Mathematics, Sciences and ICT

Michèle Artigue

Université Paris Diderot – Paris 7, Laboratoire de Didactique André Revuz

Bayreuth, First Fibonacci Conference, 21-22 September 2010

An unquestionable reality

The influence of technological advances and computer sciences:

- on scientific practices;
- on research perspectives and agendas in science;
- on the ways scientists communicate inside their own communities and with the outside world.

In mathematics…

- A dramatic change in the means and economy of experimental work, in its visibility and image.
- An enriched vision of the applicability of mathematical models and structures, blurring the traditional frontiers between pure and applied mathematics.
- New resources and tools for communicating about mathematics.

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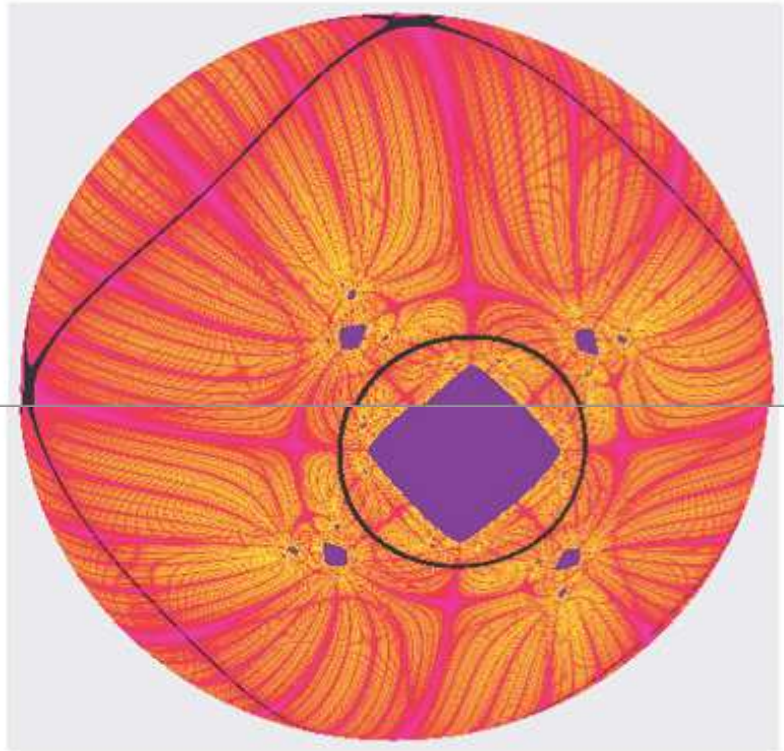
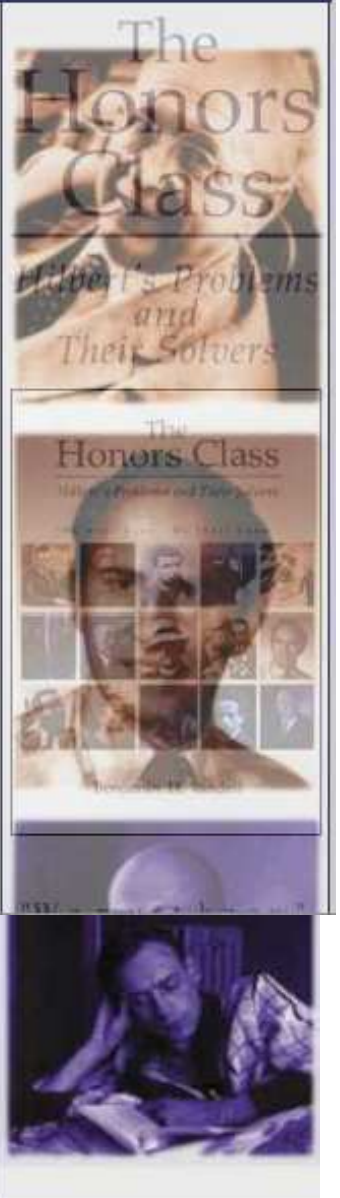
Experimental Mathematics, refereed in the traditional manner, is led by a first-rate editorial board. A high standard of exposition is maintained, in order to reach as many readers as possible.

Cassini quartic with $k = 1/8$, but using the map with parameter $a = 2$. Bonifant et al. "Elliptic Curves as Attractors in P^2, Part 1: Dynamics" *Experimental Mathematics* **16:4** (2007), 385–420.





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The Fibonacci Project

Images des mathématiques

La recherche mathématique en mots et en images

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Identification

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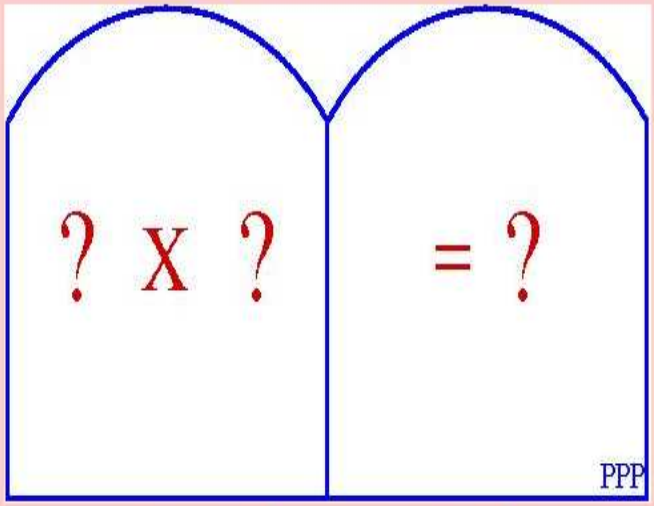
À la une : Quelle loi pour les tables ?

Le 16 septembre 2010, par **Patrick Popescu-Pampu** — **Café des maths** — **Piste verte**



Est-il encore nécessaire d'apprendre les tables de multiplication à l'âge de l'explosion informatique ? Je discute cela à partir d'affirmations d'Umberto Eco et d'Etienne Ghys.

