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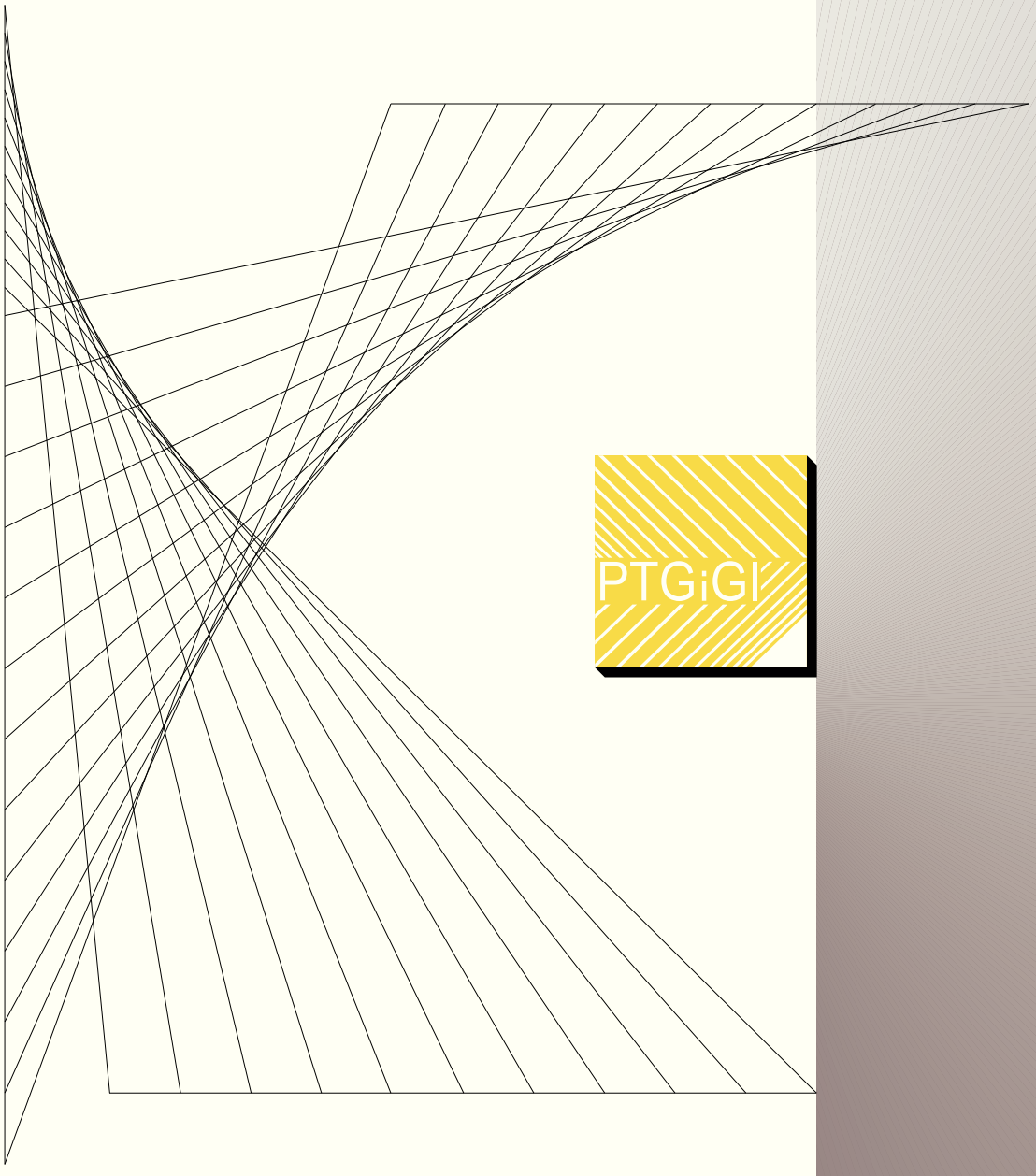

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ARCHITECTURAL DESIGN AS EDUCATIONAL STRATEGY "GEOMETRY ORIENTED"

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Abstract. This contribution is about an educational test carried out in an elective course titled *Geometrical Complements of Graphic Representation*, proposed and taught by the author in the master program at the Politecnico di Milano since the Academic year 2010/2011, where targeted design tasks are used as 'picklocks', together with digital modeling, in order to get also advanced students interested in Descriptive Geometry, and to prove the power of Geometry as a relevant part in the *lifelong learning* processes, as well as to highlight the need for changes necessary in the *teaching styles*, given the present *learning styles* of our students.

