Interview with Philippe Tondeur

The future of the mathematical sciences

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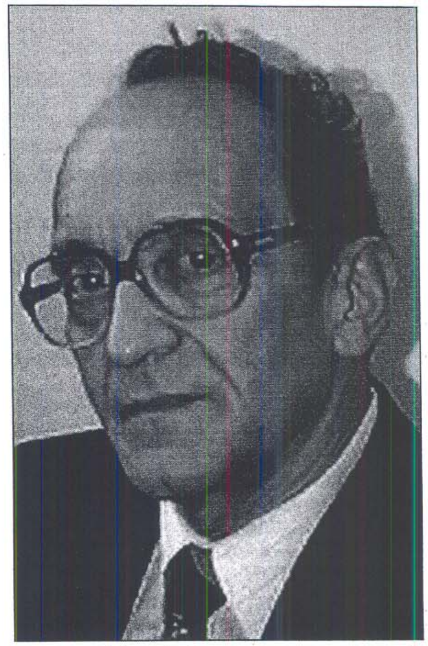

Philippe Tondeur's lifelong involvement with mathematics started with a Ph.D. in Zurich, followed by various research and teaching positions in Paris, Harvard, Berkeley and many other places. He joined the mathematics department of the University of Illinois at Urbana-Champaign in 1968, where he is now Emeritus professor. From 1999 to 2002 he was Director of the Division of Mathematical Sciences at the U.S.A. National Science Foundation (NSF). Thanks to his work and power of vision, the annual NSF budget for mathematics has approximately doubled in four years, whereas over the preceding ten-year period it had increased at an annual rate of 1.5%. He is obviously a key witness and actor in the development of mathematical research.

How do you see the future of mathematics, in this period of rapid societal changes?

Mathematics is a key science for the future, both through its fundamental development and through its enabling role for science, engineering and technology. This is illustrated by dramatic advances in communications, bioinformatics, the understanding of uncertainty, and dealing with large data sets. All these developments are fuelled by ongoing advances in fundamental mathematics and the impact of computing.

Mathematics is thriving as a discipline, but its future is fragile – because the worldwide flow of talent into this science is at risk. One impediment to this necessary talent flow is the decreasing interest of young people in this exciting, but admittedly difficult, discipline.

A functional modern society requires a massive improvement in mathematics education at all levels. Mathematical scientists certainly share responsibility in this endeavour, but the endeavour is a huge challenge for mankind. Higher education in the mathematical sciences can contribute by developing in all students a sense of the embeddedness of mathematics in the broader science enterprise, and in doctoral and postdoctoral students a sense of the stewardship responsibility for the mathematical sciences.

In the future the increasing importance of interdisciplinary research will require more flexibility in career pathways, and a greater adaptability of academic research portfolios to evolving research agendas. Society's interest in an adaptive scientific workforce is paramount. No other investment will have more significant long-term impact on education, health, and the economy.

How could governments steer the development of mathematical research?

In my view, governmental support for the mathematical sciences should not be focussed on trying to guess future successful themes, but should rather concentrate on the development of human resources and facilitating infrastructure. This corresponds to Alexander von Humboldt's idea of the University, where research and education are inextricably intertwined. Society's interest is in the development of a diverse globally competitive and globally engaged workforce of scientists and engineers, and in a broader sense, a scientifically literate citizenry. The mathematical sciences are key to this development. Science innovation and the integration of the disciplines into the evolving science machinery is inseparably bound to the education process at university level.

What could be done to improve future developments?

I want to list some practical recommendations for the improvement of the health of the mathematical sciences. They resulted from a 1998 report circulating widely as the *Odom report*, named after the chair of the committee issuing the report; this report is accessible under the title *Report: International Assessment of the US Mathematical Sciences* at the webpage *http://www.nsf.gov/mps/dms/* under Research Highlights). The recommendations have been influential guidelines for action at the U.S. National Science Foundation over the last few years. They are tailored to the specific higher education structure of the U.S., but with proper interpretation seem to me to make sense for a large portion of higher education throughout the world:

- undergraduate students have to believe that a career in the mathematical sciences offers exciting opportunities.
- graduate trainee and postdoctoral positions are needed to attract and support the best talent.
- undergraduate and graduate education in the mathematical sciences should be broadened by increased exposure to other fields.
- interactions among university-based mathematical scientists and users of mathematics and statistics in other disciplines, in industry and government, should be encouraged and supported.

The implications for financial support of the mathematical sciences are to:

- increase the support for undergraduate, graduate, and postdoctoral students;
- support collaborative research in addition to the traditional support of individual researchers;
- encourage cross-disciplinary research and training;
- improve the support of the infrastructure.

One exciting infrastructure project in need of international support is the Digital Mathematics Library (digitisation of the entire mathematical research literature), adopted by the Committee on Electronic Information Communication of the International Mathematical Union: see the documentation at *http://www.library.cornell.edu/dmlib* and *http://www.ams.org/ewing/Documents/Twenty_centuries.pdf*).

You have clearly convinced the NSF of the importance of mathematics. Do you have a secret recipe?

You have to advocate what the mathematical sciences can do for society. Mathematics is a key science for the future, both through its fundamental development and through its enabling role for science, engineering and technology.

How do you see the classical dichotomy between 'pure' and 'applied' mathematics?

I do consider fundamental and interdisciplinary mathematics as overlapping, mutually reinforcing agendas: they are inseparably intertwined, intellectually as well as budgetarily. I think that this is a more realistic view of the dynamics of the science enterprise than the classical dichotomy, which I strive to avoid. The NSF leadership completely concurs with this view.

A conclusion?

The opportunities for the mathematical sciences at the beginning of this century are fantastic. This century is going to be one of unprecedented pervasiveness of mathematical thought throughout the sciences and our learning culture. In a data-driven world, mathematical concepts and algorithmic processes will be the primary navigational tools. The challenge for the mathematical sciences community is to seize this opportunity, and thereby help to shape the world of tomorrow.