Actualités

Quelques brèves :

16 septembre 2010 - 25e championnat des jeux mathématiques
15 septembre 2010 - Exposition sur l'histoire de l'informatique
9 septembre 2010 - Cent-cinquantenaire de la naissance de Frank Morley
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Événements à venir :

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Festival Pariscience
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Revues de presse :

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Quelques remarques personnelles

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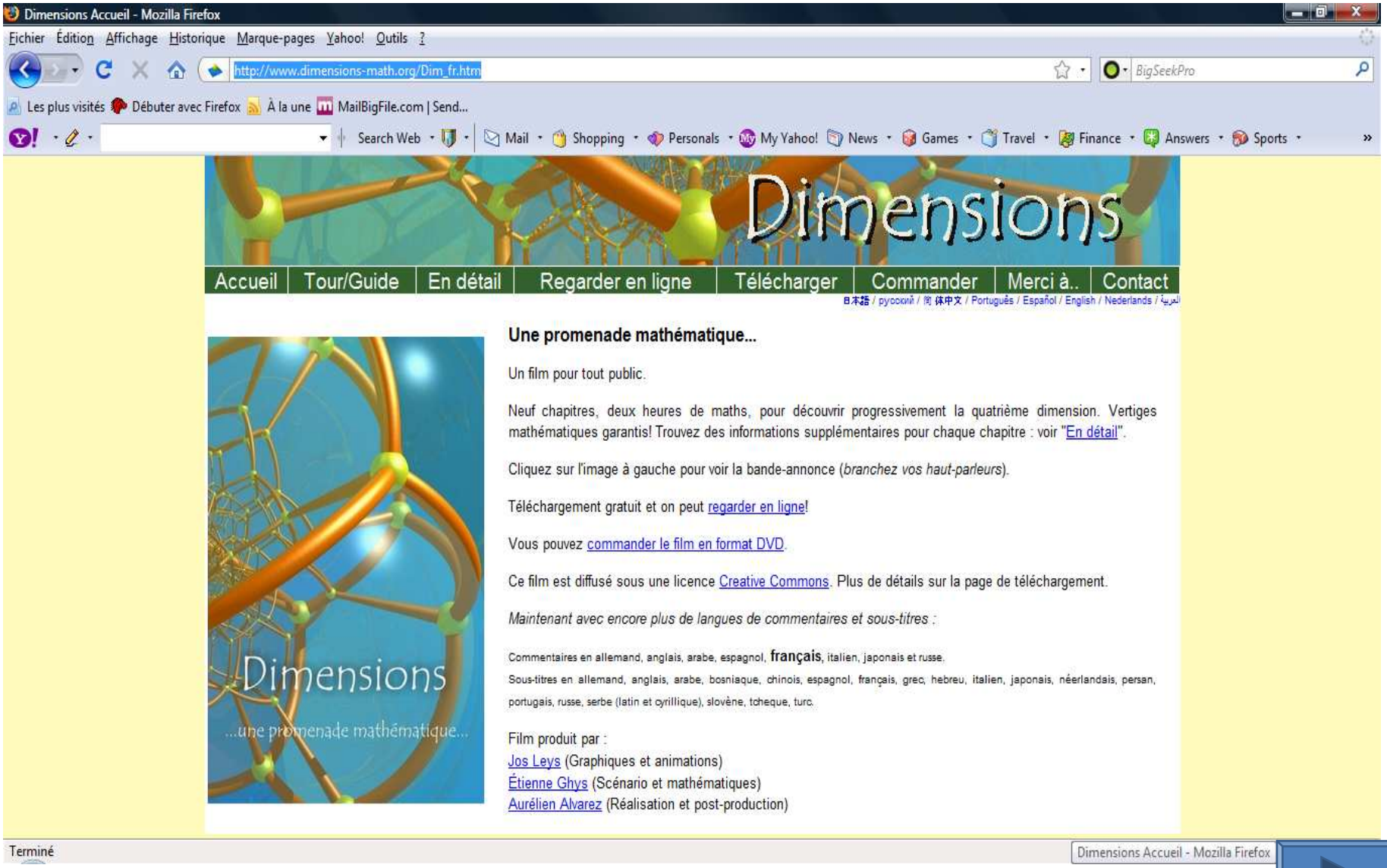

On the educational side, the early emergence of….

- The conviction that computer technologies have a strong potential for enhancing sciences and mathematics learning.
- The conviction that these technologies should make easier the desired evolution towards constructivist approaches to teaching and learning (Cornu & Ralston, 1992)

Leading to…

- The development of specific educational artifacts:
  - educational interfaces for supporting the collection and analysis of experimental data in a diversity of scientific domains;
  - simulation tools for compensating experimental limits and exploring the behavior of complex systems;
  - microworlds with among these dynamic geometry.
- But also, the educational use of spreadsheets, statistic packages, and other professional tools for numeric and symbolic computations, for graphical representations…

More than three decades of research and innovation in that area…

- Increased understanding, accumulation of successful experiments (Hoyles & Lagrange, 2010)
- But:
  - until now, a limited and questionable impact on educational systems at large;
  - until now, an unsolved problem: how to efficiently deal with up-scaling issues.

- Can the Fibonacci project overcome these limitations, and especially help ICT use support the dissemination of inquiry-based education in mathematics and science?

The potential offered by contextual changes

- Changes in the technological context with the development of Internet and mobile technology.

- Changes in the institutional context with the increasing attention and support given to large-scale and dissemination projects, capitalization of research, and the development of networks.

