Technology as an instrument for teachers

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1. Aim of the inquiry on the place of technology in the ICMEs of the last decade

For now more than 20 years, integration of technology is an issue debated in research as well as in the reality of the classrooms. Many countries support this integration at the institutional level but the everyday practice of a large part of teachers generally does not follow this institutional demand.
Since the beginning of the integration of technology into teaching, research has developed several theoretical frameworks related to its focus. From the beginning, a constructivist perspective in a broad sense was generally adopted in research on the role and use of technology in the teaching of geometry: learning was not taken as a simple process of the incorporation of prescribed and given knowledge, but rather as the individual's (re)construction of mathematics. The interactions taking place between the learner and the machine were viewed as impacting this reconstruction. Later additional theoretical perspectives have been used and/or developed taking into account: the structure of knowledge to be (re)constructed, and the environment of the learner – in particular, the social interactions in which learning takes place as well as institutional constraints coming from the institution "responsible" for learning (e.g. the school embedded within the larger school system).

The ICMEs are a place where researchers, teacher educators and practitioners meet. To what extent do they reflect the evolution of the trends of research and/or of integration of technology into the real practice? Another question of this paper deals with teacher using technology. A review of research (Lagrange et al. 2003) concluded to the relatively weak number of systematic studies devoted to the ways teachers appropriate technology and integrate it into their practice. By the expression "instrumentation of technology by teachers", we refer to two levels of instrumentation: at a first level, teachers are able to use technology for carrying out a mathematical activity, at a second level, they are also able to use technology as a tool for teaching and in particular for fostering students' learning. What is the place given to the instrumentation by teachers in the ICMEs and in particular to the second level of instrumentation?

In order to answer these questions, we analyzed the Proceedings and programs of the last ICMES over the past decade. It must be pointed out that the Proceedings may not reflect the opinion and work of all participants in ICMEs as there is a limited number of participants presenting in groups or offering lectures. The small number of pages allotted to group reports may also not do justice to all points of view and interventions expressed during the group work. This is a weakness of the methodology adopted here but we can take advantage of the selection operated by the Proceedings by considering that our inquiry in the Proceedings of ICMEs will offer an image of the major official stands of ICMI as far as the leaders of the groups as well as the lecturers are chosen by a committee nominated by ICMI who is responsible for the text of the Proceedings.

2. The place of technology in the ICMEs over the past decade

A first rough indicator of the place of technology in the ICMEs is given by the lectures and groups devoted to this topic. In the table below are taken into account only activities mentioning technology in their title.

ICME	Working Groups (8&9) Discussion Groups (10 & 11)		Topic (Study) Groups		Lectures		Others
	On Techn.	Total number	On Techn.	Total number	On Techn	Total number	
8 (1996)	2	26	3	26	6	57	
9 (2000)	1	13	*1* *	23	4	52	
10 (2004)	0	24	1	29	9 (Survey team 1 out of 5)	85	1 Thematic Afternoon (4 themes) Workshops 12/45
11 (2008)	1	28	1	38	Survey team 1 out of 7		

Table 1 – Frequency of the activities devoted to technology in the ICMEs (past and next one)

*The title of the Topic Study Group is "The use of Multimedia in Mathematics Education" (TSG7)

The importance of activities related in an explicit way to technology seems to have decreased over the ICMEs and on the surface does not appear as a major concern. ICME 8 was the congress exhibiting most an interest for technology with

- 2 Working Groups entitled: « The impact of technology on the mathematics curriculum » and « The role of technology in the mathematics classroom »
- and 3 Topic Groups entitled: "Role of calculators in the classroom", "Computer based interactive learning" and "Technology for visual representation".

The denomination for groups of the following ICMEs was more general.

A possible interpretation of the decreasing number of Working, Topic and Discussion Groups since ICME 8 could be related to the fact that integration of technology into mathematics teaching makes its use less extraordinary and does not require several specific groups devoted to the topic. In that case, it should go with a larger place given to technology in the other groups focusing on other topics, such as the groups devoted to the teaching of specific matters (algebra, geometry, calculus…) or to the teaching at specific levels (secondary or tertiary for example). A review of the reports of these groups at ICME 8 and ICME 9[1] was carried out to test this hypothesis.