Keywords: architectural design education, Descriptive Geometry, lifelong learning processes, educational test, learning process

1 Introduction

University geometric education is by tradition considered as an introductory discipline in the field of Architecture, Engineering, and Design. Students are normally taught about Geometry (and Graphics) at the beginning of their curricula, and subsequently involved in the use of them in the project activities. Descriptive Geometry is the basic subject matter at the beginning of the training in the abovementioned fields. Sometimes, after these early educational stages, Descriptive Geometry is integrated in the architectural design workshops, where the teacher works side by side with the leading teacher of the workshop on specific projects, but in any case Descriptive Geometry itself is perceived as belonging only to the *fundamentals* of education, and with the advent of CAD systems, and Computer Graphics in general, it has almost disappeared from the courses listed on the University programs. This contribution is about an elective course titled *Geometrical Complements of Graphic Representation*, proposed and taught by the author at the Politecnico di Milano since the Academic year 2010/2011, where targeted design tasks are used as 'picklocks' for getting also advanced students from the master programs interested in Descriptive Geometry.

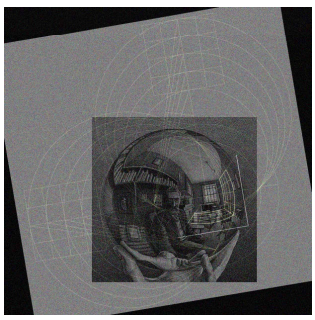

Figure 1: Projective investigation on *Hand with Reflecting Sphere* by M. C. Escher (1935). Graphic Pattern by the student Alessandro Bianchi (2010). Graphic composition by the author