The Kaleidoscope Network of Excellence
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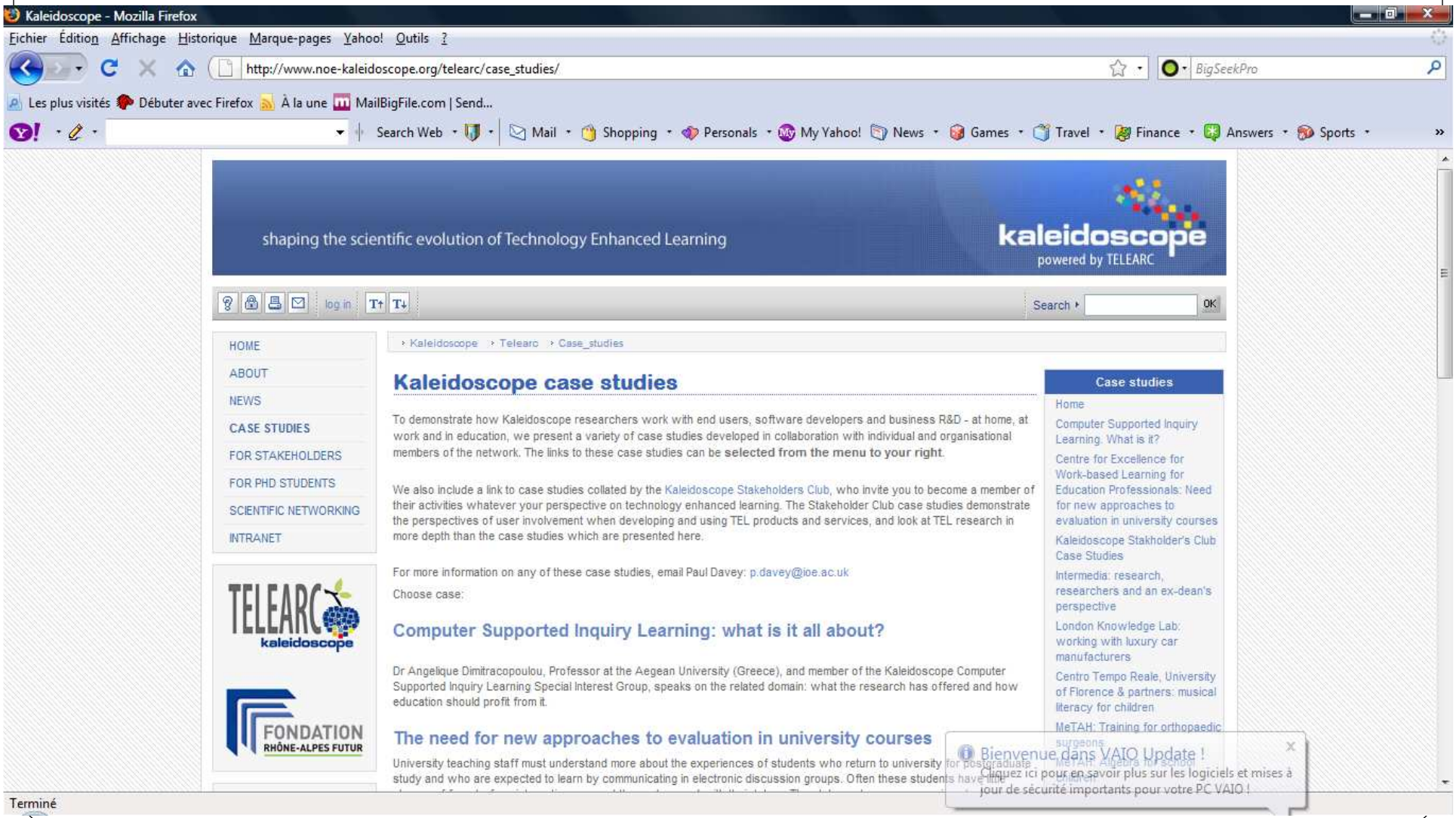
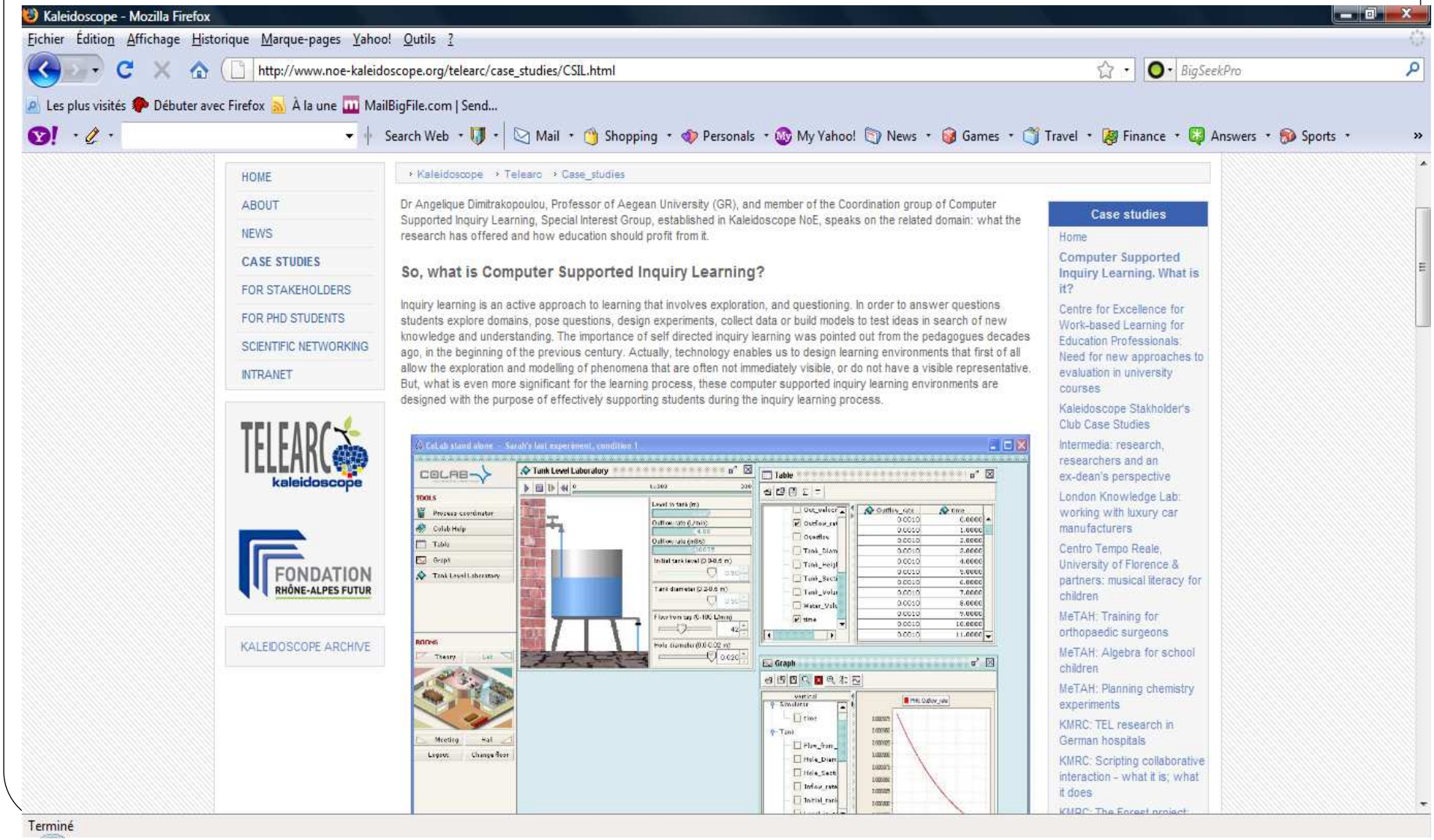


