Introduction

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The project "Mathematics and Art" started in 1976. Perhaps better said, I started to think about the project that year. I started thinking about it for essentially two, or perhaps three, reasons.

First, in 1976 I was at the University of Trento, in the north of Italy, working in the area called the calculus of variations, in particular, minimal surfaces and capillarity problems. I had received my degree from the University of Rome in 1970 and had started my career at the University of Ferrara, where I was very lucky to work with Mario Miranda, favorite graduate student of Ennio De Giorgi. Then I met Enrico Giusti and Enrico Bombieri. It was the period in which, in the investigations of partial differential equations, of the calculus of variations, and the perimeter theory—introduced by Renato Caccioppoli and established by De Giorgi and Miranda—the Italian School of the Scuola Normale Superiore of Pisa was one of the best in the world. Just in the year 1976 Enrico Bombieri received the Fields medal. I was, by chance, in the right place at the right moment. All the mathematicians in the world working in these areas of research had to be up-to-date on what was happening in Italy.

Also in 1976 Jean Taylor proved a famous conjecture posed experimentally by the Belgian physicist Joseph Plateau, over a hundred years earlier, having to do with the types of singularities, i.e., of edges, that soap films generate when they meet. Plateau had experimentally observed that the angles generated by soap films are of only two kinds. Jean Taylor, using the theory of integral currents introduced by Federer and researched by Allard and Almgren, was able to prove that the result was true. A few years before, Ennio De Giorgi proved in his generality the existence of the solution of the Plateau problem, that for any chosen boundary it is possible to find a minimal surface that has this boundary. He was also able to prove the isoperimetric property of the sphere in every dimension *n*. In three dimensions this is the case with soap bubbles: there is a surface with assigned mean curvature that must contain a fixed volume of air.[1]

In 1976 *Scientific American* asked Jean Taylor and Fred Almgren (they were married a few months before) to write a paper on the more recent results on the topic of minimal surfaces and soap bubbles. A professional photographer was asked to realize the pictures for the paper. The same year they were invited to the University of Trento as visiting professors, and during the summer they gave a course in Cortona, near Arezzo. When Almgren and Taylor came to Trento in 1976, their paper in *Scientific American* had just been published. The photographs accompanying the article and the cover were quite beautiful and interesting. Looking at the pictures inspired me to make a movie about soap film in order to show very well, close-up and in slow motion, their shapes and geometries. I discussed the project with my wife Valeria, who lived in Rome with our two sons, and she was very pleased and interested by the idea.

For me, thinking about making a film was quite natural. My father, Luciano Emmer, is a film director. (Marcello Mastroianni made his first film with him, *Domenica d'agosto*, in 1949.) When I was a child, I was always involved in filmmaking—as collaborator, organizer, even as an actor in several of my father's movies. Both Almgren and Jean Taylor were very interested in my project. In any case, my idea was not to make a *small* scientific film, a sort of scientific spot just to show some little experiments with soap bubbles and soap films. I was not at all interested in filming a lesson by Almgren and Taylor, with them explaining their results and here and there inserting some images of soap bubbles and soap films. Almgren and Taylor concurred.

Now the second reason. I was working at the University of Trento while my family lived in Rome. Every Friday I left Trento for Rome (seven hours by train), and every Monday I returned to Trento. I have always been a lover of art—of any kind, of any culture and period. Of course I have my own favorite artists. In Trento I learned of an exhibition in Parma dedicated to one of the most important artists of the last century: Max Bill. I was already familiar with some of the sculptures of the Swiss artist, but I had not had the occasion to visit a large exhibition like the one in Parma.

As Parma was more or less on my way from Trento to Rome, I decided to stop on my way to see the exhibition. Bill's topological sculptures were, for me, a real discovery. Years before I had seen a large exhibition in Florence of the works of Henry Moore and many other artists, but Bill's almost immediately gave me the impression of visual mathematics. The *Endless Ribbon*, that enormous granite Möbius band, was a revelation. Its shape, its real tridimensionality, makes it live in space—living mathematical form. This was the missing idea. Mathematicians in all historical periods and in all civilizations have created shapes, forms, and relationships. Some of these visual shapes and relationships can be made visible, as witnessed by the great success of computer graphics in some sectors of mathematics. In these same years the mathematician Thomas Banchoff was making his first short animated films of mathematical surfaces, but at that time I was not aware of his work.

