

CONNECTING SPHERE

CONNECTING THE UNIVERSITY OF SCIENCE AND TECHNOLOGY OF LILLE (FRANCE) WITH THE WORLD

MATHEMATICS : WHAT FOR ?

Since the year 2000 has been coined the “Year of Mathematics” (see box on page 3), Jean d’Almeida, Professor of Mathematics at the USTL, researcher at the AGAT* laboratory, agreed to tell us how Mathematics are interrelated to other sciences for Sphere. Unlike what most people think, it seems their role is predominant.

Sphere : Put simply, those of us who are not mathematicians always ask the same questions about Mathematics: “What are they really ?” and “What are they for ?”

Jean d’Almeida: A good definition of Mathematics is the quest for structures and forms that bring order and simplicity to the universe. The starting point of a mathematical analysis is not as important as its resulting



Jean d’Almeida

coherence, which can in turn be used in an entirely new context. Mathematics are dual in essence. On the one hand they are an authentic discipline, the foremost qualities of which are precision and inherent beauty. They are an essential part of our universal culture, and one should therefore do mathematics as a tribute to the “honor of the human spirit” (J. Dieudonné). On the other hand, mathematics are also useful tools for various applications.

Chantal COBET • USTL



JUNE 00

EDITOR’S NOTE

The image conveyed by Mathematics is not a very positive one for most people. They seem abstract and mysterious, raise questions as to their usefulness in everyday life, are used as a means to select the best students...on the whole, Mathematics are often ill-perceived.

So what are Mathematics really about ? One of the objectives of the International Year of Mathematics in this year 2000 is to readjust that image. The pertinent, enlightened and enthusiastic interviews in this issue of Sphere are meant to be a part of the rehabilitation program for Mathematics.

Rather than summarize the current research projects and their results, a perilous exercise for even the most on-the-edge scientists, Sphere has chosen to highlight the connections between Mathematics and our everyday life, to reinstate them into a world made of men and women...and children, too.

As for the importance of Mathematics, what better celebration can there be than the recent announcement made by the Directing Committee of the Clay Mathematics Institute to allot 7 million dollars to the finders of the solutions to the 7 major mathematical problems that continue to challenge the community ?

Patrick Caron,
Vice President,

Head of the Department of Training
University of Science
and Technology of Lille



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Computers would not have been invented without Leibnitz' binary code, nor would Einstein have established his formula on relativity without the riemanian geometry. The development of quantic mechanics, cristallography, or telecommunications would not have been possible without the progress made in the group theory. Mathematics undeniably entertain close relations with other sciences.

- *Algebraic geometry was used by physicians in their quest for a unified theory of fields, a theory that could account for all 4 fundamental forces in physics (gravity, strong nuclear forces, weak nuclear forces, and electromagnetic forces). As a result, the string theory was enunciated, a theory that assimilates the constitutive elements of matter as tiny vibrating cords resembling those of a violin. This finally led a team of physicians to a series of spectacular predictions on purely mathematical objects.*
- *In the 1920s, Vito Volterra, an Italian mathematician, suggested the first models to describe the prey-predator relationship. These methods have since been applied to epidemiology. Progress over the last decade has led scientists to redefine several aspects of immunology, genetics and neurology. As a result, biologists' perception of the VIH virus changed and led to multi-drug*

treatments.

- *The Nobel Prize winner of Physics, Richard Feynmann, suggested in 1982 that only a new generation of computers called quantic computers could simulate extremely complex situations. In 1994, mathematician Peter Shor demonstrated that such a computer could rapidly factorize large whole numbers, and therefore break every encrypting code considered to be secure today. But constructing such a computer remains a challenge.*
- *One of the current problems in Economy is the necessity to extend the mathematical general equilibrium theory to include price adjustments. The function "excess demand" can be interpreted as a field of vectors on part of a sphere. The equilibrium point is found by means of a theorem established by Hopf, a mathematician.*

As one can see, the outlook on Mathematics is a paradox: while their influence is perceivable in almost every practical aspect of our everyday life, most people, including the media and nation leaders, have a rather "contrasted" view, shall we call it, of the science.