The Kaleidoscope Network of Excellence



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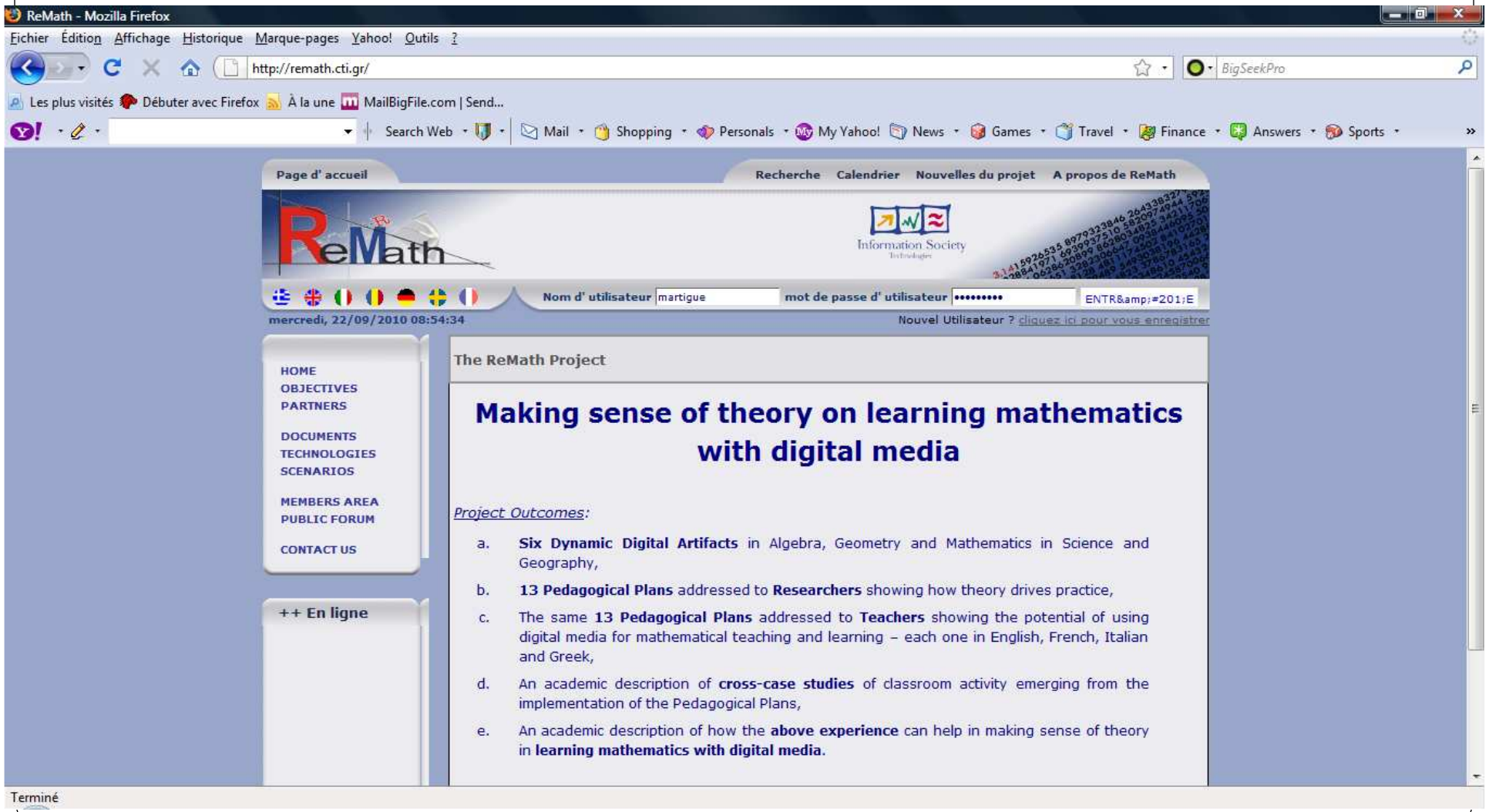

