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Mathematics and the Ecole des Hautes Etudes en Sciences Sociales[1]

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1. WHAT MATHEMATICAL ACTIVITY?

Does a mathematical activity specific to the Ecole des Hautes Etudes en Sciences Sociales exist? What style? What were, over forty years, the attempts, the results, but also the disappointments? Jacques Revel asks for a true portrait, without euphoria, from the genesis of the Group that became the Centre d'Analyse et de Mathématiques Sociales; and Nathan Wachtel makes inquiries about the movements of the discipline toward the social sciences, at the beginning and now[3].

To try to explain all this, we must adopt multiple points of view.

First, explain the mental tendency the Group chose from the beginning, mainly that mathematicians rarely put themselves where they are expected, but rather to the side, playing the role of agitators in interdisciplinary work more than that of superaccountants. Then, take an inventory of some successful engagements between social practices and mathematical theories. Next, evoke the important moments of the dissemination of these abstract ideas, often considered unappealing. Finally, observe how, with the time, research experiments, specialized research as we call them, have become more frequent.

One can then take a step back: what permanence was there, what evolution? But one will not know for all that, if, as innovative as we were able to be among our contemporaries, we were not taken with the fashions and the tendencies or the times. That is to say we were shunted, with

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[1] This text was initially published in the collective work led by Jacques Revel and Nathan Wachtel, *A School for the Social Sciences. From the 6th Section to the School of Higher Studies in Social Sciences,* Paris, EHESS Press and CERF Press, 1996, p. 167-184. We thank the author and the editors to have graciously authorized the reproduction of this text.

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[3] Needless to say, the author takes all responsibility for the form of the present essay, inspired by the collected remarks in the course of an interview with Georges-Th. Guilbaud, Marc Barbut, Jacques Revel and Nathan Wachtel, .

our abstract language and our style of autonomous, comfortable questioning, by social currents of an entirely different nature entirely we are not aware of.

2. THE SIDE LIGHTING

Legend says that George-Th. Guilbaud and Benoît Mandelbrot would tell each other the same story:

> Braudel put me some series under the nose: rises in the water level of the Nile, variations in the price of wheat, exchange rates, etc… and asked me, with no other form of trial, if I could, with all this, create something using my powerful abilities. Understood, nothing came from it, as there was no question!

And both of them gently mocked the colleagues who do the math responsible for all the numerical series. In fact, Guilbaud often attends Fernand Braudel's seminar, but he responds to his calculating questions a bit on the side, wanting first to inquire after the historian's hypotheses, wanting to understand the steps and not the figures. Nothing pathological in this *side lighting*, a mental tendency which since the times distant favored the construction of a science in which everything piles up, in which nothing is ever truly forgotten, even if one is often reduced to change completely the perspective on its objects. It's in tracking the mental processes that we are able to define what objects to analyze.

Lucien Febvre knew it, when in spring 1956 he received George Guilbaud after his election to the Ecole des Hautes Etudes en Sciences Sociales: "What do you want to do?" Invite without order. Guilbaud responds: "Social mathematics, *à la* Condorcet." He proposes prolonging the ill-appreciated efforts of Condorcet in studying relations between mathematics and social life. And to affirm this patronage, he attaches *Centre Condorcet*[4] to his door. But all this without truly convincing, for, at that time, the image of the revolutionary that was Condorcet was still hiding his mathematics. *Social Mathematics* irritates a little with its ambiguity. It's too short! Braudel preferred *Group of Social Mathematics and of Statistics*, which would later become *Center of Analysis and of Social Mathematics*.

The brief title, in the affiliation of Condorcet, Cournot, Pareto, von Neumann and some others, clearly signifies: for those who want to reflect upon the social phenomena and manipulate global and integrating concepts, a well advised mathematical apprenticeship is worth it intellectually. Then there was also a snag; mathematics is itself a historical and social phenomenon to be observed. The math worker is always interested in situating his own practices in the long span of his discipline. Mathematics is not only an instrument; it has an autonomous life, a history, a history very long and very different from all other disciplines. There isn't another example of science in which we have such a direct contact with the thoughts of men from twenty-five centuries ago; for what we can read of their writings remains for us, today, fresh and a source of new ideas. One can understand that the mathematician encloses himself first in his discipline, of which he has a relatively stable perception through the years, even though he asks himself understandably about the firmness of the social sciences. Do they truly exist? There certainly exist social analyses bringing into play more or less abstract concepts and arguments, but do these reasonings constitute a science?