2 A glance into projective space

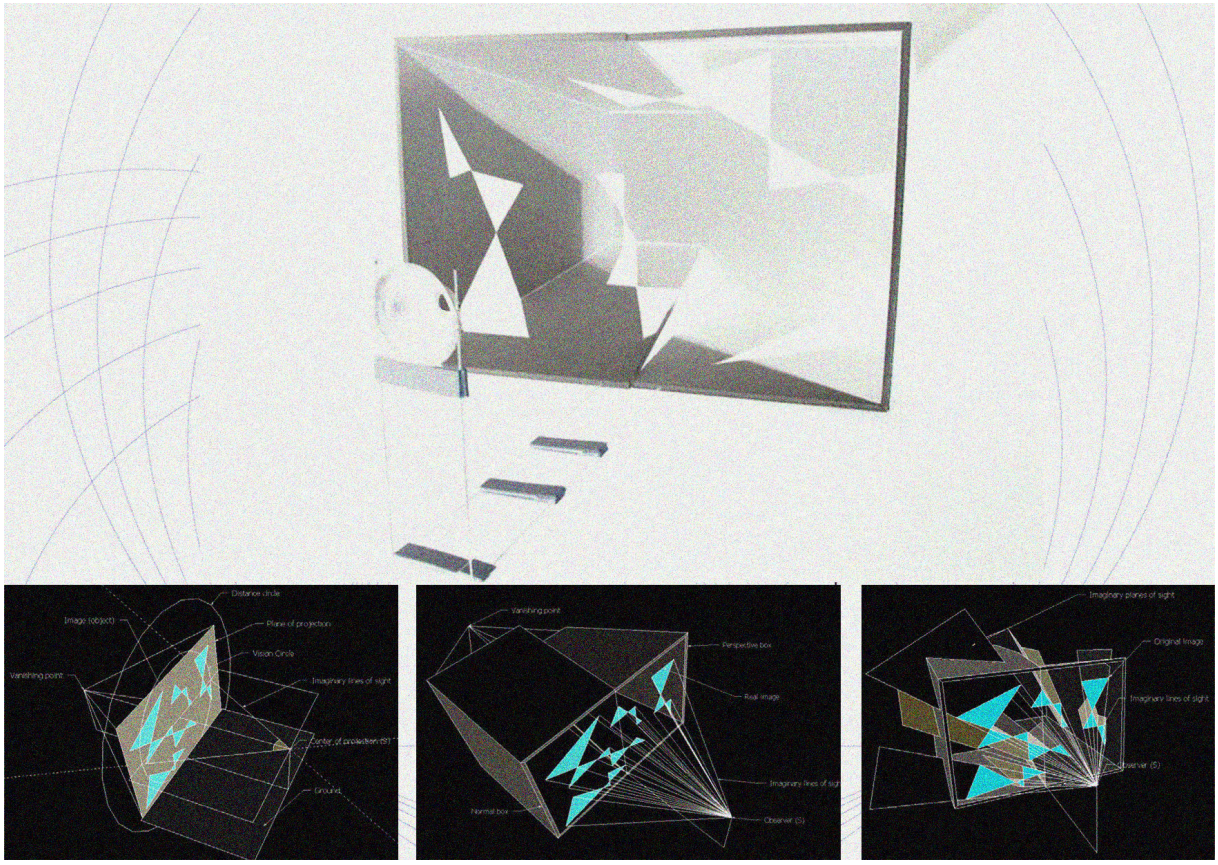

Figure 2: Interaction between optics and perspective in the three-dimensional space: image, measure, construction. Student author: Delphine Bakhsiss (AY 2010/2011). Graphic composition by the author

The first three editions of the course have been focusing on the wide spectrum of the projective approaches possible in the field of architecture, either *descriptive* (in the direction of analysis, based on spatial visualizations by means of images and models) or *constructive* (in the direction of project, based on spatial transformations by means of images and models). Class activities have dealt with digitally re-mastering theoretical milestones of knowledge like historical treatises and manuals or modeling unbuilt masterpieces, as well as investigating the projective properties of vision, drawing, photography, or developing small targeted projects emphasizing the links between architectural space, metrics, and visual perception. Digital modeling has been used here either as an efficient tool for application, or as a supporting device for understanding the theoretical properties of spaces, and also as a way to translate historical documents and sources into an updated language, so familiar and attractive to the new generations. Some results have been presented during the celebrations for the 150th anniversary of the Politecnico di Milano in 2013, and included in the book *The Visual Language of Technique. Volume 3. Heritage and Expectations in Education* edited by the teacher and published by Springer.

