Mathematics and its interfaces with science, technology and society

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Although the role of mathematical sciences in civilization has been of central importance for many centuries, the current trend towards a global economy and a knowledge society has made information and innovation technologies increasingly dependent on scientific research driven by mathematics. In the present day context, mathematical sciences, including statistics and computing, are accepted as an integral part of technological progress.

Mathematics provides the context for communication and discovery in many scientific disciplines and modern industry. It is the language of innovation, which is vital for society and industry. As an analogy, it is impossible to argue with the fact that the development of speech has had an enormous impact on the development of the human race and has added to the richness of human culture.

Mathematics, as the oldest of sciences, has also contributed substantially to the development of our civilization and began its advance at the moment when it became necessary to count and when counting became a part of every language. It is interesting, however, that the written symbols, namely figures, by which numbers are expressed, appeared only in Arabic and Roman characters.

Different historical eras required different types of mathematics. Its development was accelerated by the tasks that naturally arose at different stages of social and technological progress. Nowadays research in mathematics is responsible not only for continuing to produce a language that would universally allow us to understand a variety of deep phenomena but also to provide a link between pure mathematics and its applications that would serve the community.

Two thousand years ago mathematics was very close to philosophy. Plato and Aristotle used relatively advanced mathematics to solve practical problems and also as a means of understanding life.

Starting with Newton, mathematics became a tool in the explanation of physical processes. Basic equations describing classical mechanics were set up and could be considered as a starting point of the incredible technological development that we observe today.

So, what is the mathematics of today? Many people often wonder if there is anything left to discover and are surprised that mathematicians are still involved in mathematical research.

It is true that many new results in mathematics do not have immediate applications but, eventually, most of them do become applicable. Let me mention a few recent examples where the use of mathematics has proved crucial:

- Integral geometry, dealing with so-called inverse problems, has provided a methodology used in: medical imaging for identifying tumours, weather radars, the search for oil fields, astronomy, etc.
- The creation of modern fibre optic cables would not be possible without the discovery of special solutions of non-linear equations called solitons.
- The arrival of the Internet made people fear that the world would be drowned in vast amounts of information. This problem has been successfully resolved by Google, which invariably delivers, instantly, the information sought. It seems like magic but the searching algorithm of Google was in fact provided by mathematicians.
- The theory of wavelets has been enormously important in telecommunications. It allows us to transmit information in a most compact way and ultimately gives us the possibility of all sorts of wireless connections.
- Credit card security is only possible thanks to cryptology, which uses a branch of number theory.
- Mathematicians are involved in improving the understanding of fundamental problems in genomics research, cell signalling, systems physiology, infection and immunity, developmental biology, the spreading of disease and ecology.

- Together with theoretical physicists, mathematicians are working on the unified physical theory that involves the latest developments in algebraic geometry.

The mathematical theories used in these examples were not originally developed with any particular application in mind but purely as a result of the curiosity of scientists.

Nowadays, funding agencies are taking different initiatives in defining (top-down) prioritized research areas within mathematics. These areas often have an interdisciplinary nature and usually financial support of such initiatives is provided by making cuts in the funding of core activities in mathematical sciences. Because the nature of mathematical research is often far from being directly applied, mathematicians are not always considered as major contributors to such projects. For example, within the EU Frame Programme 7 (FP7), networking projects are required to have links with industry. As a result, FP7 has awarded almost no networking projects in mathematics during the last few years.

Although influenced by tasks driven by applications, the progress of mathematical research is also measured by its own natural development motivated by the curiosity of mathematicians. This fact is recognised less and less by funding agencies in many European countries, where funding of fundamental research has dramatically declined. For example, during the last five years EPSRC in the UK has reduced its funding of mathematics from £21 million to £12 million. The vital role that research in mathematics plays in the general progress of technology is not sufficiently acknowledged.

North America still remains a very attractive place for many European mathematicians because, thanks to the US Natural Science Foundation (NSF), mathematical sciences are very well established.

European mathematicians feel positive towards the creation of the European Research Council (ERC), which provides support for fundamental sciences. However, the small number of Starting and Advance Grants within PE1 Mathematical Foundations, distributed by the ERC, have not, so far, had a serious impact on the level of mathematical research in Europe.

Traditionally, most research in mathematics takes place at mathematics departments of universities. Besides "proving theorems", mathematicians are usually involved in teaching. During recent decades the number of students at European universities has increased substantially whereas the number of professors and lecturers has remained almost the same. Professors and lecturers are overloaded with the teaching of basic courses and are left with very little time for research. Indeed, at many universities their research is considered a personal hobby.

It is not only the large number of students that makes teaching mathematics difficult.

The majority of first year students we receive at our universities are poorly prepared for the study of this subject. Modern schools often focus on weaker pupils and do not provide adequate support for those who are more talented. One of my former PhD students, for example, really suffered at school. Mathematics classes were boring for him mostly because the teacher did not allow him to solve mathematical problems as fast as he could, believing this would psychologically damage some of his classmates who were not as quick as he was.

Such methods of education contribute to the fact that students arrive at our universities unprepared and university teachers are forced to lower the standards of their courses. Ultimately, this affects the technological development of our countries since European industry is unable to find enough engineers who are sufficiently educated by our universities.

Recently, on 2 October 2008, the European Round Table of Industrialists (ERT) organised a meeting in Brussels on how to harness the potential of mathematics, science and technology to drive innovation and competitiveness in Europe. The main concern at this meeting was the poor level of mathematical education and its consequences regarding European economy and society. This important initiative was intended to unite industrial commitments with a systematic, large-scale approach that would support education and research. At this meeting the need for a strong collaboration between schools, universities, businesses and governments, concerning the promotion of mathematics, science and technology, was unanimously recognised. The main reason for such an initiative was the dissatisfaction of European industry with the quality of specialists emerging from European universities.

About two years ago the European mathematical community discovered that, when defining European research infrastructures, Brussels had decided not to consider mathematical science as a separate infrastructure but instead include it under the title "Computer and data treatment". Fortunately, this upsetting error was later rectified and we are now looking forward to Brussels' call for a project on "Infrastructures for mathematics and its interfaces with science, technology and society at large". This is a small step in the right direction.

The level of competence of European mathematicians is still high but they desperately need appropriate support and official recognition of the enormous importance of their research.

In conclusion, I would like to point out that mathematics is one of the core subjects in almost any science or engineering education. Research mathematicians provide a culture of logical thinking, develop a language that explains many complicated processes around us and secure the essence of technological development. I find it ironic, dismaying and deeply saddening that mathematics, a subject that over the last 2000 years has been largely responsible for human progress, still has to fight for its existence and true acknowledgement.

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