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[4] Name made official in 1960 by a convention between Georges Guilbaud, representing the 6th section, Roger Daval, representing the Institute of Applied Human Sciences from the University of Bordeaux, and George Darmois for the Institute of Statistics from the University of Paris.

The essential part was to not let oneself become imprisoned: doing math, inviting others to do it and not to learn it, and this in multiple contexts where one reasons and for multiple causes. In 1958, a small group[5] moved into 17 rue Richer, between the Folies Bergères and some Polish restaurants, at the second floor of the Hotel des Maréchaux d'Empire, run by a woman in retirement from the jersey industry who lent us her old furniture and who threatened to raise rent during her annual visits.

From the beginning, Claude Lévi-Strauss and Charles Morazé sponsored the operation. The intellectual connections of a mathematical nature at the beginning were the economic projection and the national accounting of the Ministry of Finance, more precisely of the Center of Studies of Economic Programs founded by Claude Gruson; it was equally the inferential statistics of George Darmois at the Institute of Statistics in Paris, the econometrics of Edmond Malinvaud, and finally the operational research of the Shell company, of the electricity company EDF with Marcel Boiteux, then of the gaz company GDF and the train company SNCF with Jean Mothes, finally of the Society of Economy and Applied Mathematics with Patrice Berthier and Bernard Roy.

The *Condorcet Center* did not have to be a center for economy, even less a center for computations or computer sciences. To be knowledgeable with the practices, or rather with the reasonings behind the practices, it was better to remain a fundamentalist. A new term popular after 1960: "mathematical praxeology", in the course of discussions about the rationality of human actions, we had to represent the math side. Von Neumann's theory of games of strategy, in the first place, became the major theory for the analysis of adversity; it did not tell us how a player must play, but how he can reason simultaneously about his choices and those of his adversaries or competitors: Pierre Massé and Georges Guilbaud theorized the concepts of sharing, of optimization and equilibrium that preoccupy business economists, readers of Oscar Morgenstern. On the theme not of adversity but of uncertainty, subjective probability precisely, a collaboration was opened about the mathematical foundations of *Decision*[6], with the algebraist Marcel-Paul Schützenberger and the Italian subjective probabilist Bruno de Finetti.

In order to go in the right direction in these new fields of praxeology, it was necessary to shed light on the mathematical edifice outside of the zones recognized by scholarly programs: sometimes the simplest algebraic forms, the combinatorics, the partial orders, the networks, all things not taught in France but already practiced far to the West and East. With Guilbaud we reached the mathematical cathedral through hidden doors, without prerequisites, starting from a concrete problem: the constant reconstruction of math.

In the 1960s, new collaborators acquired a status[7]. Followers of genetic psychology, François Bresson and Pierre Gréco, arrived and settled next to us in rue Richer. With them, we exchanged problems on the structure of children's learning as Piaget and his laboratory in Geneva saw them. Bernard Jaulin and his Center of Calculus of the Foundation Maison des Sciences de l'Homme were close to us; for example, upon a study on the bell ringers in England who have spontaneously used theory of groups for centuries, or regarding Pierre Soury's

[5] Georges Guilbaud, Roger Daval, Marc Barbut, Pierre Guilbaud, Micheline Petruszewycz had a small laboratory in another location in Chauchat Street since 1956.

[6] Two collective works: *The Decision*, International Colloquiums of the CNRS, May 25-30, 1960, Paris, CNRS Press, 1961; *The Decision. Aggregation and Dynamics of the Orders of Preference*, International Colloquium of the CNRS, July 3-7, 1967, Paris, CNRS Press, 1969.

[7] The collaborators were first associates and then named to the School: Pierre Rosenstiehl (1960), Josette Brançon (1962), Jacques Bentz (from 1963 to 1967), Bernard Monjardet (1963), Charlotte Carcassonnet (1964), Jean-Yves Prévot (1967), Claude Barbut (1968).

inventions on Borromean knots, which Jacques Lacan greatly appreciated. The dialogue was fully opened to new depths with historians of sciences, Pierre Costabel, Jean Itard, René Taton and Ernest Coumet. With the other historians, some loose relations. But on the whole, inside the Ecole : always few demands, not enough relationships[8].

On the other hand, exchanges were becoming more and more intense *next to* the Ecole. We allied ourselves notably with the Institute of Psychology[9] and with the Center for Sociological Studies[10] and the University Office of Operational Research at the University of Paris[11].

From all these contacts came the seminar named *Mathematic Models in the Social Sciences*[12]. Work groups were implemented with the economic engineers and operational researchers[13], in search of methods of optimization, with the military looking for strategic theories in the American way, with the logicians such as Dominique Dubarle (O.P.) who attacked the praxeology, and finally with the musicians, including Yannis Xenakis[14] for stochastic music.