References to technology in ICME8 and ICME9 groups not devoted to technology

The review of those reports showed the diversity of attitudes towards technology among the various groups. Several categories can be distinguished among the groups whose main focus was not technology, as shown on Table 2. The category "Technology scarcely mentioned" refers to the fact that it is part of one or few presentations and it is not quoted as an issue in the discussion. "Technology questioned" refers to reports evoking possible dangers and questioning about the appropriateness of using technology.

Technology	not mentioned	scarcely mentioned	questioned	as a future issue to be addressed	as a tool (and not discussed)	as an issue	largely discussed
ICME 8 26WG 26 TG	14 WG 12 TG	4 TG	2 WG 2 TG	4 WG 1 TG (17)	1 WG 2 TG (17 & 23)	5 WG 2 TG	1 WG 1 TG
ICME 9 13WGA 23 TSG	4 WGA 11 TSG	2 WGA 4 TSG	2 WGA	5 WGA	2 TSG	4 TSG	1 WGA 1 TSG

[1] At the time being, when this paper is written, there is no available Proceedings volume of ICME 10.

Table 2 - Distribution of the groups not devoted to technology according to categories of treatment of technology
A group may belong to several categories

From Table 2, it appears that it cannot be concluded that technology was more taken as an issue at ICME9 than at ICME8 in the groups not specifically devoted to technology. The table seems even to show a slight decreasing presence of technology at ICME9. Globally on both ICMEs, only a minority of groups really tackled the issue of technology (less than 20%). More than half of the groups do not mention technology or very little. The tendency to postpone technology as an issue for the future has not decreased! Less information is available on ICME 10 in absence of Proceedings. Nevertheless from the ICME 10 program, it is possible to get an idea about the place of technology in the groups not devoted to it.

Technology	not mentioned	scarcely mentioned	questioned	as a future issue	as a tool	as an issue	largely discussed
ICME10 24 DG 29 TSG 5 TA	20 DG 12 TSG 3 TA	1 DG 5 TSG	TSG	TSG	1 TSG 1 TA	1 DG 3 TSG	2 DG 7 TSG

Table 3 – ICME 10 Distribution of the groups not devoted to technology
according to categories of treatment of technology

The move from Working Groups for Action at ICME 9 to Discussion Groups at ICME 10 led to a strong absence of technology at least in the presentation of the Discussion Groups in the program. On the other hand, technology is more explicit and taken as an object of study in the Topic Study Groups (10 out of 29 groups)[2]. Over the last years technology seems to have given rise to works taken into consideration in the review of the state of art done by TSGs whose main focus is not technology. But its place in teaching and learning is not enough important to be mentioned among the key topics of the discussion groups not devoted to technology. Does the increasing presence of technology in the TSGs reflect the beginning of an evolution? An answer can only be given after ICME 11!

3. Working themes and points of discussion about technology

3.1 In the groups not specifically devoted to technology

When technology is questioned, "danger or pitfalls of technology" are evoked, sometimes under the more balanced expression "promises and pitfalls", often without referring to what the danger, the pitfalls or the promises consist of.

The groups for which technology is an issue or which devoted a subgroup about technology are listed in a table in Appendix. From the themes of the groups and the focus of the discussion as mentioned in the reports, technology was an issue for four main reasons:

- it is a catalyst for change in the curriculum or in the teaching practice (Alsina et al. 1998, ICME8: WG13,WG11, WG19)
- it is a tool deeply changing the mathematical activity: such as modelling or processing data in statistics, experimenting in algebra or geometry (spreadsheet, dynamic geometry), visualizing in geometry (Alsina et al. 1998 ICME8: TG12; Fujita et al. 2004 ICME9: TSG1)
- it may help students construct a better understanding: technology offers an intermediate level between the physical reality and the formal mathematical model (Alsina et al. 1998 ICME 8: WG12, WG14, TG17, Fujita et al. 2004 ICME 9: TSG4). By means of technology, mathematics become more experimental and allow the students to change the conditions of the problem, to check strategies, to receive feedback.