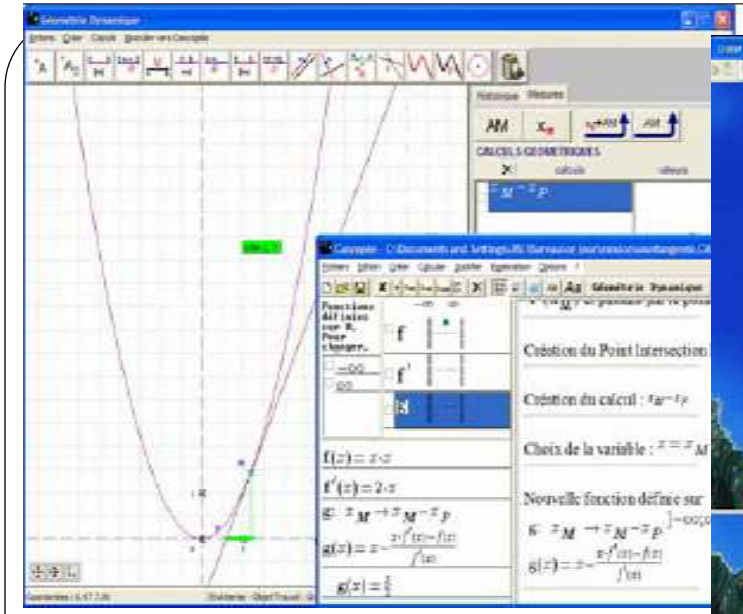

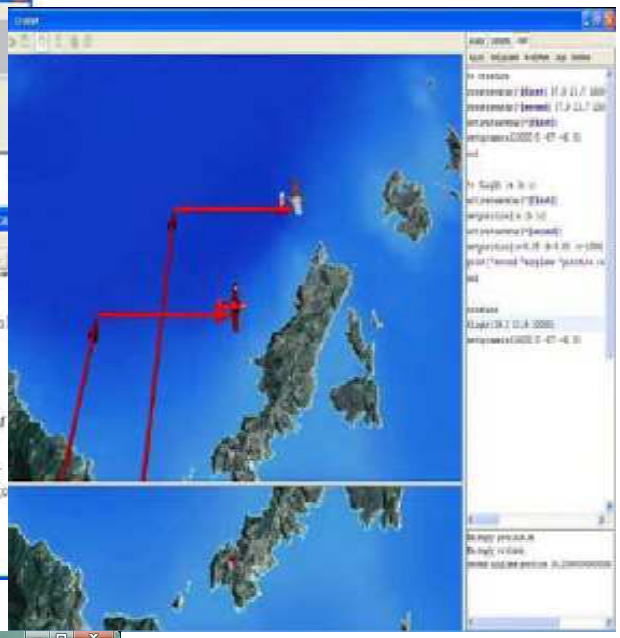

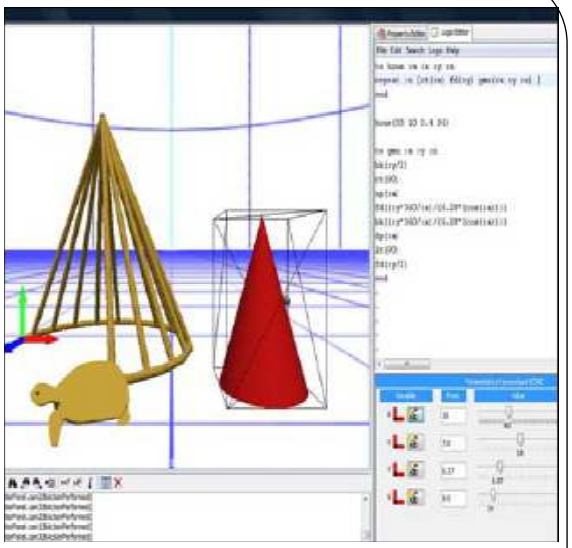

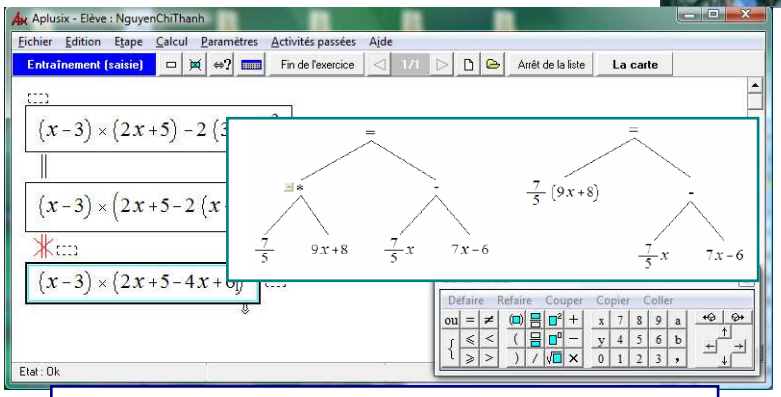
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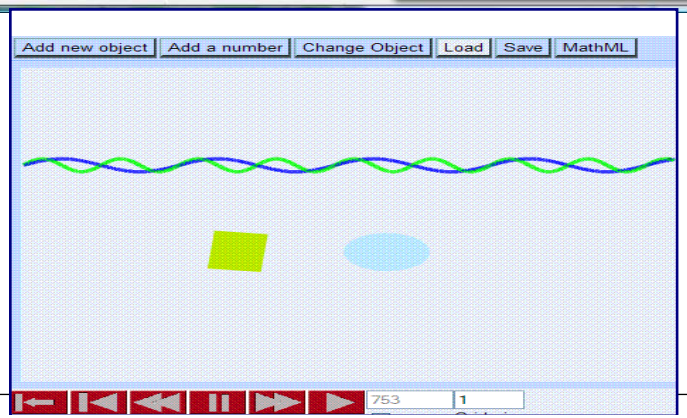
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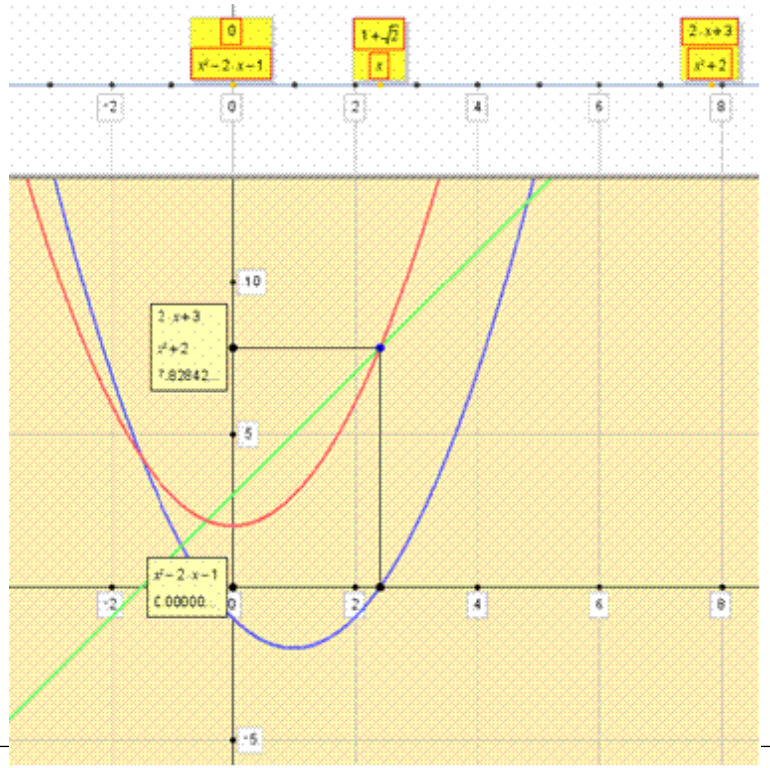


The potential offered by contextual changes

- Changes in the technological context.
- Changes in the institutional context.

But also:

- Changes in the scientific context at large, and promising evolution of educational perspectives.