*AGAT: Laboratory of "Arithmetics, Geometry, Analysis, Topology", part of the CNRS (Centre National de Recherche Scientifique, *National Center for Scientific Research*) and the USTL, headed by Daniel Tanré (see Sphere No. 10, March 1998)

NEW EDUCATIONAL PATHWAYS

Although straightforward pathways to Mathematics degrees are the rule among those who wish to teach or do research in the field, there are some who create their own smart paths to combine more or less closely related fields. Could this be the starting point for a new kind of research ?

Hélène Touzet, assistant professor, has a p.H. D. in computer science with a mathematical subject. She is now working in the field of bio-information systems. "Along with other trained mathematicians, we are following a self-established program in biology, biochemistry, and genetics, that uses BA courses, congresses and articles in specialized journals to acquire the necessary knowledge", she says. Their interdisciplinary training is well complemented by that of one of their colleagues, initially a molecular biologist. Their everyday work is based on the DNA sequencing recently accomplished. Although medical advances made thanks to the sequencing of DNA is often advertised, one should not overlook the capital input of bio-computer scientists in the process. For the data provided by the sequencing (roughly, a list of nucleotides) is impossible to use as such. The role of bio-computer scientists is to analyze the molecular structure, to fragment the series of nucleotides into "units" with a specifically defined biological activity. Thus the research programs decided by the "bio-information systems" team at the LIFL*, to which Hélène Touzet belongs, revolve around the development of algorithms to analyze the DNA sequences and the study of the secondary structure of RNA. With the newly established Génopole**, a number of projects are likely to appear. One of them is the opening of the new DESS (*Degree of Specialized Higher Education*) in bio-information systems planned for 2001. A curriculum that was almost unheard of 5 years ago is now becoming official, as a result of the application of numeric, statistic and combinatory methods to molecular objects.

Pierre-Yves Louis is currently pursuing a p.H. D. in Mathematics at the USTL. After two years of prep school he was admitted to a nationally renowned engineering school but preferred the University to pursue a double BA in Mathematics and in Physics. "I didn't want to have to chose between one or the other", he says. He then went on with a DEA (*In-Depth Post-Graduate Degree*) in Mathematics, a family tradition. His training in Physics provided him with interesting openings to work at the interface of both disciplines. The subject of his p.H. D., related to a part of the theory of probabilities that deals with the mathematical processing of phenomena in statistical physics, is a good illustration of his choice. More specifically, it deals with the macroscopic study of the evolution over time of a physical system with large numbers of components (e.g., particles) that interact on the microscopic scale. Only their global statistic behavior can be studied by means of probability models. For example Ising's model is used to define the changes in magnetic characteristics of solids such as iron, as there are several statistical states possible. This phenomenon is called phase transition. Since the 1960s, a whole new field of knowledge has been developing and has added to the theory of probabilities a series of new models full of physical meaning. These have given mathematical bases to statistical physics.

* The "bio-information systems" team of the Laboratoire d'Informatique Fondamentale de Lille, *Laboratory of Fundamental Information Systems of Lille* (LIFL) includes 5 scientists and is headed by Jean-Paul Delahaye

** The Génopole includes every research project in the region, regardless of its hosting organism, that deals with genetics. Look for an article on the Génopole in an upcoming issue of Sphere !

Operation «Math 2000»

The International Mathematics Union (IMU) decreed the international Year of Mathematics in May 1992 in Rio de Janeiro (Brazil). It is supported by the UNESCO. The object is to use the 2000-milestone year to acquaint as many as possible with the purpose of mathematical research, its many applications in everyday life and Economics, and its current vitality. Worldwide events follow one of three main themes, namely:



- *Challenges for the 21st century*: renowned mathematicians will describe what they see as fundamental problems that have yet to be solved;
- *Mathematics, a key for development*: to give a thrust to education, research, and most importantly to access to scientific information (with electronic libraries, for example) in countries where Mathematics lack drive and energy;
- *The image of Mathematics*: to enhance the image of Mathematics and demonstrate their role in Society. Large-scale actions such as billboard campaigns in the subways of large cities around the world are one of the many aspects of this theme.

