Informatics, Mathematics, and ICT: a 'golden triangle'

IFIP Conference on the teaching of mathematics and informatics

By Rosa Maria Bottino

Consiglio Nazionale delle Ricerche

Istituto Tecnologie Didattiche

Italy

The International Federation for Information Processing (IFIP)[1] is a multinational federation of professional technical organizations concerned with information processing. It is a non-governmental, non-profit international organization established in 1960 under the auspices of UNESCO with the mission to encourage and assist in the development, exploitation and application of Information and Communication Technologies (ICT) for the benefit of all people. It is recognized by United Nations and other world bodies and represents IT Societies from 56 countries or regions, covering all 5 continents. It runs thanks to the work of more than 3500 scientists from Academia and Industry, organized in 13 Technical Committees (TC) and more than 100 Working Groups, with a total membership of over half a million of people. IFIP sponsors numerous conferences yearly, providing unparalleled coverage from theoretical informatics to the relationship between informatics and society.
Among its 13 TC, TC3[2] is dedicated to Education. It aims at providing an international forum for educators to discuss research and practice in teaching informatics and in the educational uses of information and communication technologies. TC3 is structured into 7 Special Interest Groups (SIGs) and one task force. A variety of events, ranging from international congresses to seminars and working conferences, are organized regularly by TC3 and its related WGs on different themes connected with technology and education.
IFIP TC3 and, in particular, WG3.1 (Secondary education) has a tradition in organizing conferences focused on mathematics education with technologies. Previous conferences on this theme were held in Varna (Bulgaria), 1977, Sofia (Bulgaria), 1987, and Grenoble (France), 1997. In 2007, the fourth working conference of the series is organized by WG3.1 together with WG5.1 (Primary Education) in Boston, Massachusetts (USA), from the 27th to the 29th of June[3]. It focuses on the teaching of mathematics and informatics and on the use of ICT for teaching and learning.
Informatics underlies nearly all of human intellectuals endeavor today, yet its core principles are little understood among the general population. Broadly speaking, it is possible to identify various influences that informatics and ICT technologies may have in mathematics education:

- use of ICT tools as mediators of teaching and learning processes in mathematics;
- changes in the content of mathematics curricula as consequence of the widespread diffusion of new technologies;
- teaching of mathematical topics as a basis for computer science education.

The first influence, the use of ICT-based tools for supporting teaching and learning processes in mathematics, can be implemented at different educational levels (elementary school, secondary school, college, university) and involves relevant methodological changes. One can think, for example, to the use of well known tools such as dynamic geometrical software, spreadsheets, or computer algebra systems, as well as to more recent developments in, for example, distance education and networking. ICT can help to provide different opportunities to teaching and learning processes in mathematics, such as, for example: new ways to give meaning to mathematics concepts; new relationships between students and knowledge; new kinds of social interactions among the different actors of the learning/teaching process; new teaching and learning situations embedding technological tools.

As the matter of fact, while mathematics is traditionally perceived as abstract and formal, ICT can facilitate access to mathematical concepts by means of the exploration and the manipulation of concrete

representations (such as visual, motor, perceptive, etc.). This approach lends itself naturally to establish social processes of knowledge construction based on negotiation of meaning. Of course, the use of ICT in mathematics education requires the revision of the educational strategies and of the activities that students engage in. Careful attention should be given not only to technological tools but also to the teaching and learning situations and contexts where those tools are used. The context/situation in which technology is embedded is at least as important as the technology itself (Bottino, 2004).