3 Perspectival illusionary spaces

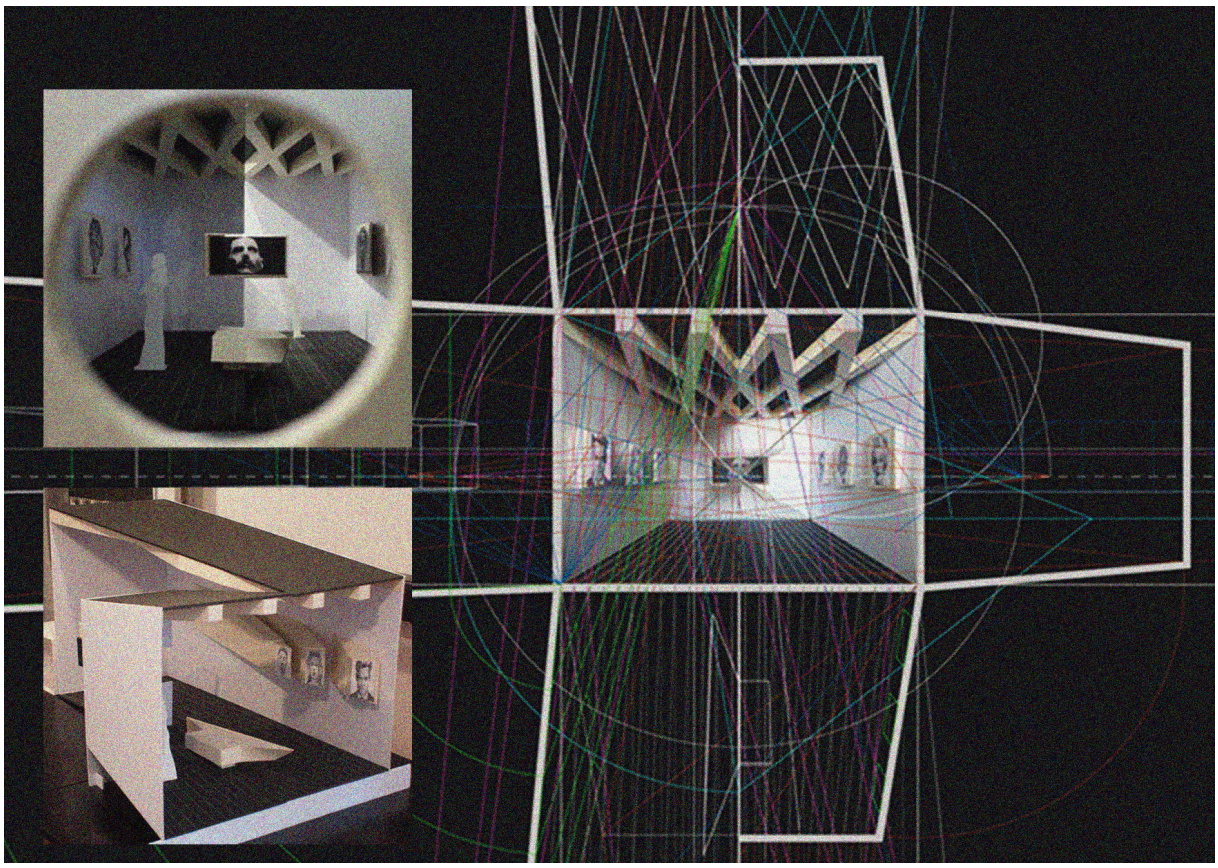

Figure 3: *Layering Space*, project for a perspectival exhibition room: view from the peephole (above, left), scaled paper model of the real space (below, left), homological relationships of the main perspective view with the illusionary and the real profiles of the room. Students authors: Marko Babic, Martin Huba, Michael Iannaco (AY 2013/2014). Graphic composition by the author

Inspired by some experimental perceptual spaces like the Ames Room, the first part of the course was about the theoretical approach behind the perspectival illusions, and students went back to some great masterpieces of our architectural tradition like Palazzo Spada in Rome by Francesco Borromini, Piazza del Campidoglio in Rome by Michelangelo Buonarroti, the apse of Saint Satiro's Church by Donato Bramanate in Milano, and to some key theoretical treatises from Andrea Palladio and Guidubaldo Del Monte (XVI and XVII) to Wilhelm Fiedler (XIX and XX), in order to understand the geometrical structure of those three-dimensional perspective spaces. The second part of the course was about the possible architectural applications, and students designed their own illusionary spaces, which were shown in a public exhibition at the end of the semester, while some selected projects were also presented at International Conferences in UE and extra UE universities, as well as at the International Conference on Geometry and Graphics in 2016. In a nutschell, in these projects students translated the *geometry of sight* into the physical *geometry of space*.