When I arrived in Rome, I spoke again with Valeria. The project was becoming clearer: to make a film, two perhaps, in which I would compare the same theme from both the mathematical and artistic points of view. I would not just film a long discussion among artists and scientists on the vague theme of the connections between art and science; rather, I would confront the visual ideas of artists and mathematicians—to make visible the invisible, as the artist David Brisson says in the film *Dimensions*, made in 1984 with Thomas Banchoff. So the general scheme of the project would be to make two films on the visual relationships of the forms created by artists and mathematicians. The themes of the two films were soap bubbles and topology, in particular the Möbius band. To have more visual ideas and objects to film, we would include the connections among mathematics and architecture, all the other sciences (in particular biology and physics), literature, and even poetry—and why not cinema, too? From the beginning, the idea was to focus on the cultural aspect of mathematics, the influence and the connections of mathematics and culture, starting from the premise that mathematics has always played a relevant role in culture. As these were the general lines of the project, it was quite natural to consider also the organization of exhibitions (many were made in the next years), congresses, and seminars, and the publishing of books (with many illustrations!) and even theses for students of mathematics, art history, and architecture.[2]

I contacted Max Bill by letter. He was very kind and invited me with my troupe to his house in Zurich; he gave me permission to film everything I was interested in, including his fabulous collection of contemporary art. There was one exception: it was strictly forbidden to film a little window in which lay his collections of forms—topological forms made in paper—very small objects, his database for future works. He was afraid someone might see and copy his projects. We then became friends, we made two exhibitions together and a film on *ars combinatoria*. We both were on the editorial board of the journal *Leonardo*, at that time published by Pergamon Press, later by MIT Press. For my book *The Visual Mind: Art and Mathematics*,[3] Bill revised the title and made some changes to his famous paper originally written in 1949, "A Mathematical Approach to Art." Two of Bill's works are reproduced on the front and back covers of the book.

As I wrote in 1992 in the introduction to the "Visual Mathematics" special issue of *Leonardo*,[4] the precursor to the book *The Visual Mind*, I had in mind Piero della Francesca's famous painting *The Flagellation*. Morris Kline, a mathematician, in *Mathematics in Western Culture* describes Piero della Francesca as one of the greatest mathematicians of the fifteenth century: "Piero's *The Flagellation* is a masterpiece of perspective. . . . Here, as well as in other paintings, Piero used aerial perspective to enhance the impression of depth. The whole painting is so carefully planned that movement is sacrificed to unity of design."[5]

The Flagellation, one of the paintings I most love, is actually in the Galleria Nazionale delle Marche, in the rooms of the Palazzo Ducale of Urbino, Raphael's birthplace, in the center of Italy. Valeria, my wife, had a country house in Senigallia, a small town on the Adriatic Sea eighty kilometers from Urbino. She died of cancer in 1998 and is buried in the cemetery of Santa Maria delle Grazie, on a hill near Senigallia, very close to her house. The church of Santa Maria delle Grazie is very famous because of another painting of Piero della Francesca, the *Madonna of Senigallia*. During the Second World War the painting, for security reasons, was transferred from the church to the Palazzo Ducale in Urbino. It is still there, even though the City Hall of Senigallia has asked many times to have it back in the church.[6]

In preparing the second volume of *The Visual Mind,* I always had in mind this other work by Piero della Francesca, the *Madonna of Senigallia*. In the introduction to the previous volume in 1993 I wrote:

0.1 Piero della Francesca, *Madonna di Senigallia,* c. 1470, oil on panel, 61 × 53.5 cm. Galleria Nazionale delle Marche, Urbino. By courtesy of the Ministero per i Beni e le Attività Culturali. (See also plate 1.)

The use of visual computers gives rise to new challenges for mathematicians. It is difficult to predict future directions and relationships between arts and mathematical research. In any case, this volume is the result of my proposition to compare the research of mathematicians and the works of artists in order to discover what interesting results we can expect, in both the arts and the sciences, from the burgeoning field that we can call Visual Mathematics.

I think that, ten years later, I can only confirm what I was writing. If it was hazardous to write books then on the relationship of mathematics and art, let's say on mathematics and culture, in the last years the interest in mathematics has matured considerably. In books, films, and theater plays there is an increasing interest in mathematics on the part of non-mathematicians.

After ten years, it is interesting to look again at all these phenomena from the point of view of artists and mathematicians.

Notes

1. For a story of soap bubbles in mathematics, art, chemistry, architecture, and biology, see M. Emmer, *Bolle di sapone: un viaggio tra matematica, arte e fantasia* (Florence: La Nuova Italia, 1991).

2. In 1997 I started organizing, with the help of Valeria, the annual congress on mathematics and culture at the University of Ca' Foscari in Venice. Proceedings are published every year by Springer Verlag. See <http://www.mat.uniroma1.it/venezia2005>; the last part of the address changes every year, e.g., venezia2004.

3. M. Emmer, ed., *The Visual Mind: Art and Mathematics* (Cambridge: MIT Press, 1993).

4. M. Emmer, ed., "Visual Mathematics," special issue of *Leonardo* 25, nos. 3–4 (1992).

5. M. Kline, *Mathematics in Western Culture* (Harmondsworth: Penguin, 1953).

6. M. Emmer, *Lo specchio della felicità* (Milan: Ponte alle Grazie, 2000); V. Marchiafava, *Lo specchio della felicità* (Venice: Centro Internazionale della Grafica, 2001).