Efforts made for capitalizing on research and innovation: the ICMI Studies

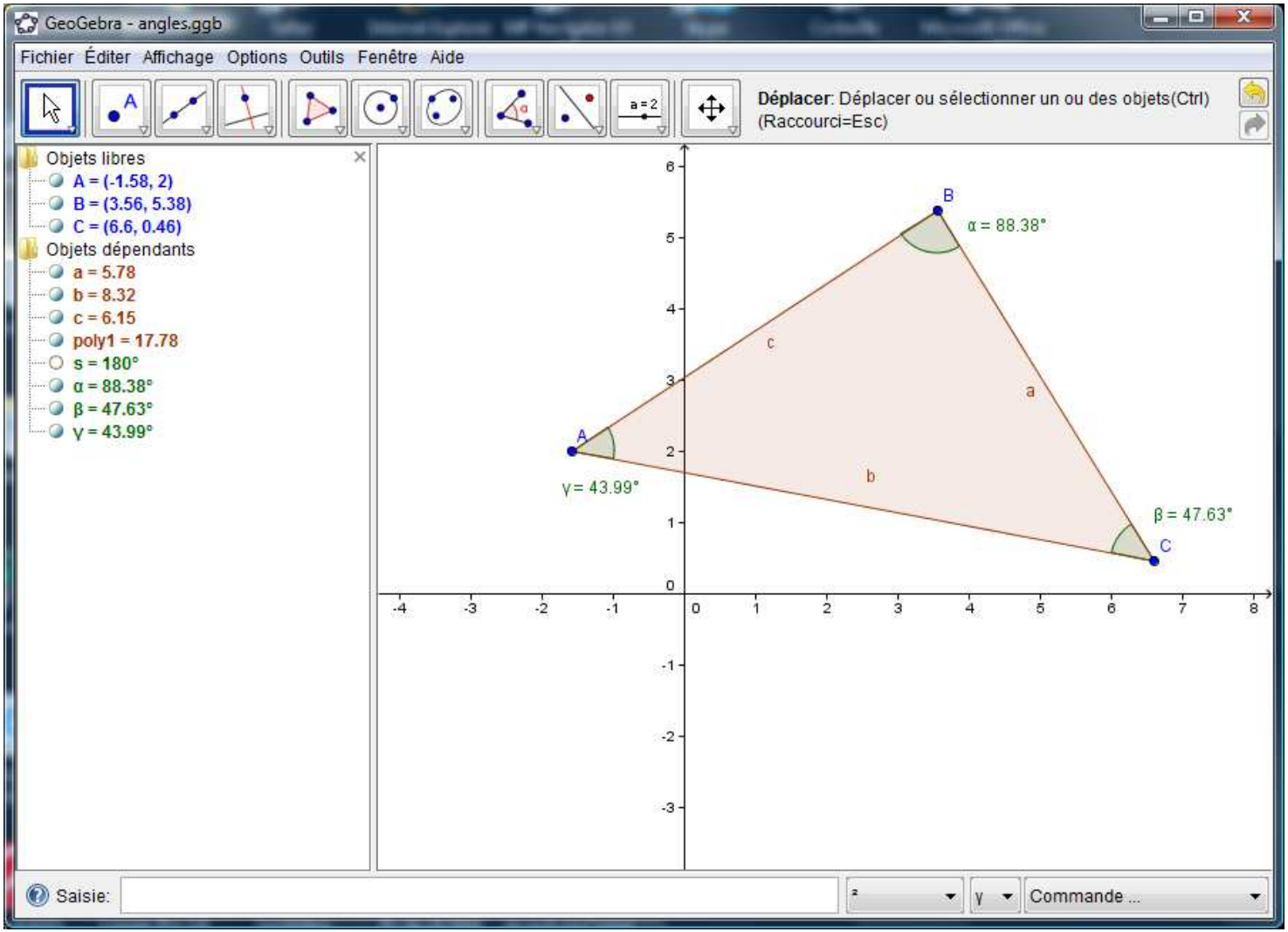
Nevertheless, many challenging issues to face, and among these…

1. The attractiveness of ostensive and pseudo inquiry-based practices.
2. The under-estimation of instrumental issues.
3. The specific ecology of most successful experiments.
4. The diversity of educational cultures and contexts.
5. The connection between maths and sciences.

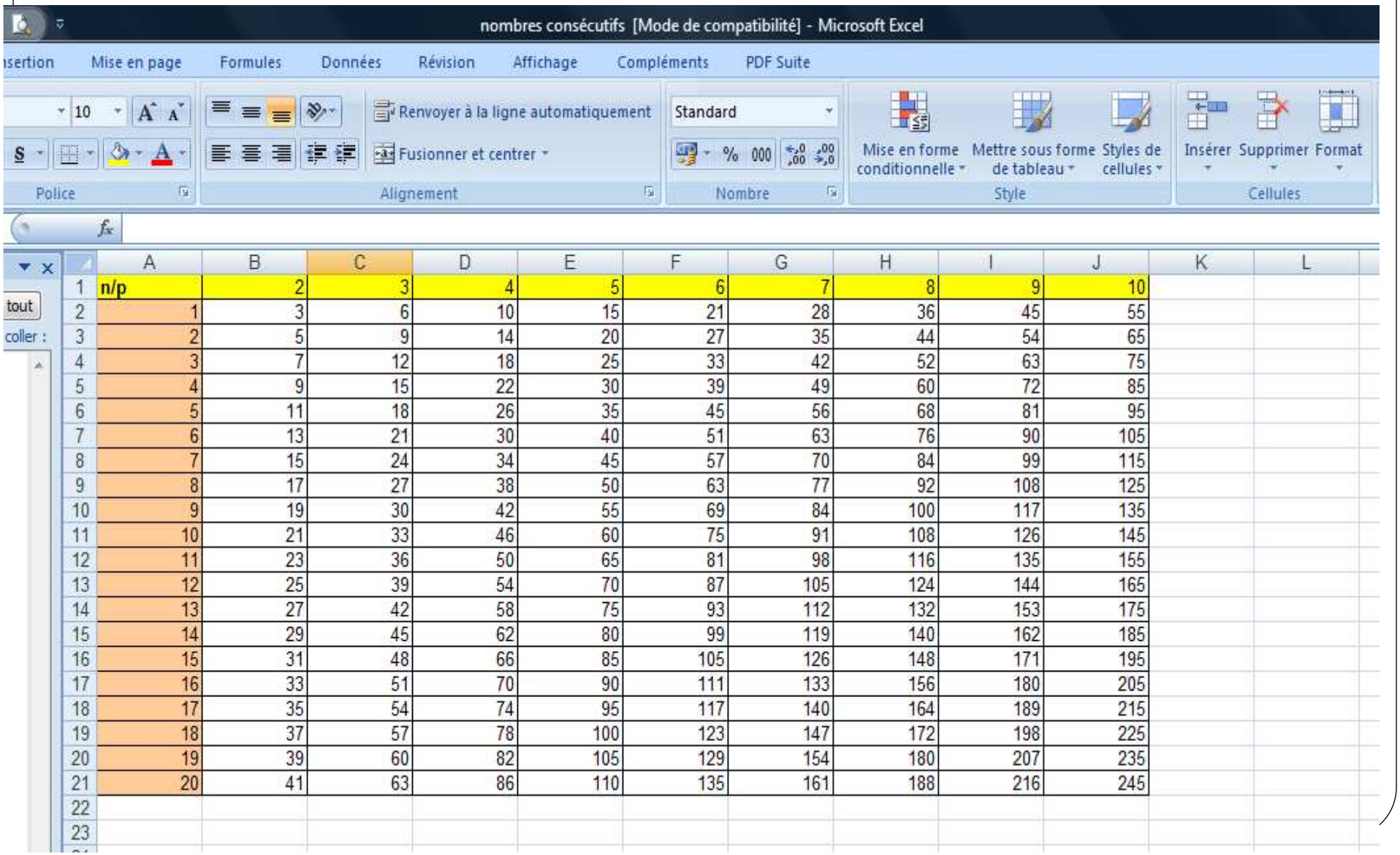
1. Does ICT use really serves inquiry based practices?

