Some courses are taken on the internet while others are in classroom settings. You might wonder, what is a course in interdisciplinary studies? The word "interdisciplinary" implies this course will serve to bridge two different fields. This could be as part of a broader college degree or to help you transition from one field to another. Some examples of interdisciplinary fields include culture and trade, art and history, language and education, and geology and ecology. Depending on the fields of study, this course could be in a laboratory, a classroom, outside or on the internet. MIT Architecture courses available online and for free. Notable strengths of the department that cut across the discipline groups are our devoted teaching, the grounding of architecture in both social and material issues, interdisciplinary nature, and the remarkable internationalism of faculty, students, teaching and research. The Course 4 Undergraduate Architecture Program. Flash and JavaScript are required for this feature. This video is from MIT Architecture on YouTube and is not provided under our Creative Commons license. Evan Troxel, Architect. The architecture school I went to required Trigonometry to get my degree. I took it in high school and loved it; it was pretty easy for me as I always did very well in all of my math classes. Then I took Calculus during my senior year and bombed (because the teacher sucked, I swear). We use what we experience from history, art, physics, life, architecture and yes math to influence our solutions to our problems projects. Jeremiah Russell, Architect. Would-be architects should understand the principles and concepts of math mostly geometry, trigonometry and basic physics. Located at the intersection of architectural practice with subjects such as mathematics, computer science, cognitive science, and anthropology, this two-year program pushes its students to challenge the limits of current design processes and practices. Cite: Suneet Zishan Langar. "7 Alternative, Interdisciplinary Graduate Courses for Architects." 05 Jul 2017. ArchDaily. Accessed. ISSN 0719-8884.