In 1970, we had to leave the rue Richer [15] and rejoin the new building of the Ecole at 54 Boulevard Raspail, whose cells rarely facilitated community life. And a great blow for Guilbaud: audiovisual activities, film, which would be in question later, would not be settled in the same building because of no room : the construction of a parking was prefered to them. To diffuse our ideas, we had to, in this situation as well, *shine nearby*.

3. CONNECTIONS TO THE SOCIAL SCIENCES OR AUTONOMY?

Social Mathematics, as it was practiced, did it achieve a true dialogue? By this we don't mean applications, as is often said, for it is naïve to think that preexisting models, easy to use, could be flattened on particular, thus original, steps of the social activity. We of course mean a dialogue in which two parties inspire each other reciprocally and exchange their codes and their implications. Or rather was it the total opposite, a monologue? Would the social part have been only a pretext, very full of metaphors and problems, permitting mathematicians to gain autonomy while cultivating new virgin territory in mathematics? The two attitudes were in fact at the same time. Let's come to some meeting points between mathematics and the social activity.

One successful example of dialogue about the structures of similarity, as it was between André Weil and Claude Lévi-Strauss, is the dialogue between Georges Guilbaud and John Manou with the ethnologist Jean Guiart as mediator, all three attempting to describe the primitive way of thinking. The native of the New Hebrides, John Manou, stated many words to

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[8] Historians such as Robert Mandrou roped in Marc Barbut about Machiavelli (*Annals ESC,* 1970). Charles Morazé attracted Jean Petitot to the School.

[9] Paul Fraisse, Claude Flament and Henri Rouanet.

[10] Joffre Dumazedier, Jean Stoetzel, Jacques Maitre, François Isambert.

[11] The BURO: Jean Bouzitat, Marc Barbut, Maurice Girault, Germain Kreweras, Georges Morlat and Édouard Valette, around Georges Guilbaud.

[12] Six installments were distributed by the Center from 1960 to 1962 about the meetings of the seminar *Mathematic Models in the Social Sciences*.

[13] Georges-Th. Guilbaud was elected president of the French Society of Operational Research the year of its creation.

[14] The Mathematic and Music Team (EMAMU) operated from 1966 to 1972.

[15] In the 1970s we rejoined Christiane Boghossian (1970), Josiane Leconte (1971), Hélène Geroyannis (1971), Jean Petitot (1971), Marie-Ange Schilz (1972), Denis Bresson (1975), Catherine Guéraud (1977), Hubert de Fraysseix (1977), Jean-Paul Gilg (entered in the School in 1969, he rejoined the Center in 1980).

the ethnologist (son, father, uncle, …) used to describe his parentage in the dialect of Ambrym Island. He explains himself by citing a hundred or so identified relations among which vocabulary ambiguities were quickly revealed. The mathematician had the idea to break with the habits of genealogical diagrams, and represented the individuals not by points but by traits and represented the unions by points of convergence of two traits from where the child-traits start. So a diagram specific to this dialect appeared to describe the words of parentage: the structure of the dihedral group, a familiar object in our mathematical universe. The diagram Georges Guilbaud traced was communicated to John Manou, who in it recognized the drawing the elders of his tribe used to teach the young about ancestry rules.

Later, in collaboration with Michel Perrin of the Laboratory of Social Anthropology, Jean Petitot addressed the canonic formula of the myth of Lévi-Strauss, as a sort of fundamental equation for which numerous myths can be the solution.

Another point of attachment: the analysis of ballots. We strip a ballot in which each vote is an order of preference on proposed projects. In this sort of vote, only the first preferences of the electoral body are in fact retained. It quickly appears that the majority considered pair by pair is not coherent; it is often not transitive: It's what Georges Guilbaud calls the *Condorcet effect* and what he links to general problems of the central values of statistics, to Arrow's theorem of coherence of the principles of choice, and to Quetelet's concept of the average man. To get out of the paradox, we define trellis algebra on a polyhedron, which we baptize *permutoèdre*, whose peaks represent all the possible votes. A space of compromise is deduced: one can research on this polyhedron a collective decision that will serve as generalized median. That is the starting point, for several among us, of multiple works about the link between median and metric in the trellises, about intermediary relation and about consensus in general. The *permutoèdre* becomes a classical object of mathematics and makes a career in the international academic community: it is given extensions in Coxeter's finite groups.