At the USTL, in addition to the usual events for scientists, a series of conferences on Mathematics was given in February 2000 with the “Galileo Symposium”, followed in March by the Academic Days on the history of scientific teaching. In June, the Conference on Statistics and the Second French-speaking Symposium on Polls were both held on our grounds. The University will also take part in the worldwide billboard campaign. Finally, during “Science Week” (Oct. 16th - 22nd, 2000) a small exhibit entitled “Every Man Counts” will be open to the public.

For Pierre-Yves Louis, USTL correspondent for large-scale actions, Math 2000 is a good opportunity to “polish up the image of Mathematics for non-initiated publics, outside the world of Universities and Professors, and to break down the many preconceived ideas on the subject”. A number of interconnections bear witness to the inherent assets of Mathematics, its largely unexplored potentials, and possible synergy with other scientific and technological fields. “It would be a good thing if Math 2000 provided the community of mathematicians with the opportunity to show that mathematical objects and theories are actually involved in many aspects of every day life, and that behind the apparent complexity and particular language of Mathematics one can find the simplicity and universality of ideas”.

Regional Library for Mathematical Research

With its 15,000 books and 320 different periodicals, the Library for Mathematical Research can boast ranking among the first five such libraries outside of Paris. Its size and importance reflect the large mathematical community in the area. Since 1993, it is housed in modern facilities with an architecture geared towards light, financed by the Ministry, the Region, the FEDER (Fond Européen de développement économique, *European Funding for Economic Development*) and the CNRS (Centre National de Recherche Scientifique, *National Center for Scientific Research*). The two-story, 800m² building stages 2 km of bookshelves. But beyond its architectural aspects, the library’s main purpose is to provide mathematicians with the tools they need to continue their work, just as chemists need a spectrometer or biologists a microscope. This tool, however, was specially designed to become a central meeting point and encourage communication around books. Both mathematicians and physicians from the area and far beyond, whether French or foreign, are granted direct access to older authors or current international journals and magazines. Modern information tools have not been left aside, since the “Bib des Maths” (*Math Library*) along with the Common Documentation University Department, is one of the intersections in the National Mathematics Library Network created in the 1980s by the French National Society of Mathematics and later supported by the MEN (Ministère de l’Education Nationale, *French Ministry of Education*) and the CNRS. Using the same computer standards as the rest of the network, documents can be accessed from Mathematics libraries and laboratories around France. The yearly operating budget runs around one million Francs, currently supported by the Ministry (via a specific plan for training), USTL laboratories of Mathematics and the UFR (Unité de Formation et de Recherche, *Training and Research Unit*). Note that a contract is currently under way to formalize the financial participation of other laboratories in the area in the development of the library.

Contact:
<http://www.univ-lille1.fr/bibmath>

Claude NODOT • USTL



The math library

FOCUS ON THE FUTURE

ON THE ROAD TO EQUAL OPPORTUNITY

In May 2000, the French Ministry of Education published a report on women and the university. It stated that women are drastically under-represented among teachers and scientists in what is commonly referred to as “hard-core sciences”. In the field of Mathematics, Anne-Marie Marmier, Director of the Training and Research Unit of Mathematics at the USTL, describes a situation that confirms the report and attempts to pinpoint its origins.



Anne-Marie Marmier

Chantal COBET • USTL

For a long time university knowledge was not accessible to women, since the only purpose of education was to equip them for their future role in Society. Common girls destined for

some kind of handiwork were only given primary education while upper class young women were trained for their future position as a wife and mother.

Today one can list women’s victories and the once unfathomed positions they now hold. The feminine condition has indeed gained a much greater degree of freedom. But changes in Society are actually overrated while persisting behaviors are underestimated. Though women may have access to knowledge, they find it difficult to be recognized as having it. Sociologists have studied this phenomenon and the media has publicized it: girls are more successful in school than boys, perform better in most exams, but are later found crowded into a small selection of degrees with limited outcome. Girls in curriculums with high prestige or better job outcomes are still the exception, such degrees relying heavily on Mathematics. So we see that coeducation is still a myth.

