A Mathematician at MUSE, the Science Museum of Trento

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MUSE, the Science Museum of Trento

At the beginning of the 21-st century the local government of the Provincia Autonoma di Trento decided to create a new museum of science; this is a part of the larger program of investments into research, innovation and culture, for which, since 50 years, it has been putting a large part of Gross Domestic Product. In 2011 I was nominated chairman of MUSE, to cooperate with the director, Michele Lanzinger, in order to set-up this new and innovative museum. In this paper I briefly describe my experience, of a mathematician, professor of Geometry, in this unusual role and, at the same time, I try to give an idea of what MUSE is.

The building has been conceived and realized by the architect Renzo Piano and his Italian team. It has been designed via projective geometry, following the Italian tradition, its skyline representing the dolomites (see Fig. 1). The museum is a part of a larger architectural project which redeveloped an abandoned industrial area, in accordance with Piano's vision of residential areas.

The building displays the architect point of view as a flight towards knowledge. Let me quote Piano's words, taken from an interview in Metropolis Magazine titled "How to design the perfect Museum", see [3]. *Buildings like these allow people to share experiences together, to enjoy and share life.... They fly, they are rooted, but they lift up, above the ground and that lets light to come under and inside and allow the ritual of the city life to merge with the ritual of the building life. By lifting the building, the ground floor becomes almost a continuation of the public realm. You leave space beneath it for life to happen.*

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M. Emmer, M. Abate (eds.), *Imagine Math 6*,
https://doi.org/10.1007/978-3-319-93949-0_4

Fig. 1 MUSE's skyline; reproduced with permission from Archivio MUSE, Museo delle Scienze-Trento

Fig. 2 The big Void; reproduced with permission from Archivio MUSE, Museo delle Scienze-Trento

Completed on July 2012, within one year it has been furnished and prepared for the inauguration in July 2013, saving money compared to the initial budget plan. For the first time the Renzo Piano Building Workshop took also care of the furnishing. It has been an intensive year of debates, sometime harsh, between architects, scientists and furniture workers which produced a lot of creative, but scientifically rigorous, solutions. Among all, the Piano's idea of the Big Void in the central building, with many taxidermied animals suspended in the void and displaced appropriately according to their area of living (see Fig. 2).

MUSE focuses mainly on natural science; it is a modern version of the nineteenth-century science museum of Trento, depicting the beautiful nature of our region, the Alps and the Dolomites (World Heritage Site of UNESCO), with the eyes, the instruments and the method of scientific research.

MUSE promotes the public understanding of science, focusing in particular on the future perspective of the world we live in, on the significant global impact that human activities have on the ecosystems, based on objective data and on theories debated by the large international scientific community.

MUSE is in between a museum and a science center; many multimedia and interactive features are installed near taxidermied animals, dinosaurs, glaciers, aquariums, green house. We introduce new technologies, like augmented reality, tomographies, interactive exhibits or boards. We keep searching a good equilibrium, beyond a certain limit abstraction (and mathematics) can annoy and prevent comprehension.

Beside ruling the administrative board, the obvious question was what could be my role, as a mathematician. I had to balance my idealist view (from old Plato to the present of Alain Connes), according to which everything in nature is written in a mathematical language, with the need of being comprehensible and tasty for a large public. This is actually a core problem for a science museum. The role of mathematical models in natural science, concretely discussed by Galileo, is more and more essential and unavoidable nowadays. To organize and understand huge quantities of data, to foresee evolutions, to test human influence on the natural environment. Moreover, a modern museum of science should support the slogan raised recently by life sciences: *converging science*, which has mathematics and informatics in its core. Therefore my main concern was to combine the natural exhibits with quantitative models, with numbers and statistics, to give meaning and support to scientific interpretations.

Different exhibits point in this direction, as an example let me take *Science on a Sphere (SOS)*, a global display system, made by the federal US agency NOAA (National Oceanic and Atmospheric Administration), that uses computers and video projectors to display planetary data onto a three meters diameter sphere; a giant animated globe of atmospheric storms, climate change, ocean temperature, volcano's activities used to explain complex environmental processes via true data (see Fig. 3). At the beginning architects strongly opposed the idea to put a *curved shape, spherical object* in a building in which everything is linear. Eventually, the captivating communicative quality of this all-round and steady representation of data won their opposition. We also use SOS *to play* with geometry: we presented some visualizations of platonic solid on the sphere at the *Imaginary - Open Math* conference in 2016.

Some Important Features of MUSE

MUSE supports exhibits and expositions with a research activity in the fields of communication, of natural science and of education, also via collaboration with universities and research centers all over the world. It has a crucial role in the European networks of Museum and Science Centers (ECSITE). It is part of my job to enlarge the net of collaborations, to convince political representatives that a good scientific communication as well as a good educational program can be achieved only together with a solid international research activity.

Fig. 3 Science On a Sphere and Fabrication Laboratory; reproduced with permission from Archivio MUSE, Museo delle Scienze-Trento

Another crucial goal of the museum is to show that scientific innovation is a key factor for our cultural, social and economic development. Let me mention in this respect our Fabrication Laboratory (Fab Lab), with 3D printers, laser cutters, arduinos, etc. (see Fig. 3) General public as well as private costumers can find experts to help in *building their ideas*; it is turning out to be a central tool for innovation all over the world. Here, of course, Mathematics plays a fundamental role. With the help of many math students on *stage* we have constructed, using different digital techniques and materials, classical mathematical objects like regular solids, special curves, algebraic surfaces (in the old spirit of Klein-Castelnuovo), Klein bottles and so on. A perfect and modern way of *touching the abstract*, using Enrico Giusti title of his talk in the last conference in Venice.