One very successful attempt with the logician Louis Frey from Aix-en-Provence: an original approach of the filiations of the Evangelicals. A systematic study of the permutations of the verses, resting on the permutoèdre, confirms the hypothesis of the theory called "of multiple documentation" among current hypotheses among exegetes.

In the field of numismatics, Charlotte Carcassonne, together with our colleague historian Julian Guey, analyzes, with the probabilistic tool, the empirical rules for the size of coins stated since the Middle Ages. One example is the one of the coiner that must produce in principle, beginning with one marc of gold, 54 *flans* destined to be hit into deniers. But an allowance on the weight of each flan is accorded by the king so that the coiner taps into his costs; allowance called *the remedy*. The coiner must therefore "tickle the remedy at best". As for the king's control, it consists of identifying the twelve heaviest deniers and the twelve lightest deniers in one bundle, and to verify that they are situated in an officially permitted interval. Next is a probabilistic calculation that shows the degree of validity of certain practices. This work is written in the collection of reflections on approximation (*à-peu-près*) conducted by Georges Guilbaud and that gave rise to two books[16] and to a colloquium at Urbino in Italy, with Pierre Gréco and Umberto Eco, where the conference on the "remedy" had been one of the most exciting moments. Numismatic statistics attempts inferences on the base of an imposed sample: the archeological treasure. This situation of impossible sampling is found again with the same conceptual

[16] G.-Th. Guilbaud, *Lessons of Approximation*, Paris, C. Bourgois, 1985; *The Approximation. Ancient and Modern Aspects of the Approximation*, works led by the Center of Analysis and of Social Mathematics, Paris, EHESS Press, 1988.

difficulties in Marie-Ange Schiltz's works on the prevention practices against AIDS in a given social network.

The object labyrinth is a transdisciplinary theme par excellence, full of concepts. In the course of the 1970s, in the international academic community, the analysis of non numerical algorithms was developed, which is to say the organized manipulation of objects other than numbers, so as to end up with a result, such an optimal configuration, the jagged cut of sheet metal with fewer scraps, the march of a knight covering the chessboard. Exploring the labyrinth, like Theseus with the string, constitutes the first algorithm of History in the non-numerical. The idea of retracing his footsteps — coiling the string when necessary — defines a family of structured sequences of basic paths of hallways, one time in one direction, one time in another, which simulate all the possible myopic progressions across the labyrinth. Ariadne's string proves to be a theory of zero degree of the *combinatorial complexity*. The subject comes to preoccupy those who are interested in heuristics, in exploration processes, of the writer in particular. Roland Barthes, who would hold a course at the Collège de France on Proust and *The Research,* invited me to share the annual seminar on the theme of the labyrinth: Gilles Deleuze, Octave Mannoni, Jean-Louis Bouttes developed there, each in his language, the movements of his personal heuristics. So historians charge us with comparing the Chartres labyrinth to other similar labyrinths. Chartres is a string with folds, which simulate exploration in a maze and whose convolutions constitute a complex configuration, almost regular and difficult to reproduce. And nevertheless it spread in the Middle-Ages, identical to itself across Europe: we know twenty-nine instances of it. But no writings on the subject from the time, the historians tell us. Yet it appears that here it is about a universal, stable configuration, without variation, because it is characterized by rules and thus able to be recovered by wandering companions. And in Volterra, Italy, on the opposite side of a lectern, we guessed a thirtieth instance of the object, homage to Daedalus. So with Daniel Arasse, Paolo Fabbri and Louis Marin, we organized the international colloquium in the city of Siena: *la Cifra e l'Immagine*.

Mathematics retakes the top: in terms of labyrinthine algorithms, Hubert de Fraysseix and our students invented algorithms to master a reticular map, to create schemas, put them flat, deform them on the computer to satisfy the ergonomic properties that certain jobs such as complex system designers, circuit installers or site plan managers controling schedules require. In this way we developed, together with Robert Tarjan of the New Jersey Bell Laboratory, a new kind of high-performing schematic cartography, which can, be situated in the tradition of Jacques Bertin's *graphic* and his ingenious maps. Our software[17] began to work in factories.

Another development of the labyrinth consists of representing the blind step by a network of automatons. We thus established, upon the advice of Marcel-Paul Schützenberger always close to our Center, the theorems of global properties attained by finite localized calculus, acentered, on structures extended as large as we wanted. We developed with Jean Petitot the abstract concepts of *acentrism*. Gilles Deleuze and Félix Guattari from it made their book *Rhizomes*. And in a more technical aspect, our works with Jean Berstel on acentered networks of finite automatons were continued in Canada in the creation of split electronic systems and in France in the systematic study of neuronal networks to represent cognitive phenomena.