Many studies have shown how, just as the educational system transmits selective knowledge depending on the student’s social category, it also selects knowledge for the female category. The same studies demonstrate that Mathematics play such an important part in producing the elite that they have become overly selective. They also show how that girls censor themselves when choosing their future career and are thus excluded from the most selective curriculums that would otherwise have led them to a more prestigious social position. The very small numbers of women among the elite can be seen as reproducing masculine domination, a self-inflicted heritage of history. There has been and there still is a social consensus that states a girl’s inaptitude to study Mathematics. Girls themselves and their parents have become convinced of this, while the educational system confirms and legitimates

it. All that is needed to establish the so-called “incompatibility between women and Mathematics” is to let people believe that qualities required to pursue them are those that are classically attributed to males, i.e. a taste for the abstract world, games, and competition. Remember that at the turn of the century, girls were considered inapt to learn Greek or Latin, which were, at the time, mandatory to further one’s studies in the humanities. It seems their incapacity has since

A FEW FIGURES

Rather than a slow and constant progression in the rate of girls registered in scientific curriculums, their numbers have stabilized. The rate of girls in high school sections where science is predominantly taught reached a peak in 1981, decreased thereafter and has stabilized around 40%. In Mathematics degrees, women become fewer as the years of study go by.

The current situation at the Lille university provides a good example of the trend, although the numbers here may be better than elsewhere in France. In 1999, 49% of the recipients of a MIAS DEUG (Diplôme d’Etudes Universitaires Générales, *two-year general degree*) were women, and 52% of the registered students in license (*Translator’s note: equivalent of a BA*) are female, but every year they are fewer in the class. They constitute less than a fourth of the class in master’s degree, yet over 36% of the graduates. Six women out of 11 receive their agrégation (*Translator’s note: teaching degree for high schools and universities*), 6 out of 28 are successful at the DEA (*In-Depth Post-Graduate Degree*), and a little under half the recipients of the CAPES (Certificat d’Aptitude au Professorat de l’Enseignement du Second Degré, *teaching degree for junior high and high schools*).

At the Mathematics UFR (Unité de Formation et de Recherche, *Training and Research Unit*) of the USTL, women account for 37% of assistant professors but only 14% of professors. As for the upcoming generations, the situation is far from being reassuring: among the 47 p.H. D. students this year, only 7 are women. These figures have remained more or less unchanged over the past four years. Finally there are only 3 female ATER (*Attache Temporaire d’Enseignement et de Recherche, temporary assistant professor*) out of 27.

This is representative of what is happening all over France. Careful analysis of recent recruitment has shown that few women go into research, that they usually succeed in becoming assistant professors but more rarely professors (30% of assistant professors recruited in 1998 and 7% of professors).

Numbers may be a crude way of analyzing the situation, but overall, they reflect the more general status of women in Society, although the image is somewhat worsened by the reference to Mathematics and the symbolic power they represent.

disappeared, since ancient languages are now considered to be a women's prerogative !

In this closed-circuit system, women who seek to transgress the rule may be excluded before they even start. How many times have we not heard regrets over such or such a brilliant female student whose scholarly type of intelligence is not adapted for research ? But did anybody think of telling her about it ? Did anyone take the time to help her realize her own worth ? Women may earn respect by showing their intelligence and stubbornness, but excellence is usually the exception. When it is found in a woman, it is all the more easily accepted that she is usually assimilated to a man, so that masculine domination is not threatened. A famous example of this is found in Emmy Noether's case, who was the first to introduce structural algebra. She was far from being pretty and was referred to as "Der Noether". Mrs. Dubreil wrote this about her: "The work of Emmy Noether does not place her among the very top female mathematicians, but among the very great mathematicians". This just goes to show how difficult it is to find positive role models within the community of mathematicians and to feel invested with the heritage of Mathematics.

Another possible interpretation of women's eviction from hard-core sciences is to consider that women make reasonable choices in anticipation of a likely future and that they are not willing to pay the –sometimes high- price in terms of family and affective sacrifices to enter the masculine ranks. They are less submitted than young men to the system that values hard-core sciences and competition as a means of accessing high-rank executive positions, and therefore have more freedom to choose to work and study in fields of interest to them. Have not young women benefited from the creation of new curriculums and degrees ? Have they not massively turned to business, law and political science schools of higher education ?

