



# 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.

# EXPERIMENTAL MATHEMATICS

Home

Statement of  
Philosophy &  
Publishing Criteria

Subscription  
Information

Submission Guidelines

Articles

Editorial Board

For subscription or  
editorial inquiries, please  
contact us by [email](#),  
telephone, or mail.

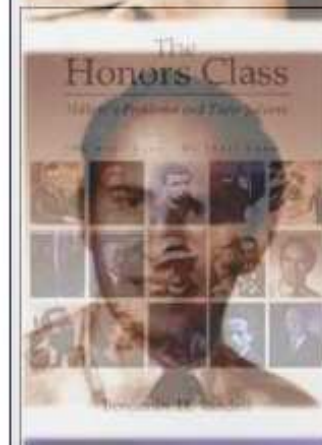
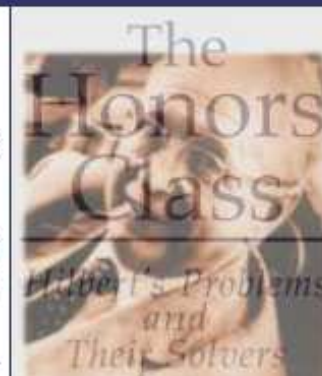
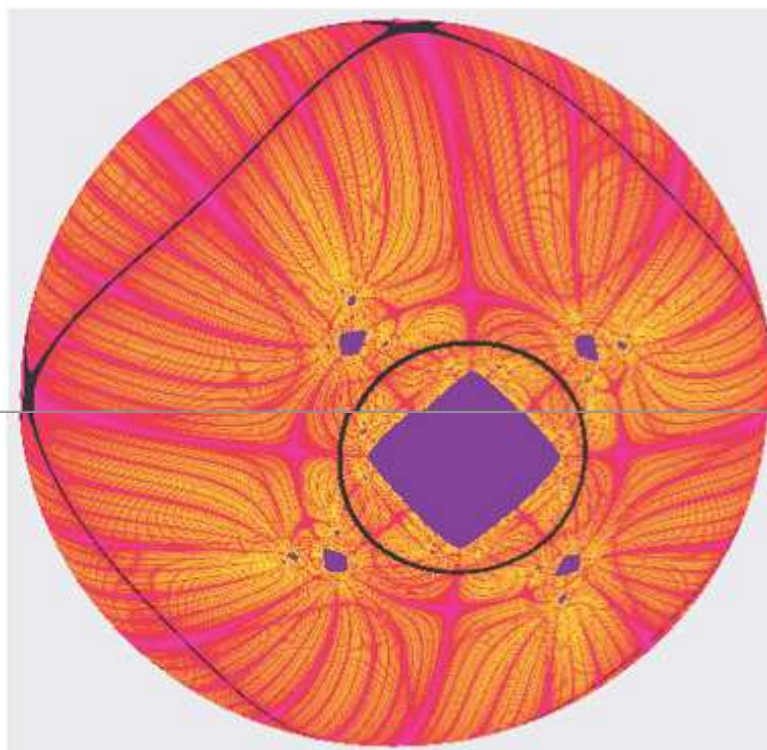
A K Peters, Ltd.  
5 Commonwealth Roadt  
Suite 2C  
Natick, MA 01760-1526  
Tel: 508.651.0887  
Fax: 508.651.0889  
<http://www.akpeters.com/>

~~Are characters missing or~~  
[replaced by rectangles?](#)

Welcome to *Experimental Mathematics*, a journal devoted to experimental aspects of mathematics research. It publishes original papers featuring formal results inspired by experimentation, conjectures suggested by experiments, and data supporting significant hypotheses.