4 Space, projection and reflection in *Las Meninas* by Diego Velazquez

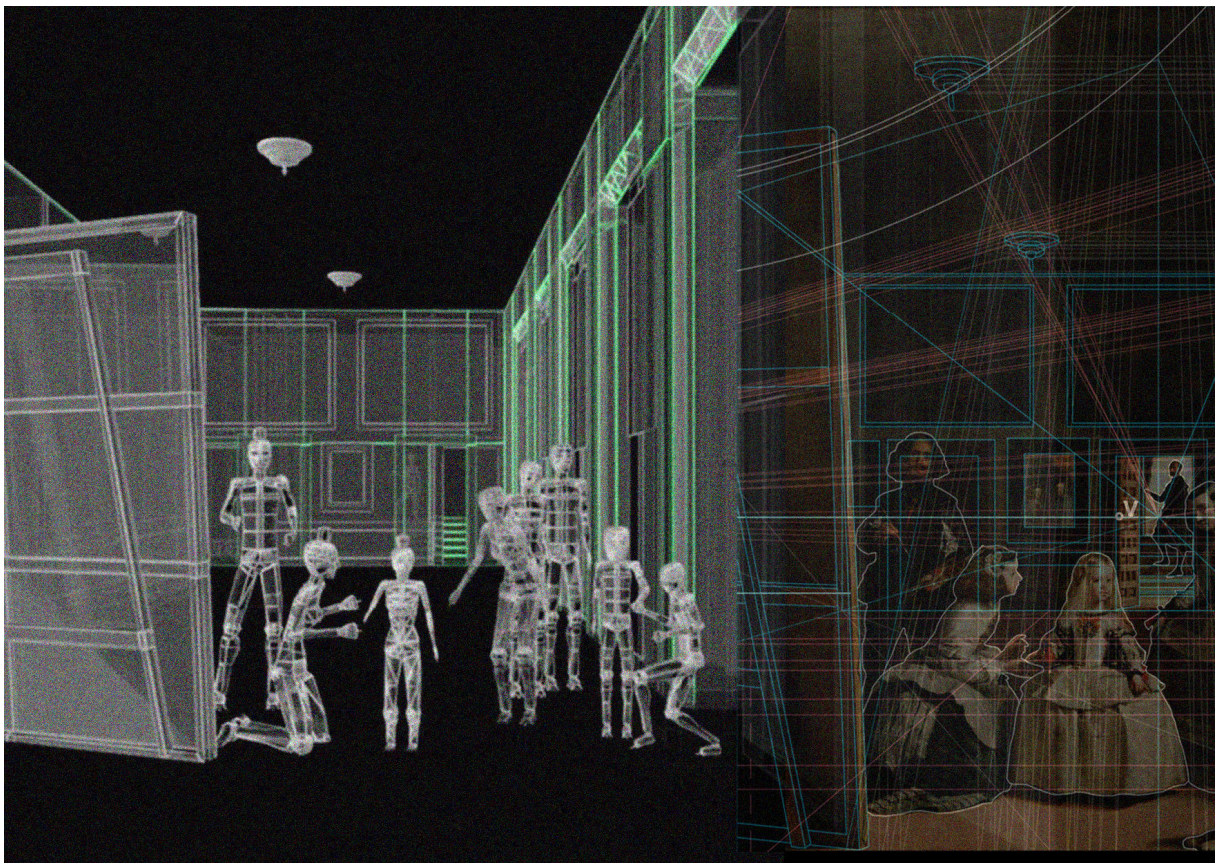

Figure 4: Digital reconstruction of the space (left) based on the perspective investigation of the painting (right). Students authors: Robert Al Haddad, Ksenia Bisti, Miroslav Cvjetovic, Inkoom Ekow Aseda (AY 2014/2015). Graphic composition by the author

In this edition students focused on the multiplicity of related focuses possible in a pictorial representation. Reference masterpiece was *Las Meninas*, painted by Diego Velazquez in 1656, maybe the highest example from history of art in this field, where sight point, mirrored images, people and space represented, are interlinked in an impressive visual network, also full of symbolism. Aim of the class activities was to reconstruct the spatial set from the graphic information in the painting. The loss of the real room, burned on Christmas Eve of 1734, made the task even more intriguing and challenging, requiring to compare geometric information obtainable from painting, with historical documents and coeval maps of the castle of Alcazar. Students could then propose some reconstructions of the three-dimensional scene, first through 2D inverse homological perspective procedures, then by 3D digital and physical reconstructions as the final double check. The class results, dealing here with the connections between *geometry of image* and *geometry of space*, have been presented in some national and international conferences, and an essay on this perspective painting has been published by the author on *KoG*, the Journal of the Croatian Society for Geometry and Graphics.