As it turns out, only recently have girls started to pursue long studies. And this stems from the same global existential drive that led them to obtain the right to contraception, to become a part of the work force, and hold high-rank positions.

But we should also look into Mathematics themselves and the way they are taught here or abroad. The contents of Mathematics are far less known and understood than those of other sciences. Mathematics are perceived as abstract, eternal, and far removed from this world. As we have seen, they are dangerously branded by their use as a means to select the elite (mathematicians failed to foresee danger early enough). They are seen as "superpowerful" because of their ubiquity in techniques, but reduced to a utilitarian language for the very same reason, servile to other scientific fields. They are devalued and hated to the point that it is considered hip to declare one's lack of its knowledge.

Mathematics are a human activity to many who labor daily and may reap pleasure or pain from them. The myths on Mathematics are far removed from the way they actually occur. The history of science gives a good account of the fact, with the long elaboration of concepts where thorough rationality goes along with imagination, poetry, intuition and aesthetics.

The hidden presence of Mathematics in technique is amazing when it is unveiled. Yet it is only the sign of a deeper presence in the intellectual grasping of the world and its symbolization. Therein lie the roots of the effectiveness of Mathematics. If the educational system and math teachers would take this reality into consideration, we might not lose girls and women along the way !

Briefly...

- **Cassini Mission** : the project is to send a space probe to Saturn in order to observe its satellites. Astronomers of the USTL are working to represent the movement of the planet's 8 major satellites (see Sphere No. 14, June 1999). The new theory they are developing should provide better knowledge of the masses and dynamic parameters of Saturn's system as well as the position of the planet itself. It should also reveal the existence of weak interactions (possibly non-gravitational interactions) that have, to this day, never been reckoned with.

- In the **Laboratory of Mechanics of Lille** (see Sphere N. 12, December 1998), Mathematics are a necessary tool. One of the current projects entails creating a model for the transportation of particles via convection and diffusion in environmental fluids. The circulation and pollution in the French-British Channel is one of the regional projects developed by the laboratory with numeric methods. Long-lasting collaboration with the Institut Electronique et de Microélectronique du Nord (IEMN, *Institute of Electronics and Microelectronics of the North*), also gave birth to a mathematical model and numeric simulation of time reversal of acoustic waves in magneto strictive materials, proving in the process that it is feasible and applicable to very promising ultrasound imaging techniques.

- An **IBM supercalculator** is being installed at the Centre de Ressources Informatiques (*Center for information system resources*) at the USTL. By the end of the year 2000, its final version will be able to process 100 billion operations per second (Maximum Power: 100 Gigaflops). That ranks it among the top 500 most powerful machines in the world, and among the top 15 French machines, whether state or privately owned.

- The USTL department for customized teaching via the media, in partnership with the IUFM (Institut Universitaire de Formation des Maîtres, *University Institute for Teacher Training*), created a web site on numbers as a part of the DREAM European project (Developing and Raising European Awareness of Mathematics). DREAM aims to continue the various events initiated with Maths 2000.

- During "Science Week" (October 16-22, 2000), the USTL will be sponsoring a small exhibit entitled " Every Man Counts" at the Village des Sciences et Techniques de Lille. Put together by the Association Science Technologie et Société (ASTS, *Association for Science, Technology and Society*), held by teachers and scientists from the University, the exhibit uses treasures of imagination to help visitors playfully discover just how familiar and accessible Mathematics really are.

- **Fresh off the press !**

The IREM of Lille has just signed a book on numbers. High school, University and IUFM teachers, along with French and foreign scientists from the CNRS, chose some of the conferences of the IREM Symposium on the Hadamard-De la Vallée Poussin theorem to make the book. The theorem deals with the behavior of prime numbers under n .

The book is mainly geared to high school teachers who wish to take different approaches to numbers, but also to all those who may be interested !