[2] The fact that this review is made from the program and not from reports (which are longer) may explain why there is no intermediate categories. Either technology is mentioned as an issue in the program or it is not. There is not enough space in the program to make explicit the nature of its role.

The emphasis is mainly on the content taught with technology and the interactions between technology and the student, the changes brought by technology on the students' strategies and interpretations of representations. Sometimes it is expressed that teachers must learn how to use technology (Alsina et al. 1998 ICME8 WG19: « Teachers need to be guided and supported in using IT »). Groves (WG11, ICME8 Alsina et al. 1998 p.149): « It is not trivial matter to use technology effectively in classrooms. Teachers need to rethink maths and children learning of maths as well as develop new and substantially different skills for teaching and assessment ».

3.2 Focus of the groups on technology: an evolution from ICME8 to ICME10

The reports of the groups on technology of past ICMEs confirm that the focus was more on the impact of technology on the curriculum and on the learning than on the teachers themselves. However, from the information available in the reports and in some additional texts of presentations within the groups (in particular in Borba et al. 1997), it is possible to identify an evolution in the ways of approaching the issue of integration of technology into the teaching.

At ICME8 (more than 10 years ago), the perspective of technology as a "catalyst for change" in the teacher role was generally adopted. Some reports on long term experiences (Alsina et al. 1998 Dugdale ICME8WG15, Olive ICME8WG16 and Borba et al. 1997) reported significant changes in the teacher's role when calculator or computer are used extensively in the mathematics classroom: teacher becomes more a stimulant, a manager for learning, an orchestrator of the interactions between technology and students… The theoretical frameworks of these projects was often situated in a socio-cultural approach in which interactions among students and between teacher and students are critical. In those long-term projects (several years), the teachers were very much supported by summer institutes and worked in strong interaction with researchers who could impact on the nature of activities given to students. Nevertheless some difficulties for teachers are expressed in those presentations: a teacher experiences difficulty to engage in a discussion with students in which she missed the main conflict (Hershkowitz & Schwarz 1997), teachers' difficulty of matching the intentions of students in their reactions (Olive 1997). The presentation of Valero (1997) about teachers' beliefs about calculators stressed the length of the process of change and the importance for teachers of being part of a research team in the curriculum design. It was unanimously agreed that teachers need to be provided by resources as well as assessment activities for limiting their uncertainty when using technology. Allen (ICME8 TG19) insisted that the principal vehicle through which teachers could reconstruct their pedagogies is the writing and use of teaching scenarios.

Less information is available on ICME9 as there was only one Working Group and therefore one report. The enthusiasm of the ICME8 presentations on the impact of technology on teaching is far less apparent. Technology is no longer presented as a catalyst for change. The need for more work on several aspects of integration of technology is expressed at several places. Whereas the activities making use of technology at ICME 8 seemed to be open ended, rich and long, the nature of the activities given to students was discussed at ICME9: simple tasks supporting learners versus giving access to more advanced topics for bright students. The subgroup devoted to conceptual and professional development of students and teachers expressed the concern of professional development of teachers without any other precisions on the research studies and innovative projects on the topic. Briefly speaking it seems that at ICME 9 more questions arose about a use of technology less innovative but more in tune with the reality of the classroom: "It was felt that more work was needed […] to make the many creative ideas still more adapted to practical conditions and to know more how pupils and teachers make use of these ideas" (Fujita et al. 2004, p.276).

ICME10 Topic Study Group about Technology and Mathematics Education 15[3] expressed the move of research focus "from the individual doing mathematics with software to research attempting to recognize the role of the teacher and curriculum demands on the learner". One unanimous point was the need for more research that takes the teacher as central focus, and in particular the relationship between the teacher and technology. It is not because a powerful feature is in a software program that teachers will use it. For example dragging for testing is not really used by teachers who have a history of mediating learning through static representations (Abigail Lins in ICME10TSG15). It is recognized that the theoretical approach of instrumentation in which the artefact becomes an instrument for the user was not really applied to the appropriation of technology into teachers' pedagogical practices.