5 *Stereotomy* as a source between architectural geometry and construction

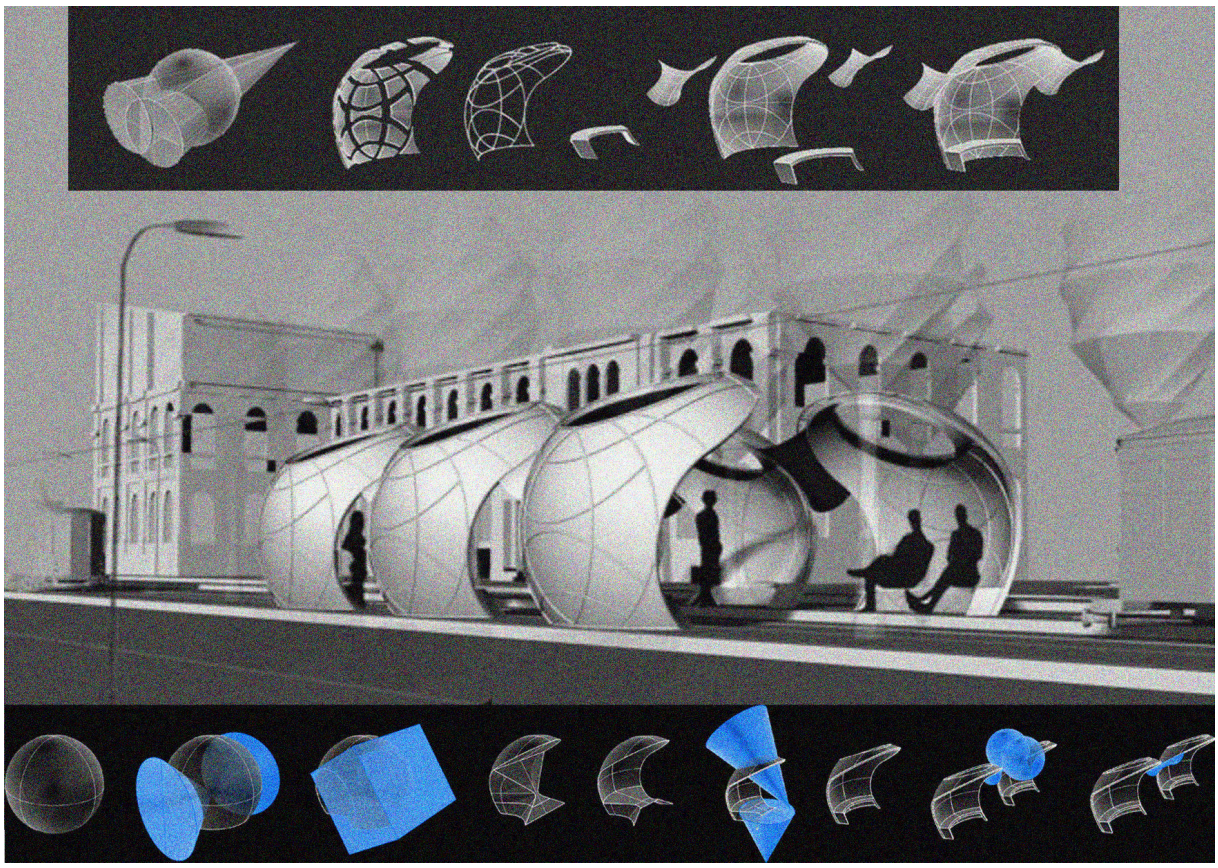

Figure 5: Design process and results: *configuration* (below), *tessellation* (above), and a view of the final project in the urban context. Students authors: Eduard Avramescu, Luciano Espinoza, Daniel Favaro (AY 2015/2016). Graphic composition by the author