Les Nombres by the IREM de Lille, Ellipses Ed. ("Mathématème" Collection)

Jean-Paul Delahaye, Professor of computer science at the USTL, has just published a book on prime numbers. It is a unique mixture of explanations shedding light on theoretical notions and piquant anecdotes that restore colors to the shimmering world of prime numbers.

Merveilleux Nombres Premiers by Jean-Paul Delahaye, Belin Ed.

"Pour la Science" Collection)

IREM (Institut de Recherche sur l'Enseignement des Mathématiques, Institute of Research for the Teaching of Mathematics)

IREMs were created nearly 30 years ago after modern Mathematics were introduced in school. There are a total of 26 such institutes (one per regional academy). Commissions from the different IREMs meet yearly to discuss themes that range from Geometry or Math History to calculators. Some of their work is published in the IREM's journal called "Repères" (*References*).

The Lille IREM, bound by contract with the Mathematics UFR, has been headed by Valerio Vassallo since 1994, successively assisted by Daniel Deleforge, Marie-Claude Deblock and for the past few years by José Bonet. The IREM is equipped with a secretary, a library and a multimedia department. One of the unique features of the institute is that about 50 math teachers from grade school on through the university work together. Teachers from the IUFM and the CNRS also participate on occasion. The institute's main activity consists in providing continuous education for math teachers via training courses (400-600 teachers are trained yearly) and in rethinking the way Mathematics are taught.

Valerio Vassallo and his team also promote cross-cultural exchanges between math and other fields. With this in mind, and also to further research on teaching methods, a host of symposiums have been organized on topics such as "Art and Mathematics", "Mathematics in Junior High", "Italian Algebraists of the Renaissance", "Galileo", "Academic Days on the History of Science Teaching of the 20th Century", and "Geometry in Grade School". The more fun-oriented yearly Math Rally has become increasingly successful with young students since it was created 8 years ago. The finals on June 3, 2000 saw several hundred children team together to solve enigmas, manipulate mathematical objects and use the compass, T-ruler and other instruments. Their quest always makes them think, requiring logic, rules and basic theorems. Children have lots of fun and ask for more ! Beyond the institutional relations with the USTL, the Rectorat (*Translator's note: institution in charge of education in each*

regional academy), and the IUFM, the IREM has regional cultural partners such as the Italian Cultural Institute, the Academic Commission for the Promotion of Culture, the Forum des Sciences (a local interactive museum on science), and the Goethe Institute. The IREM is also supported by the Conseil Régional, the Conseil Général and by some cities.



Valerio Vassallo

Valerio Vassallo and his team still have many projects in mind. They would like to organize "Cinema and Mathematics", participate in "Cité Philo: Mathématiques et Philosophie" (Mathematics and Philosophy), host the Ecole Normale Supérieure de Pise's exhibit on curbs now showing at the Palais de la Découverte in Paris. He wonders "Would it be too extravagant to dream of some kind of place where mathematical instruments and objects could be displayed for all to see?"

Contact: <http://www.univ-lille1.fr/irem>
e-mail: irem@univ-lille1.fr
phone: 33 3 20 43 41 81
fax: 33 3 20 33 71 61



FOCUS ON SKILLS

NUMERIC ANALYSIS

Numeric analysis is a subdivision of Mathematics. Two assistant professors at the USTL affiliated to the Laboratoire d'Analyse Numérique et Optimisation (ANO, *Laboratory of Numeric Analysis and Optimisation*), Caterina Calgaro and Nathalie Revol explain their field's outlook and present a few practical problems that numeric analysis has helped solve.

Most objects and services used in our everyday life were designed by numeric simulation. Former trials on prototypes and reduced-scale models are increasingly being replaced by calculations on computers. Examples of this can be found in the fields of aerospace and nuclear safety, where some numeric results are now considered as valid experiments. Numeric computation is a tool with many applications, such as weather forecasting, constructing mechanic structures (planes, car bodies), and

medicine (heart valves, prostheses, imaging, virtual practice before surgery).