The other influences that informatics and new technologies can have on mathematics education mainly concern secondary school level onwards and lead also to specific problems of content choice. One can think, for example, to the changes in mathematics curricula induced by the widespread diffusion of computers that allow to face new topics related with data processing, like statistics and probability, and, also, to the introduction of basic elements of informatics in mathematics curricula.
As the matter of fact, the history of computers and informatics and the history of mathematics prove that natural links exist between the two disciplines (Goldstine, 1972). Pascal's calculating machine was conceived for computing purposes, say, for helping mathematicians to solve problems. Conversely, mathematics offered the ground for the birth and the development of computer science. The links are emphasized both by the developments of outstanding researches in theoretical computer science and by the applications of computers in solving classes of mathematical problems.
Indeed at university level, the importance of mathematical contents present in computer science curricula was widely recognized (see, for example Ralston, 1981 & 1984 and Berztiss, 1987), and some mathematical subjects (like algebra, numerical analysis and logics) are considered to be a necessary background in computer science education, thus providing their teaching of further motivations. This last issue is less influential in school education, because, at the ages in question, the development of propaedeutic mathematical topics is a difficult objective to be pursued at a degree of depth suitable for illustrating the links between the two disciplines. In the course of time, the introduction of computer science elements inside the mathematics school curricula has been motivated by both cultural and pedagogical considerations with an accent on the affinity of some methodologies and abilities peculiar of the two disciplines. As a matter of fact, many underlying educational objectives of the two disciplines, at the ages under consideration, are, for the greater part, similar: decoding problems, modelling of situations, use of correct and not ambiguous language, passage from natural languages to artificial languages (of mathematics and of computer science).
The problem of curriculum changes and the consequent renewing in teaching emerges periodically in the mathematics instruction of secondary school. Wojciechowska (1989) focuses two major changes that took place in the mathematics curriculum of secondary school in this century. The first one, referring to the *Meran Syllabus* (1905), had as a principal advocate Felix Klein who individuated the development of pupil's geometrical imagination and functional thinking as the basic objectives of mathematics teaching. The second major change, dating back to the early 60's, was supported by the French group of mathematicians known as Bourbaki: it ascribed a central role in mathematics to the abstract notion of structure, based on set theory.

We can say that the great challenge offered to mathematics education by computers has led to a third curriculum change. Unlike the previous ones, this change does not come from the interior of the mathematical community as a consequence of certain cultural developments of the discipline, but it is the consequence of the great changes on the social and economical reality provoked by the impact of new information technologies.

The studies on the consequences of this impact in mathematical instruction show that the influence of computers in mathematics teaching is a complex phenomenon that has been approached according to very different orientations depending on the context in which curriculum changes are carried out and also on the cultural (mathematical and technological) background of mathematics educators. The relationship between informatics and mathematics was considered with great interest especially at the beginning of educational computing research. An important survey on the influence of computers and informatics on mathematics and its teaching was performed in ICMI studies (Cornu and Ralston, 1992) to give a perspective of the different orientations observed in research and in school practice. This work suggested that it was possible to introduce computer science elements in school mathematics without relevant additions in contents and radical substitutions. Such introduction could offer not only the chance of approaching a new discipline and of reviewing mathematics concepts, but it also fostered a more critical view and a better mastery in the use of computing machines.
The brief excursus made above shows that many different opportunities are offered to education by the reciprocal influences of mathematics and informatics and by the use of ICT for teaching and learning. But, notwithstanding this and the positive results produced in experimental settings by a number of research

projects, one can also observe that the integration of ICT in classroom practice is not, up to now, a widespread phenomenon. Such resistance from the educational system, which is reported at the international level (see, for example, Artigue, 2000; Sutherland, 2004) is a matter of concern for mathematics education research and obliges to question the research paradigms used when investigating in this area.

Considering also this concern, the multi-faced theme of mathematics, informatics and education can be discussed according to different perspectives and viewpoints that can help to enlighten not only the opportunities offered but also the problems posed and the challenges not yet met. The IFIP Boston conference will provide a forum for such discussion which will be afforded according with a variety of topics ranging from using ICT for enhancing learning, to fundamentals of informatics education, and to topics more specific to mathematics teaching and learning. I think that it will be a very stimulating and interesting meeting held, as it is usual in IFIP TC3 events, in a very friendly and warm atmosphere.

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[1] See: http://www.ifip.org/home.html (accessed June 2007).

[2] More information at: http://www.ifip-tc3.net/ (accessed June 2007).

[3]More details on the conference can be obtained at: http://www.ccs.neu.edu/imict2007/Home.html (accessed June 2007).