Hervé Le Bras' arrival to the head of the laboratory of Historical Demographics of the Ecole in 1990 opened new fields of mathematical research around morphologies and textures: it was about modelizing local configurations, whether of networks of sociability and relationship or

[17] EHESS theses of taxiplany: Marc Bousset, Pascale Kuntz, Xavier Jeannin, Jean-Louis Jardrin.

of human peopling. With the help of Russian physicist Andreï Mogoutov, Maurizo Gribaudi translated objects of the new history into graphs of relations that, by their particularities and their complementarities, similar to organic molecules, were combined to engender a connected society. Hervé Le Bras empirically showed that the local repartition of the population, modeled by Pareto's laws with a variable exponent based on place, obeys a multifractal law. Paradoxes on the spatial segregation, on the dispersion of the population and on the "rank-size" regularities in this way found a new framework of explanation. The published illustrations, with vibrant colors that recall abstract painting more than math, appear on the computer space of the Villette Science Museum (in the noth of Paris) to illustrate patterning in social sciences.

When the Center with Hubert de Fraysseix and Patrice Ossona de Mendez invested in graphic computer science, our experiments on the transfer of images between the colored spaces concurred with the research of the high fidelity colorimetry, and implied contacts with art historians, graphic designers and form recognition analysts.

A genuinely intimate dialogue between computer sciences and geography or land planning, was conducted by Jean-Paul Gilg's group, which was dealing with data of remote sensing[18]. It defined the good field questions one can ask photography and compared diverse algorithms or software in order to provide an automated response: these are mathematical morphology experiments across the territory, certainly full of pitfalls, but gratifying.

One other particularly successful interaction is the one with morphodynamic models from the theory of catastrophes, first with linguistics then with cognitive sciences. The main difficulty, well vetted in the debates of the 1950s and 1960s between structuralists and historians, is to reconcile the static descriptions with their genesis and their history. After René Thom, Jean Petitot[19] showed how one can introduce structures' generating *dynamics* in the field of humanities. With his morphodynamic models he explained, for example, the phenomenon of categorical perception in phonetics.

4. THE GOOD TIMES OF DISSEMINATION

One can wonder why researchers attached to the historical tradition of mathematics exerted such an intense effort to promote ideas of which they were not the only authors, and which would have been disseminated without them anyway. Georges Guilbaud had an idea (I would dare to say an obsession): it was necessary to break the mathematical theology of the Ecole Polytechnique that had frozen the French engineer-researcher's baggage by keeping it in a field restricted to the mathematical universe — the baggage being the toolbox of mechanics and of astrophysics. Nothing regarding the theory of choice, optimization, finite structures, and no inferential statistics. Taking a closer look, no one, not even at the Ecole Normale Supérieure, did any better. What is worse, Jean Dieudonné, a Bourbaki's backbone, didn't have a strong enough word for the combinatorics. It took his retirement for him to consent to authorize letting the combinatorics into the Bourbaki seminar. In 1980 his disciple Jacques Tits lent us his support so that we could create — with another academician, Marcel-Paul Schützenberger — what would

[18] The Laboratory of Remote Analysis: Space and Society (LATES), created in 1981: Jean-Paul Gilg, director, Anne Chatelain, Hélène Geroyannis, Danièle Larcela, Marie-Claude Lortic, Sylvie Soukup.
[19] Jean Petitot was in 1986 elected vice president of the International Association for Semiotic Studies.

become, thanks to the publisher Academic Press, a international review of high-level mathematics: the *European Journal of Combinatorics*[20], one of the rare math journals in France and diffused across the world.

The very first home-made publication, the review *Mathematics and Social Sciences,* was launched in 1962, an inspiring day, by George Guilbaud and Marc Barbut following an internship at the Claude Lévi-Strauss Laboratory at the Palais de Chaillot. Called since 1988 *Mathematics, Computer Sciences and Social Sciences*[21], it has published 200 issues. It isn't particularly read even at the Ecole, and yet, contrary to the preceding journal, it is written for the Ecole, and should be read! It targets practitioners of the Social and Human Sciences who are interested in statistics, in models, in computer sciences, and it targets mathematicians or computer science specialists in these fields.

With Bernard Monjardet's initiative, the Center circulated another bulletin of university meetings from 1974 to 1982: *L'Echo des Messaches* good and less good pages of exchanges and information on mathematical practices in the human sciences. It just recently revitalized these liaisons thanks to the European Network of Discrete Mathematics[22].