The work of numeric mathematicians starts with finding an equation that represents the problem, a step they refer to as **modelization**. In this step factors implied in the equation must be identified and defined by equations that describe their behavior and interactions. For example when studying the dynamics of gas, pressure, temperature and speed will be the unknown factors. Equations that qualify these factors

will then be written, for example conservation of the gas' mass in a given volume, conservation of the quantity of movement and conservation of the energy provided by the system. The equations use partial derivatives. Equations are usually best defined by specialists of the problem itself, assisted by numeric mathematicians. The former are also the ones who can simplify equations when they are too complex, i.e. decide to neglect factors that have little effect on the phenomenon, relatively speaking.

A **mathematical analysis** is then carried out to study the problem, to determine under what conditions there is a solution (choice of parameters), if there is a single solution, and if not, to select the solution that fits the actual physical situation.

Since it is impossible to compute a very large number of figures, much less an infinity of figures, the problem has to be approximated by calculating the value of unknown factors in certain predefined points. This step is called **discretization**, and must be balanced by measuring the degree of error caused by the approximation. The degree of error provides the distance between the approximation and the real solution of the initial problem, according to various parameters such as the size of the numeric problem and the regularity of the solution.

But discretized problems may still be too complex to solve numerically. In this case, an additional **simplification step** is required. It may consist in making non-linear problems linear, for example. The problem then becomes easier to solve with high performance numeric methods such as the resolution of linear systems, optimization with a method of gradients, the eigenvalue problem.

The **algorithmic aspect** can subsequently be dealt with, that is, entering the method of resolution on the computer. First, a bite-saving and easy-to-use diagram of memorized data is selected. In cases of a repeat method, the steps from an arbitrarily chosen initial solution to the solution of the problem, or an acceptable solution according to predefined criteria, have to be defined. When equivalent mathematical

formulations are numerically different, the most stable one should be chosen in order to obtain reliable results. The next steps involves writing **the program**. This needs to be efficient, adaptable, transferable from one computer to another, easy to understand and easy to use by others. Note that what makes an algorithm difficult is not so much how long it takes to develop it, but how long it takes to compute before the problem is solved.

Once the results are fed out by the computer, one must still be careful and study the **sources of error**, whether the data itself, the approximation, or the method used. Another source of error is the very essence of the problem, i.e. the **conditioning** : a figure that measures the amplification of errors. When a problem is not well conditioned, minute differences in the data can lead to very different solutions. In meteorology, this amplification is known as the butterfly effect: a butterfly's flap of a wing in Brazil can trigger a tornado in Texas. This is due to the very essence of weather-related highly non-linear equations. That is why weather forecasts are not reliable beyond 5 days in 2000.

To conclude, we would like to include what P. Lascaux, Professor at the CNAM (Paris), said about the necessity to teach numeric analysis: *"One could object that calculators and computers now come with easy-to-use computation programs, and that the user does not need to know which algorithms were used by the specialists who developed them once and for all. We believe, on the contrary, that it is highly educational to study some of these algorithms to understand the notion of stability, of precision, and the complexity that lead to the choice of the most efficient method for a given problem, that is, the method conferring the highest precision with the lowest cost possible, whether in terms of computing time or memory. In addition, it is only by studying algorithms that one can understand the limits to the validity of methods, and these should never be forgotten."*

Contact: <http://ano.univ-lille1.fr>

Numeric Analysis: a Few Examples

- Everyone has noticed that his calculator can not give an exact number for $1/3$, since the figure it gives has an infinity of threes after the decimal. Therefore the sum $1/3+1/3+1/3$ does not equal 1. This is just one of the problems we encounter daily with approximation !
- Images of the Tacoma Bridge (Washington State, 1940) swinging until it broke because of the wind, are still in everyone's mind. A similar accident, when a bridge ruptured under the feet of troop of soldiers marching across it, led military authorities to forbid infantry to march on a bridge. A study of the eigenvalue problem, indicating the amplified frequencies, would have predicted the bridge's rupture under the forced oscillation. Their computation is therefore an absolute necessity in many fields, such as the construction of earthquake-resistant buildings, statistic data analysis, or quantic chemistry.
- Say a manager wants to chose the capacity and location of his warehouses keeping working costs to a minimum and reaching his objectives such as satisfying his customer's orders. His problem is a problem of optimization with constraints .
- Equations with partial derivatives are often solved by solving a linear system, once discretization and simplification have been achieved. A first method consists in using Cramer's formulas. But to resolve an equation with 25 unknown factors on a 1 GHz PC, you would have to wait 0.5×10^{18} years ! The number of computations exceeds the number of atoms contained in the universe ! But with Gauss' method, the system can be solved within 16 microseconds. The maximum size equation that can be handled with this method has about 50,000 unknown factors. To simulate airflow around a plane, for example, requires the resolution of systems with 20 million unknown factors. Therefore new methods need to be developed with algorithms, such as conjugate gradient algorithm, krylov subspace methods, multigrid methods, stable methods, and for new tools such as super-computers.