4. Towards more research on instrumentation of technology by teachers

In the recent years, research studies started addressing the integration of technology by ordinary teachers in ordinary classes. They show that integrating technology is not an easy task for teachers who may constrain the potential of technology in order to retain control of the classroom. Ruthven et al.(2005) reported on a multiple-case study of "archetypical current practice" in using DGEs (dynamic geometry environments) in secondary mathematics education: Teachers reduce the exploratory dimension of DGE in order to control students' explorations and to avoid students' meeting situations that could obscure the underlying rule or could require explanations going beyond the narrow scope of the lesson—such as explanations about rounding measurements in a lesson about the inscribed angles in a circle.

Studies of teacher practices using technology have revealed that they must cope as well with the complexity of managing a classroom: Instead of following textbooks, the teachers must design worksheets (Monaghan, 2004); they must adapt the management of several kinds of time in their classrooms and the relationship between, on the one hand, old and new knowledge and, on the other hand, paper-and-pencil techniques and computer software techniques (Guin and Trouche 1999, Assude, 2005). Monaghan (2004) also showed how technology could affect the emergent goals of the teacher during the lesson. When a teacher integrates spreadsheet, s(h)e must simultaneously take into account the tool features, the instrumented techniques, and the concepts (Haspekian 2005). Monaghan (2006) recently pointed out the epistemic value of tasks. The design of tasks adapted for technology, in which not only the use of technology gives sense to concepts but also may change the way of thinking, requires a good appropriation of the technology by the teacher and not only a domestication of the technology by this latter (Borba 2004). It is a long term process (Laborde 2001). The study of Caliskan (2006) of French teachers using Dynamic Geometry in their classroom showed that most of the activities in textbooks or in classrooms use the dragging for observing a property and not for testing a conjecture. This was also observed by Tapan (2006) at preservice teachers in a preparation course to integrate dynamic geometry into their teaching: they designed tasks making use of the test drag only at the end of the preparation. Tapan claims that the design of adequate tasks with DGE requires four types of knowledge: mathematical knowledge, knowledge about the artefact, didactic knowledge of mathematics, and about the artefact. In a study of the impact of in-service teacher training on the use of DGE. Grugeon (2006) points out the importance of analysing practices in teacher preparation for the use of technology, in order to observe how practices take into account the multidimensional complexity of a teaching approach integrating technology. ICMI study 17 « Technology revisited » reflected this new concern of research and gave rise to the presentation of several theoretical approaches. Let us give the floor to other colleagues reporting on that study!

[3] The report of the TSG was kindly sent to me by Lulu Healy co-chair of the group

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Appendix

Groups at ICMEs in which technology was discussed as an issue

ICME	Technology as an issue in	Technology largely discussed
8	WG10 Mathematics and Language WG13 Curriculum changes WG14 Linking mathematics with other school subject matters (issue of modelling) WG17 Mathematics as a service subject at the tertiary level (issue of CAS) TG9 Statistics and probability at the secondary level TG12 The future of geometry	WG11 Curriculum from scratch TG 8 Proofs and proving
9	TSG3 The teaching and learning of calculus TSG4 The teaching and learning of statistics TSG9 Mathematical Modelling and Links between mathematics and other subjects TSG 12 Proofs and proving in mathematics education	WGA3 Mathematics education in senior secondary school TSG1 The teaching and learning of algebra
10	DG 18 Current problems and challenges in primary mathematics education TSG 3 New developments and trends in mathematics education at tertiary levels TSG14 Innovative approaches to the teaching of mathematics TSG 16 Visualisation in the teaching and learning of mathematics	DG 20 Current problems and challenges in upper secondary mathematics education DG24 Current problems and challenges in distance teaching and learning TSG 7 Mathematics education in and for work TSG9 Research and development in the teaching and learning of algebra TSG 10 Research and development in the teaching and learning of geometry TSG 11 Research and development in the teaching and learning of probability and statistics TSG 13 Research and development in the teaching and learning of advanced mathematical topics TSG 22 Learning and cognition in mathematics: Students' formation of mathematical conceptions, notion, strategies and beliefs TSG 26 Gender and mathematics education