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.





http://images.maths.cnrs.fr



## Images des mathématiques

La recherche mathématique en mots et en images



Page d'accueil  
Présentation / Plan du site  
Documentation / Lexique  
Ours / Mentions légales  
Nous contacter

  
Recherche avancée


**Les rubriques**


**Les dossiers**

**Les liens**

**Identification**

ISSN : 2105-1003

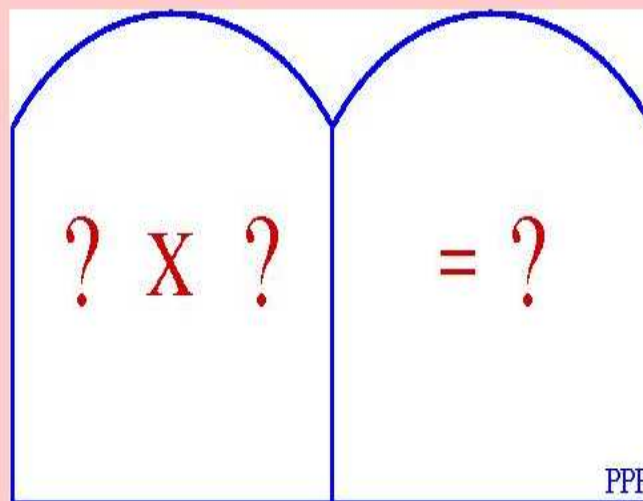
 Syndication (RSS)

Site sous SPIP 2.1 

Imprimer cette page

### 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-cinquantième de la  
naissance de Frank Morley

[Archives](#)

#### Événements à venir :

Nuit des chercheurs  
Festival Pariscience

[Archives](#)

#### Revues de presse :

1er septembre 2010

1er juillet 2010

1er juin 2010

[Archives](#)

### Les billets des habitués

Multiplier ou diviser par l'abscisse, à la

### Quelques articles récents

Quelques remarques personnelles

jsMath



# <http://www.dimensions-math.org>

Dimensions Accueil - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Yahoo! Outils ?

http://www.dimensions-math.org/Dim\_fr.htm

Les plus visités Débuter avec Firefox À la une MailBigFile.com | Send...

Search Web Mail Shopping Personals My Yahoo! News Games Travel Finance Answers Sports

## Dimensions

Accueil Tour/Guide En détail Regarder en ligne Télécharger Commander Merci à.. Contact

日本語 / pyconit / 简体中文 / Português / Español / English / Nederlands / العربية

### Une promenade mathématique...

Un film pour tout public.

Neuf chapitres, deux heures de maths, pour découvrir progressivement la quatrième dimension. Vertiges mathématiques garantis! Trouvez des informations supplémentaires pour chaque chapitre : voir "[En détail](#)".

Cliquez sur l'image à gauche pour voir la bande-annonce (*branchez vos haut-parleurs*).

Téléchargement gratuit et on peut [regarder en ligne](#)!

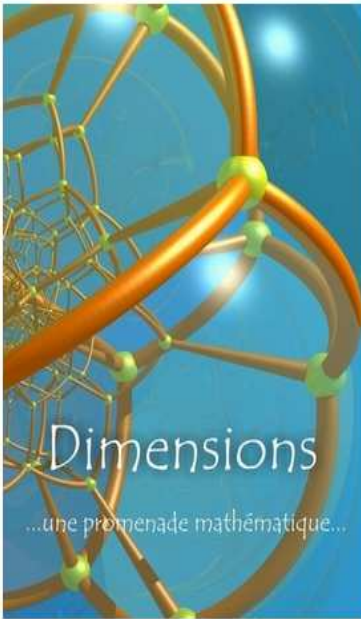

Vous pouvez [commander le film en format DVD](#).

Ce film est diffusé sous une licence [Creative Commons](#). Plus de détails sur la page de téléchargement.

Maintenant avec encore plus de langues de commentaires et sous-titres :

Commentaires en allemand, anglais, arabe, espagnol, **français**, italien, japonais et russe.  
Sous-titres en allemand, anglais, arabe, bosniaque, chinois, espagnol, français, grec, hébreu, italien, japonais, néerlandais, persan, portugais, russe, serbe (latin et cyrillique), slovène, tchèque, turc.