Let's move on to television and cinema. A great moment in the dissemination of new mathematics: the 36 shows of the Educational Television, *Mathematical Sites*, where we aimed to train high school teachers for modern math. Then 25 shows of *Mathematics for All*[23] followed, in which, from 1969 to 1972, George Guilbaud kept crowds in suspense — even crowds on the sidewalks in front of television stores, as I witnessed. With animation techniques, 15 films were also produced. One of the most notable: George Morlat and Marc Barbut performed coin tosses in real time, the graphic takeaways from which reveal the idea-force of the law of large numbers in the studies of the ratio of masculinity at birth. Several of these films received awards in short film festivals.

At the end of the 1950s, the need for mathematical praxology was strongly felt in faculties of Law and Economic Sciences. Mathematics programs were defined for economists. I was associated with a similar operation with Louis Armand, Jean Mothes and Dominique Dubarle who, taken in the decision-making movement, rethought the syllabus of Business Schools and their preparatory classes. In 1966, Fouchet put in place the reform for teaching math in faculties of humanities and social sciences. With a few, such as Jean-Louis Piednoir and Michel Schreiber, we organized internships for teachers and researchers. The Ecole considered as a duty to expand to new places. From 1960, Guilbaud at the faculty of Economic Sciences of Pantheon, beginning in 1966, Barbut at the faculty of Social Sciences of the Sorbonne, Guilbaud and myself at Nanterre University, in the departments that would light the fire: each one mixed together his four lecture halls of two thousand students per week. It was like we were missioned, associate professors, certainly in full right in councils of faculties, but sitting for a limited time; a temporary arrangement that was extended, for we had to contribute to provide a new shape to teachings after 1968! That is how Marc Barbut played a founding role in the creation of the multidisciplinary course *Applied Mathematics for the Social Sciences* (*MASS*), now implemented in almost thirty universities.

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[20] Editors-in-chief: M. Deza, M. Las Vergnas, P. Rosenstiehl.

[21] Mathematics, Computer Sciences and Social Sciences, director Georges-Th. Guilbaud until 1981, then Marc Barbut. Editorial assistant: Charlotte Carcassonne.

[22] The DI.MA.NET of the CEE.

[23] Direction of the shows and films: Pierre Guilbaud, Raoul Rossi, with the help of Catherine Havas (1964).

Concurrently, a training operation called us back to the homestead: the EPRASS[24]. This is an introductory course for research, which considered itself elitist; a shock-teaching, said Braudel. Pierre Gréco and, for our discipline, Marc Barbut dedicated themselves wholly to it. Later on, the National diplomas *Diplôme d'Etudes Approfondies*[25] would take over.

In 1960 we began the *Group of Mathematic Studies of Political and Strategic Problems*[26] to which we associate Alain Joxe and André Glucksmann. We established passionate relations with Raymond Aron, Jacques Vernant of the Center of Foreign Politics, the general Guerin of the Committee for Scientific Action of the National Defense, and the general Beaufre of the Institute of Strategic Studies. In the United States, where new concepts about engagement, retaliation, bargaining and mastery of great systems abounded, we took on an intimate dialogue with Thomas Schelling of Harvard University, Hermann Kahn of the Hudson Institute and Alan Enthoven of the Pentagon. We aimed to see right through the American argument on the bipolar world and the paradoxical theories of the two greats on the disarmament through our participation in the *Pugwash movement*. The Chinese and French strategies complicated the game to the delight of theoreticians, in particular André Glucksmann who wrote his *Discourse of war*.

In the 1970s, another great moment of dissemination was Roland Barthes' and Jacques Le Goff's reception of Giulio Einaudi, who had come to launch his Encyclopedia project[27], at the Ministry of Education, rue de Varenne. We mainly began to contribute, and above all Jean Petitot who was responsible for the organization of the mathematics articles with Ruggiero Romano. Great, comprehensive syntheses were elaborated and it is regrettable that no attempt to translate them into French or English succeeded.

It is necessary to note, apart from twenty or so published works, some additional initiatives that successfully spread the word about social mathematics.

First of all, beginning in 1974 and for ten years, a site seminar, typical of the School, reunited researchers in political lexicology[28] and humanities professors, around Georges Guilbaud, reusing the probabilistic models in a lexicological context: to hell with the Laplace-Gauss law.