In 2015/16, as well as in the current academic year, again inspired by architectural masterpieces and treatises as sources, especially those by Philibert De l'Orme (XVI century), together with current researches like those carried out by Philippe Bloch Research Group at the ETH of Zurich, the focus is on *stereotomy*, a basic chapter in the field of Architectural Geometry, historically known in relation to the stonecutters and etymologically related to the terms "stereo (3D)" and "tomé (cut)". After targeted lectures and class exercises, students develop a small project, that is, a *sphere based* cantilever roof for a *tram stop* at the Politecnico di Milano. A limited set of spatial inputs has been fixed, and emphasis on basic key steps like concept, configuration, tessellation, construction, in some cases computation, has been required, as well as public discussions in class planned, to help students to improve from each other. Due to the key role played by the visual control of the design processes, in this case students are committed to generate *geometry of space* by using *geometry of sight*. Some students' papers have been accepted for presentations at international conferences, recently at the 19th Scientific – Professional Colloquium on Geometry and Graphics.

6 Conclusion

The educational experiences here summarized, aim at promoting the *knowing use* of Geometry in the new generations of architects, by mainly betting on two levers.

First lever consists of assigning students a *project* as a course task: usually, what is felt as the most important educational goal, also works as the best motivation to learn. Geometrical restrictions and targeted inputs can be given in order to focus on specific disciplinary issues, according to the class level. On one hand it means that (of course) Geometry can be part of the *lifelong learning* process, for freshmen as well as for master or PhD students. On the other hand it requires a change in the *teaching style*, which should be more flexible and sensitive to the *learning style* of the students. Compared with the traditional teaching custom, a *bottom up* approach expanding from experience to abstraction seems more effective than the classic *top down* following the opposite direction, even in University classes. Maybe this is an effect of the way students acquire information nowadays, picking it up here and there from the *Internet*, without secure or clear logical connections, and often without tracking the navigation paths. As I already noticed in some articles, the present learning processes seem more similar to a *mosaic* where the tiles can be permanently recombined, than to the traditional *tree* where trunks and branches are once and for all hierarchically attached each other. Not surprisingly at all, the first model reminds the principle of *digit*, the latter of *logic*.

Second lever consists of motivating students to bridge current skills with traditional knowledge. Computer is of a great help in that: as an attractive and interactive tool, it can also work as an attractive tool in learning (and teaching), especially in Geometry, due to its high visual character. Once translated into the digital language of modeling and computing, indeed, and also thanks to digital graphics editing, Geometry becomes more understandable, appreciated, and consequently adequately used by students in their design activities. On our opinion, contrary to some popular beliefs, the need for Geometry is even stronger in the digital era. Given the enormous power of digital modeling, the highest benefits than ever before can be taken from the millennial heritage of Geometry. I use to tell my students that, comparing computer to a *Formula 1* and Geometry to the knowledge and skills necessary for *driving* it, it is clear that *better machine* requires *better pilot* to maximize the performance. However, from the point of view of a teacher, a new educational literature, deeply taking into account new teaching, learning, and operational styles, is still to be improved. At the moment mostly a hybrid mixture of classical paper references and digital templates is available.

Summing up, in all the cases presented above, officially published on the website of my University, deliberately the making of projects is not the main educational goal but an educational strategy, including digital as a fundamental device, to get Geometry more attractive for students, and to stimulate students to learn, practice, and sometimes rediscover (or discover) the power (and the beauty) of Geometry.

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GEOMETRYCZNIE ZORIENTOWANE PROJEKTOWANIE ARCHITEKTONICZNE JAKO STRATEGIA EDUKACYJNA

Artykuł dotyczy eksperymentu edukacyjnego przeprowadzonego w ramach przedmiotu fakultatywnego zatytułowanego Geometrical Complements of Graphic Representation, zaproponowanego i prowadzonego przez autora w programie magisterskim w Politecnico di Milano od roku akademickiego 2010/2011. W wykładzie zaproponowano ukierunkowane zadania projektowe jako „wytrychy" wraz z modelowaniem cyfrowym, aby zainteresować studentów geometrią wykreślną i pokazać siłę geometrii jako istotnego elementu w procesie uczenia się przez całe życie. Podkreślono przy tym potrzebę wprowadzenia niezbędnych zmian w dotychczasowym stylu nauczania geometrii.

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