MUSE promotes also public debates on hot themes, dialoguing with leading explorers and scientists, from the astronaut Samantha Cristoforetti to the director of CERN Fabiola Gianotti. Some mathematicians contributed to the debate, from M. Emmer to P. Odifreddi, from A. Quarteroni to G. Todesco.

The Activity of the Museum Measured by Numbers

Up to now we count more then half million visitors every year; MUSE is among the ten most visited museum in Italy, the first among science museums. The *Giornale dell'Arte* recently put it in the first position, together with Roma's Maxxi, in its ranking which measures parameters like the innovative expositive structure, with interactive and multimedia tools, the young age of visitors, the excellence of presentations and services, due in particular to the so-called pilots, young scientists which help visitors at every floor, nice cafeteria and bookstore.

It employs about 120 persons and 90 pilots (temporary job). MUSE coordinates a net of other six local museum of natural science, including one in the Udzunwga mountains in Tanzania. Its annual budget is covered half by self-revenue (tickets, research grants, European projects, ...) and half by the local government. We ran

an economic impact analysis (EIA), published by the Italian newspaper Sole24ore, which says that MUSE generates yearly an economic impact in our town which amounts to more then 50 million euros.

Life at MUSE is rich of events: special openings in the evening, cultural entertainments, conferences and debates, opening session for conferences or business activities. It is a center promoting the cultural life of the town, very active on media and social networks.

Temporary Exhibition; an Example with Math

MUSE organizes also temporary exhibitions. As an example, let me present the one held February-June 2016, titled *MadeInMath, discover the mathematics of the world*. It was a revised version of *MateInItaly*, an exhibition proposed in 2014 at Milano's Triennale; the curators were some colleagues of Milano, Renato Betti, Gilberto Bini, Maria Dedò, Simonetta Di Sieno, Angelo Guerraggio, plus myself. In the MUSE style, it has been an exhibition in between a museum and a science center, with multi-media and interactive aspects which provided direct experiences. In many respects, it continues the important Italian tradition of exhibitions of mathematics, started by Castelnuovos (father and daughter) and properly described by M. Emmer in the last edition of the Venice conferences and summarized in its philosophy by E. Giusti in the same occasion (see [1] and [2]). In the beautiful stage offered by MUSE we mixed art with advertisement and effective communication. The storyboard, which keeps in mind the historical development, describes how mathematicians, through arithmetic, geometry or calculus, organize objects and principles into logical structures and models. It shows how this gives rise to innovation and how it influences human progress (see Fig. 4). Many intriguing questions were posed like neuroscience theory on mathematics, representations of the sphere on a map, geometry in higher dimension, description of powerful mathematical models in science and in everyday life. A short video of the exhibit can be found at: http://www.science.unitn.it/~andreatt/MadeinMathPROMOver2.mov

Popularization of an abstract (and difficult) science like mathematics is much harder than, for instance, natural science. Its abstract character in particular requires to make it alive through concrete examples, connected to everyday life and to technological applications. To achieve this, the exhibition had background questions which connected different themes: *what mathematicians do, what are the result of their efforts, how have they been used?* We proposed several answers at these questions.

I should point out the fact that a visitor not familiar with mathematics needed explanations which were provided by our pilots; on the other hand this confirms the idea that the best way to learn mathematics is via *direct talking*. We collected interesting feedbacks from the visitors: many were astonished not to find abstract and obscure formula or theorems, but appealing subjects and questions, everyday

Fig. 4 Made in Math; reproduced with permission from Archivio MUSE, Museo delle Scienze-Trento

life applications, amusing interactive and stimulating exhibits, an innovative and fascinating way of using multimedia presentation.

Matched to the exhibition many side activities were performed, which gave rise to a period of debates and discussion with a miscellaneous public coming from Italy or abroad. Among others: a series of conferences on specific themes of the exhibition, a round table on the *role of mathematics in the society*, some evening entertainments on the connections between math, art, sport, ... Moreover we had many educational and recreational laboratories on Math and a *crowd project*, called Musemenger, which realized a three-dimensional fractal of paper (origami), ran for 150 days with the participation of over 5,000 people (see Fig. 5).

Conclusion

MUSE is able to collect and to interpret the need of scientific knowledge and method in our society. It helps to convince the general public that strategical choices, such as how to use natural resources or how to respect other lives, need a better scientific understanding, possibly based on numerical data and mathematical models, approved by the scientific community and used appropriately. We were able to tackle complex and deep questions, for instance: the space in 4 or more dimensions (both via physics and math), the extinctions of many species in this anthropocene period, which is probably not only unavoidable but essential in the evolution of the life (the temporary exhibition of Spring 2017).

Fig. 5 Crowd project MuseMenger; reproduced with permission from Archivio MUSE, Museo delle Scienze-Trento

Last but not least, a visit to MUSE is an enjoyable experience for a miscellaneous variety of people, from students to retired persons, from families to professional scientists.

Acknowledgements I would like to thank Michele Emmer for the invitation at the conference Imagine Math 6 in Venice 2017 and also for providing remarks and useful suggestions during his visit at MUSE.

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