Film produit par :  
[Jos Leys](#) (Graphiques et animations)  
[Étienne Ghys](#) (Scénario et mathématiques)  
[Aurélien Alvarez](#) (Réalisation et post-production)



Terminé

Dimensions Accueil - Mozilla Firefox



## 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 (Hoyle & 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

## <http://www.noe-kaleidoscope.org>

The screenshot shows a Mozilla Firefox browser window displaying the Kaleidoscope Network of Excellence website. The browser's address bar shows the URL [http://www.noe-kaleidoscope.org/telearc/case\\_studies/](http://www.noe-kaleidoscope.org/telearc/case_studies/). The website's header features the tagline "shaping the scientific evolution of Technology Enhanced Learning" and the Kaleidoscope logo, which is "powered by TELEARC". Below the header, there is a navigation menu with links to HOME, ABOUT, NEWS, CASE STUDIES, FOR STAKEHOLDERS, FOR PHD STUDENTS, SCIENTIFIC NETWORKING, and INTRANET. The main content area is titled "Kaleidoscope case studies" and contains two paragraphs of text. The first paragraph states: "To demonstrate how Kaleidoscope researchers work with end users, software developers and business R&D - at home, at work and in education, we present a variety of case studies developed in collaboration with individual and organisational members of the network. The links to these case studies can be selected from the menu to your right." The second paragraph states: "We also include a link to case studies collated by the Kaleidoscope Stakeholders Club, who invite you to become a member of their activities whatever your perspective on technology enhanced learning. The Stakeholder Club case studies demonstrate the perspectives of user involvement when developing and using TEL products and services, and look at TEL research in more depth than the case studies which are presented here." Below the text, there is a link to "Computer Supported Inquiry Learning: what is it all about?" and another link to "The need for new approaches to evaluation in university courses". On the right side of the page, there is a sidebar titled "Case studies" with a list of links: Home, Computer Supported Inquiry Learning: What is it?, Centre for Excellence for Work-based Learning for Education Professionals: Need for new approaches to evaluation in university courses, Kaleidoscope Stakeholder's Club Case Studies, Intermedia: research, researchers and an ex-dean's perspective, London Knowledge Lab: working with luxury car manufacturers, Centro Tempo Reale, University of Florence & partners: musical literacy for children, MeTAH: Training for orthopaedic surgeons, and MeTAH: Algebra for school. At the bottom of the page, there is a footer with the text "Terminé" and a small logo for "FONDATION RHÔNE-ALPES FUTUR".

Kaleidoscope - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Yahoo! Outils ?

http://www.noe-kaleidoscope.org/telearc/case\_studies/

BigSeekPro

Les plus visités Débuter avec Firefox À la une MailBigFile.com | Send...

Search Web Mail Shopping Personals My Yahoo! News Games Travel Finance Answers Sports

shaping the scientific evolution of Technology Enhanced Learning

kaleidoscope powered by TELEARC

log in T+ T-

Search OK

Kaleidoscope > Telearc > Case\_studies

### Kaleidoscope case studies

To demonstrate how Kaleidoscope researchers work with end users, software developers and business R&D - at home, at work and in education, we present a variety of case studies developed in collaboration with individual and organisational members of the network. The links to these case studies can be selected from the menu to your right.

We also include a link to case studies collated by the Kaleidoscope Stakeholders Club, who invite you to become a member of their activities whatever your perspective on technology enhanced learning. The Stakeholder Club case studies demonstrate the perspectives of user involvement when developing and using TEL products and services, and look at TEL research in more depth than the case studies which are presented here.

For more information on any of these case studies, email Paul Davey: [p.davey@joe.ac.uk](mailto:p.davey@joe.ac.uk)

Choose case:

### Computer Supported Inquiry Learning: what is it all about?

Dr Angelique Dimitracopoulou, Professor at the Aegean University (Greece), and member of the Kaleidoscope Computer Supported Inquiry Learning Special Interest Group, speaks on the related domain: what the research has offered and how education should profit from it.

### The need for new approaches to evaluation in university courses

University teaching staff must understand more about the experiences of students who return to university for postgraduate study and who are expected to learn by communicating in electronic discussion groups. Often these students have the

### Case studies

- Home
- Computer Supported Inquiry Learning: What is it?
- Centre for Excellence for Work-based Learning for Education Professionals: Need for new approaches to evaluation in university courses
- Kaleidoscope Stakeholder's Club Case Studies
- Intermedia: research, researchers and an ex-dean's perspective
- London Knowledge Lab: working with luxury car manufacturers
- Centro Tempo Reale, University of Florence & partners: musical literacy for children
- MeTAH: Training for orthopaedic surgeons
- MeTAH: Algebra for school

Bienvenue dans VAIO Update ! Cliquez ici pour en savoir plus sur les logiciels et mises à jour de sécurité importants pour votre PC VAIO !