In 1982, historians of science began a long-lasting seminar, both scholarly for its sources and often pertinent for the works of the time, on the theme *The History of Probability Calculus and Statistics*: Marc Barbut, Bernard Bru and Ernest Coumet assembled an audience of loyal followers that became larger and larger. In particular, many came from inside the Ecole: some colleagues from the Alexandre Koyré Center and from the Laboratory of Historical Demographics. Finally more recently, still with the idea to see the Center become a forum for discussion and criticism of the models, another seminar of the Ecole on *The Question of*

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[24] The Preparatory Teaching for Developed Research in Social Sciences, created in 1966, would last until 1970.

[25] André Lentin and Marc Barbut established the DEA in Mathematics and Applications for Human Sciences in order to attract doctoral students. The effects were slow but successful. Later on, we were associated with the DEA in Cognitive Sciences led by Michel Imbert and participated in two other external DEAs in Mathematics and Algorithmic that attracted high-level young mathematicians to us.

[26] The GEMPPS, directed by Pierre Rosenstiehl and Alain Joxe, ran from 1960 to 1970. Didier Pfeiffer, upon leaving the ENA, was appointed to the Group by the CASDN, during his time of national service, for the study of strategic international agreements. Juliana Karila, legal expert, attests to the documentation.

[27] Jean Petitot and Pierre Rosenstiehl contributed nine articles to the *Enciclopedia Einaudi.*

[28] From the Laboratory of Lexicology and Political Texts: Robert Léon Wagner, Maurice Tournier, Pierre Lafon, Annie Geffroy, André Salem, Majid Sekhraoui.

Modelization[29] gathered, under Jean Petitot's leadership, researchers from numerous horizons and researchers from the Center, whom Hervé Le Bras joined.

5. THE TIME OF RESEARCH

Social mathematics does not have a true network or international associations, yet mathematics, discrete or otherwise, for the youngest in particular, is seen today as networks[30]. Therefore we were supposed to quickly promote in the fields that mattered to us, fundamental investments and their publications.

This is the case, in the field of probability calculus, with the probabilistic approach of Pareto's statistical laws on the inequalities of revenues, and those of Zipf on the frequency of words in the work of a writer or a speaker. Marc Barbut's developments, which respond in particular to sociologist and historian colleagues' questions, are founded upon the mathematician Paul Lévy's discoveries and in the spirit of Benoît Mandelbrot's works. For her part, Micheline Petruszewycz dealt with lexicology following the great Markov's approach: study the little-variable proportion of vowels to consonants, stable but fluctuating the length of a work — Pouchkine's poetry for example — in studying the process of the succession of letters in the sentence.

In the field of partial orders and permutations, my first works with Georges Guilbaud on the permutoèdre and the medians are extended by the original results on the Coxeter groups, the trellis structures and their metrics, the analysis of ordinal data under the direction of Bernard Monjardet, Bruno Leclerc and Claude Barbut, in conjunction with André Lentin and Marcel-Paul Schützenberger. The lively manifestation of this research is today the collective seminar called *Discrete Mathematics and Social Sciences*[31].

In the field of fundamental computer sciences and compilation, Jean-Pierre Desclés[32] launches works on computational linguistics and constructions on treatment of language.

Claude Berge's association at the Center dates back to two twin colloquiums, pleasant and foundational from many points of view, which he organized in 1966 in a Roman hotel: Bernard Jaulin led one on Calculus and the Formalization in the Human Sciences, I led the other on the Theory of Graphs, and we officiated in parallel and simultaneously with the same coffee breaks! After that, and for thirty years, I shared a doctoral seminar with Claude Berge on the theories of graphs at the Center, out of which came numerous current researchers of the CNRS[33].

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[29] *The Question of Patterning in social sciences: mathematics and computer science*, by Jean Petitot, Marc Barbut, Jean-Pierre Desclés, Georges-Th. Guilbaud, H. Le Bras, P. Rosenstiehl (in collaboration with the Foundation House of Human Sciences).

[30] Mathematicians received as associated members at the School: the Russian Léonid Melnikov, the Hungarian Janos Pach, the Canadian Ronald Read, the Japanese Iroshi Imai, the Americans William Jewell, Richard Pollack and Robert Tarjan. Other than that, we received every year about fifty foreign visitors in our seminars. And since 1990, thanks to the international academic messaging service, the Center exchanged individualized electronic messages with about a million correspondents.

[31] The seminar *Discrete Mathematics and Social Sciences* is organized by Jean-Pierre Barthélemy, Olivier Hudry, Bruno Leclerc and Bernard Monjardet.

[32] The Language, Logic, Computer Sciences and Cognition team, under Jean-Pierre Desclés' direction, joined the Center beginning in 1983: Henri Labesse, Denise Malrieu, Razeq Afzali, Michel Bourdeau, Jean-Luc Minel, Jacques Courcier, Gian Piero Zarri.