- The attractiveness of ostensive practices in the use of ICT: the emblematic case of interactive whiteboards (Miller & al., 2005).
- The attractiveness of pseudo-inquiry activities as illustrated for instance by:
  - Laborde & al.'s research on the evolution of teachers' scenarios in a three years project with Cabri-géomètre (2001)
  - Haspekian's thesis on spreadsheets (2005).
  - Tapan's thesis on pre-service teacher education in dynamic geometry (2006).

Pseudo-inquiry: the sum of angles in a triangle



Real inquiry: What numbers are sum of two or more consecutive integers?



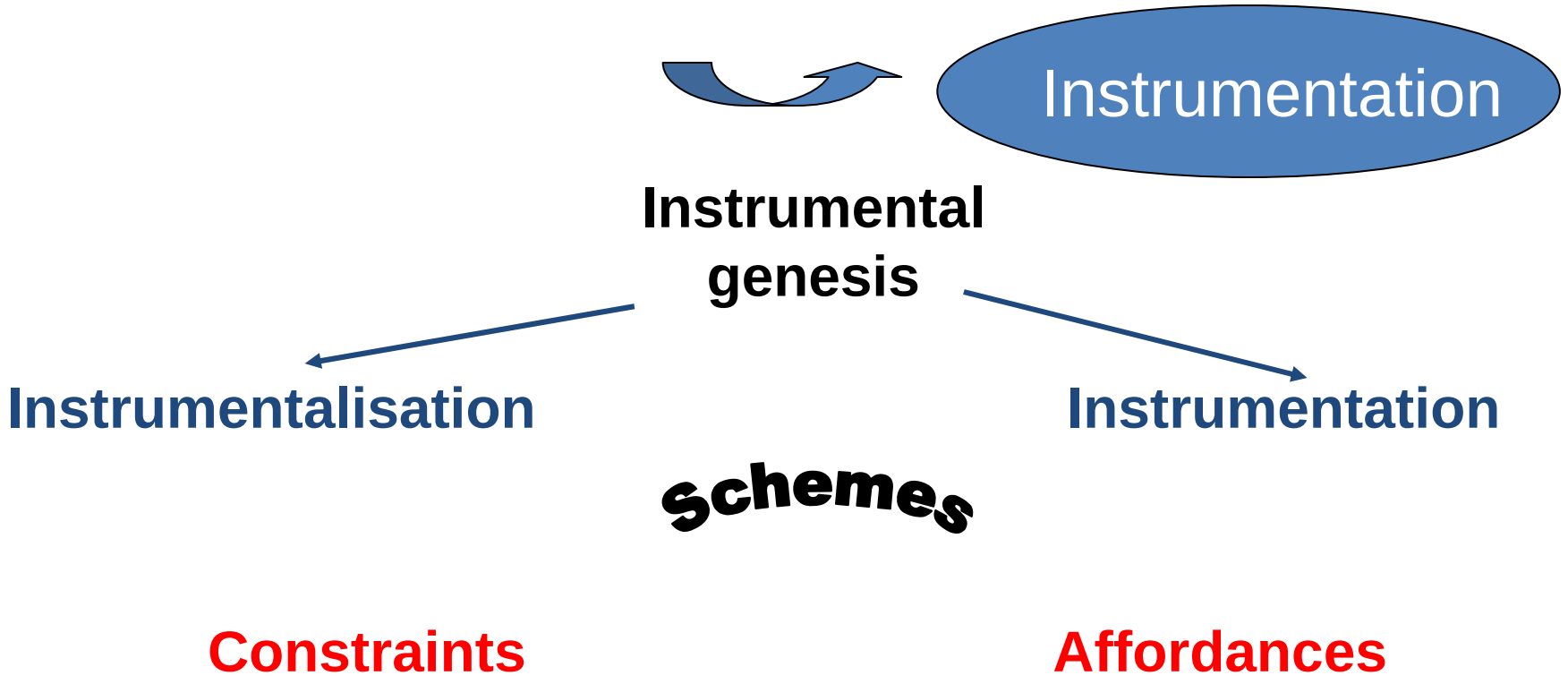
	A	B	C	D	E	F	G	H	I	J
1	n/p	2	3	4	5	6	7	8	9	10
2	1	3	6	10	15	21	28	36	45	55
3	2	5	9	14	20	27	35	44	54	65
4	3	7	12	18	25	33	42	52	63	75
5	4	9	15	22	30	39	49	60	72	85
6	5	11	18	26	35	45	56	68	81	95
7	6	13	21	30	40	51	63	76	90	105
8	7	15	24	34	45	57	70	84	99	115
9	8	17	27	38	50	63	77	92	108	125
10	9	19	30	42	55	69	84	100	117	135
11	10	21	33	46	60	75	91	108	126	145
12	11	23	36	50	65	81	98	116	135	155
13	12	25	39	54	70	87	105	124	144	165
14	13	27	42	58	75	93	112	132	153	175
15	14	29	45	62	80	99	119	140	162	185
16	15	31	48	66	85	105	126	148	171	195
17	16	33	51	70	90	111	133	156	180	205
18	17	35	54	74	95	117	140	164	189	215
19	18	37	57	78	100	123	147	172	198	225
20	19	39	60	82	105	129	154	180	207	235
21	20	41	63	86	110	135	161	188	216	245
22										
23										

Reflecting on such examples

- The importance of task design, and the attention to be paid to:
  - the quality of initial questions, be these internal to the mathematical field, scientific or coming from the real world;
  - the a-didactic potential offered by the interaction with the « milieu » and the added value of ICT use;
  - the possible sharing of scientific responsibilities between students and teacher, and how it can be optimized;
  - the mediating role of the teacher.
- All questions essential for IBSME that, in fact, goes beyond the specificity of ICT use.

2. The under-estimation of instrumental issues

What is at stake? (Rabardel & Verillon, 1995), (Artigue, 2002)



What impact on inquiry-based practices?

- The fact that inquiry-based processes generally suppose some achievements in terms of instrumental genesis:
  - the paradigmatic case of dragging in dynamic geometry studied in Restrepo's thesis (2008)
- The mixture of technological and mathematical knowledge which is involved in instrumental genesis :
  - the case of instrumental schemes attached to functional representations in graphic calculators or CAS (Guin, Ruthven & Trouche, 2004);
  - the case of copying command, formulas, absolute and relative references when working with spreadsheets (Artigue & Haspekian, 2007).
- The necessity of building resources taking in charge the progression of instrumental genesis, which has been hardly the case up to now.