Focus on Knowledge Transfer

STATISTICIAN

What is common to a marketing survey, a poll, a biometric study and quality control on a production line ? The answer is simple. They all rely on the same science: statistics. Because of the diversity in demands, complex methods and results that require careful reading, statistics are now reserved to Mathematics specialists.

About 20 graduates of the DESS of Statistic and Numeric Engineering join mostly large regional and national companies yearly. There they process growing numbers of more and more diverse data (scientific or technical data, accounting, finances, etc.) before making results understandable for the non-initiated.

A 94 graduate, Philippe Hollebeke explains what a statistician does: "We use different methods of analysis, modelization and simulation to assess a situation, define risk and establish options for the future... and ultimately assist in the decision-making process". Convinced that he wanted to work in large industries, M. Hollebeck was recruited by Usinor in 1997 after having worked shortly for the Crédit Agricole. As the only statistician in the Sollac Atlantique group, his job includes modelizing tools

of developing and implementing a Statistic Mastering of Processes in the factory for quality control. "The training I received during the DESS helped me adapt quickly to the various types of software", she says, "and have a solid basis for rigorous analyses".

As for Patrick Devos (92 graduate), he works in the statistic laboratory of the Medical Faculty of Lille: "I work on applied research, help doctors, researchers and interns of the hospital with their studies and publications, and am involved in teaching at the Medical faculty", he says. Mr. Devos started working at the University Hospital during his DESS training course, at which time his job was to optimize treatment management, i.e. to implement a system with which to determine which patients required a thorough examination. He explains that biostatisticians are not so common in hospitals, "even though statistics are becoming more and more important in research as well as health Economy", he adds.

The French National Railway System (SNCF) has also recruited graduates of the ISN DESS such as Hugues Deleu (96 graduate) who started there in 1997 to manage a ticketing project called the "transcarte", which was, at the time, being developed regionally. The object was to emit 19,000 microchip cards used as tickets on the regional railway system. Mr. Deleu's role is similar to that of a project manager, and involves defining the fore-project, needs analysis and its actual implementation: "...customers, authorities in charge of transportation, agents, it was a difficult challenge..", he admits. For him, applied Mathematics are more of a "knowledge basis" for a position that reaches into a variety of fields (strategy, marketing management, information systems, human resources, etc.) and requires technical competence (microchip cards).

When pondering what had always attracted him in Mathematics, he realized that it was not the imagination required for the formulation of a theorem nor the absolute rigor of its proof, nor even the elegance of a demonstration, it was the pleasure derived from the way the problem was spelled out.



Philippe HOLLEBEKE Chantal T • SOLLAC

Modelizing smelting furnaces at Sollac (Dunkerque, France)

(smelting furnaces, gas systems in the factory, railway logistics, metal flow, etc.) as well as steel characteristics, developing plans for experiments, metrology, and implementing predictive systems for process piloting. He regularly hosts training students from the ISN DESS such as Karine Budenhulzer (97 graduate) who now works with Alcatel Optic Fibers in Douvrin. Her first job involved defining and organizing experiment plans (for example to determine the optimal speed of the process during which a heated glass tube is stretched into the thin glass thread that constitutes the actual optic fiber). She is now in charge

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USTL-Cellule Communication-Bât. A3-Cité Scientifique-59655 Villeneuve d'Ascq Cedex France-Tel : 33 3.20.43.43.32-Fax: 33 3 20 43 68 98-

E-mail com-ustl@univ-lille1.fr