[33] Jean-Claude Bermond, Michel Las Vergnas, Jean-Luc Fouquet, Jean-Claude Fournier, François Sterboul, Anna Germa, Michel Chein, Hubert de Fraysseix, Frédéric Marie.

Note more specially the publications in the field of topological graphs and maps: with Hubert de Fraysseix and Patrice Ossona de Mendez[34], we created the international network of graph drawings and their geometric or cartographic applications.

In the 1980s, we distinguished ourselves by several proofs and algorithms that were the object of international conjectures, concerning the manipulation of lines of the plane[35]. The groundbreaking idea of the time was to track a writing structure of the objects the algorithm addressed so as to minimize the number of basic steps of the calculation. The climax was to obtain a number of basic steps that was a linear function of the dimension of the data; if, contrarily, the function was exponential, the calculation was impossible. We gave this collection of constructive research on discrete topology and geometry the name Taxiplany. We strived in the field of proportional sorting of randomly given numbers by the secant curves of the plane, and in the field of the flat representation of a planar or non planar graph, which is to say drawn with intersecting lines. Our results allowed us to enter into a group of twelve European academic centers that, under the title "Algorithms and Complexity", formed a network of innovation on the algorithms of the project ESPRIT of the European Community.

Finally, at the opposition of the combinatorial approach, the catastrophe approach — of differential equations, of stability of dynamic systems and of phase changes — allowed for a model of the qualitative phenomena of genetics. With the same tools, the cognitive processes confront more and more a quantitative patterning of neuronal, multiple and slightly erratic activity.

6. A BRIEF LOOK BACK

Let's take a step back to observe this forty-year mathematical liveliness. One can first salute the advantageous role of a happy independence of spirit, quite appropriate in our Ecole, which allowed for some audacious strikes in groundbreaking initiatives, especially on the outside, where we have been among the initiators.

Then one observes an evolution through the years toward less pedagogy and more mathematical research itself. More precisely, the study of simple and robust models, easily diffusible and whose intelligibility we have extolled, was followed by the study of much diversified models, technically more elaborate, often with computer support, and taking charge of the complexity of self-organized systems. It is true that, around the world, the hard techno-sciences opened a new front in the field of human and social sciences.

To summarize, let's cite at random the themes of research that mark our era: the algebras of similarity, the polyhedrons and the trellises of consensus, the statistical regularities hidden from social inequalities, the lexical counts and the authenticity of texts, the structures of data appropriate for the combinatorial complexity, the recognition of known forms in a scrambled image, the mathematical theory of morphologies, the cartography of synthesis and the computer model of the space of colors. But also more social activities: mathematics for all on the television,

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[34] In 1994, Patrice Ossona de Mendez defended at the School a thesis on combinatorial topology that made a great impression: *Bipolar Orientations*. It proved to be founding in the area of automatic cartography. It received the thesis award from the School.

[35] More particularly Gauss' conjecture on the characterization of sequences with double occurrences can be shown by a curve's intersections with itself on a plane (Pierre Rosenstiehl) and the problem of the characterization of the graph of intersection of a family of cords of a circle (Hubert de Fraysseix).

the implementation of math in colleges of economic sciences and then in colleges of humanities and social sciences, the advent of operational research and of strategic studies, the conquests of the probability calculus outside of the realm of physics, the sudden entrance of statistical mechanics, differential equations and dynamic systems in the field of cognition, the combinatorics raised to the rank of a discipline entirely apart in the pantheon of mathematics, finally the computer sciences of algorithms and of calculus structures, which is to say of know-how, opposed to the kind that merchants who practice the "turnkey" kind. As many defining facts that count in this half-century: the abstraction and the mathematical constructions have played their role here in a technological and social context that expected and created them.

One would ask oneself then if mathematical practices have not been simple exercises of style, behind which were the obscure but implacable currents of the time, of an entirely other nature than the one of our mind games: the obsessive efficiency of the praxis, the unlimited automation, the reduction in codes of cognitive processes, a mastery of the economic systems claiming to tame the fluctuations and mutations, the rationalizing fiction of the democratic game, the justification of the strategy of the strongest by themselves.

In wanting to be contemporaries in at-risk areas, perhaps we have served the dominant trends. However, we were loyal to the millenary tradition of our discipline, its style of questioning that always brings us back to the organization of the processes of the mind; to its wisdom as well, which invites, with a look upon the long-term, the addition of some modest leaves to a multiform and lively body of knowledge.