3. The specific ecology of many successful experiments

- Many experiments, especially at secondary level, are successful because some of the standard constraints have been relaxed: specific allocation of time for projects, multi-disciplinary activities, workshops for voluntary students, out-of-school activities…
- How to combine attention to such crucial but most often episodic experiences with the necessary attention to the development of an inquiry-base culture permeating all facets of mathematics and sciences education, taking into account curricular expectations, and the necessary progression of scientific knowledge?
- How to think and instrument a vision of dynamic realistic evolution towards such a culture ?

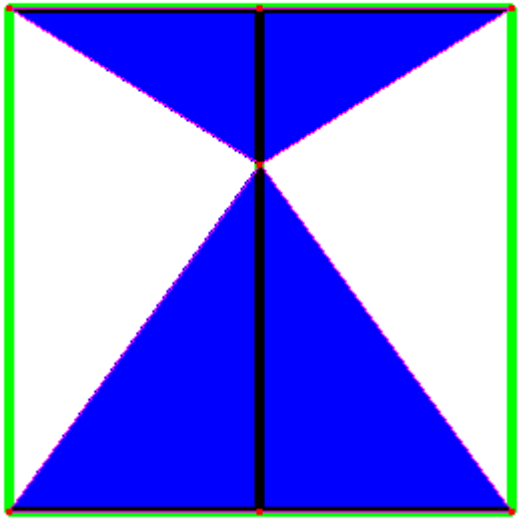
Another facet of current inquiry-based practices to take into consideration

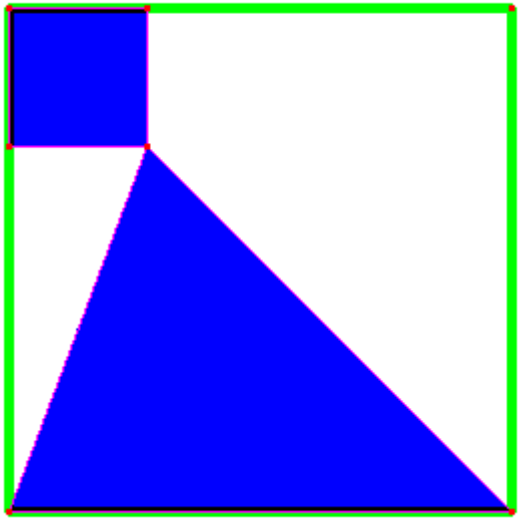
- The increasing combination of personal or group investigation and the increasing search for information and answers to initial or emerging questions through Internet use.
- The increasing inadecuacy of the usual image of the problem solver relying only on his(her) cognitive resources, even when extended to a group of learners working collaboratively.
- The interest of the vision in terms of activity of study and research, and of the associated idea of dialectics between « media and milieu » introduced by Chevallard in the anthropological theory of didactics (2002, 2006) for giving account of current inquiry-based learning practices, and also approaching the new educational needs they generate.

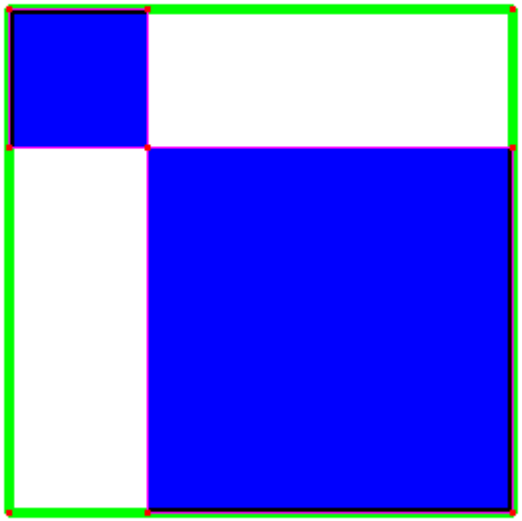
4. The diversity of educational cultures and contexts

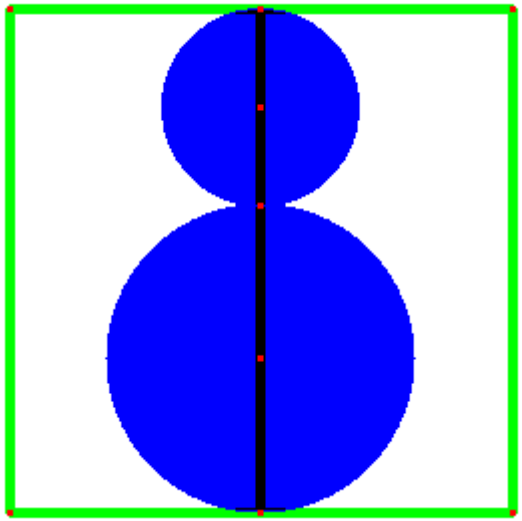
- A regional scope for the Fibonacci project: the European Union, but nevertheless a strong diversity of educational cultures and contexts, in terms of equipment, curricular expectations and policies regarding ICT, the respective importance given to their tool and object dimensions…
- The necessity for the Fibonacci project of taking in charge this diversity in its twining and dissemination practices.
- A challenge that I personally meet in the Comenius project EduMatics aiming at the collaborative production of a European course for teacher professional development in the productive integration of ICT.

The Sign family (EduMatics)









- An a priori analysis of the potential of this family for the topic at stake « Functions and modelling ».
- A range of educational scenarios for envisaging adaptation to different curricular goals, students' knowledge, didactic organizations.
- Excerpts from videos and students' productions fostering discussion and work on important issues.

The lack of connection between mathematics and science education

- A problem experienced in many countries, at least at secondary level.
- The difficulty of communication experienced even when specific didactic organizations are supposed to promote such connections, due to the limitations of teacher education.
- The importance of having teachers experience themselves the power of such connections with their scientific background.
- The experience of the modeling course in the master program for teacher educators in my university.

And, to conclude

- My personal conviction that a project such as Fibonacci can make a difference, particularly due to the experience and knowledge on which it can rely, the expertise it gathers and the original and progressive strategy it has planned for dissemination.
- My conviction that ICT is crucial for the success of this enterprise at different levels, both for supporting the ecology of inquiry-based practices, and the global ecology of the project , supporting its values of collaboration and solidarity.
- But also my conviction that, if we want to succeed where so many have failed, we must seriously take into account the lessons of these failures, and substantially progress on many challenging issues. For that purpose, we need to create original combinations of research and design.

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