Terminé



# The Kaleidoscope Network of Excellence

Kaleidoscope - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Yahoo! Outils ?

http://www.noe-kaleidoscope.org/telearc/case\_studies/CSIL.html

Les plus visités Débuter avec Firefox À la une MailBigFile.com | Send...

Search Web Mail Shopping Personals My Yahoo! News Games Travel Finance Answers Sports

Kaleidoscope > Telearc > Case\_studies

Dr Angelique Dimitrakopoulou, Professor of Aegean University (GR), and member of the Coordination group of Computer Supported Inquiry Learning, Special Interest Group, established in Kaleidoscope NoE, speaks on the related domain: what the research has offered and how education should profit from it.

## So, what is Computer Supported Inquiry Learning?

Inquiry learning is an active approach to learning that involves exploration, and questioning. In order to answer questions students explore domains, pose questions, design experiments, collect data or build models to test ideas in search of new knowledge and understanding. The importance of self directed inquiry learning was pointed out from the pedagogues decades ago, in the beginning of the previous century. Actually, technology enables us to design learning environments that first of all allow the exploration and modelling of phenomena that are often not immediately visible, or do not have a visible representative. But, what is even more significant for the learning process, these computer supported inquiry learning environments are designed with the purpose of effectively supporting students during the inquiry learning process.

### Case studies

- Home
- Computer Supported Inquiry Learning. What is it?
- Centre for Excellence for Work-based Learning for Education Professionals: Need for new approaches to evaluation in university courses
- Kaleidoscope Stakeholder's Club Case Studies
- Intermedia: research, researchers and an ex-dean's perspective
- London Knowledge Lab: working with luxury car manufacturers
- Centro Tempo Reale, University of Florence & partners: musical literacy for children
- MeTAH: Training for orthopaedic surgeons
- MeTAH: Algebra for school children
- MeTAH: Planning chemistry experiments
- KMRC: TEL research in German hospitals
- KMRC: Scripting collaborative interaction - what it is; what it does
- KMRC: The Forest project

TELEARC kaleidoscope

FONDATION RHÔNE-ALPES FUTUR

KALEIDOSCOPE ARCHIVE

COLAB

Tools: Process coordinator, COLAB Help, Table, Graph, Tank Level Laboratory

ROOMS: Theory, Lab, Meeting, Mail, Logos, Change floor

Tank Level Laboratory

Level in tank (m): 0.0000

Outflow rate (l/min): 0.0000

Outflow rate (m³/s): 0.0000

Initial tank level (0.0000 m): 0.0000

Tank diameter (0.0000 m): 0.0000

Tank height (0.0000 m): 0.0000

Water Valve: 0.0000

Flow from tap (0.0000 l/min): 0.0000

Pipe diameter (0.0000 m): 0.0000

Table

Outflow rate	Time
0.0000	0.0000
0.0000	1.0000
0.0000	2.0000
0.0000	3.0000
0.0000	4.0000
0.0000	5.0000
0.0000	6.0000
0.0000	7.0000
0.0000	8.0000
0.0000	9.0000
0.0000	10.0000
0.0000	11.0000

Graph

vertical

Time

Flow from tap

Flow from tank

Flow from pipe

Flow from valve

Flow from tap

Flow from tank

Flow from pipe

Flow from valve

# The ReMath STREP

<http://remath.cti.gr>

ReMath - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Yahoo! Outils ?

http://remath.cti.gr/

Les plus visités Débuter avec Firefox À la une MailBigFile.com | Send...

Search Web Mail Shopping Personals My Yahoo! News Games Travel Finance Answers Sports

Page d'accueil Recherche Calendrier Nouvelles du projet A propos de ReMath

**ReMath**

Information Society Technologies

Nom d'utilisateur martigue mot de passe d'utilisateur ..... ENTR&#201;E

mercredi, 22/09/2010 08:54:34 Nouvel Utilisateur ? cliquez ici pour vous enregistrer

**The ReMath Project**

## Making sense of theory on learning mathematics with digital media

Project Outcomes:

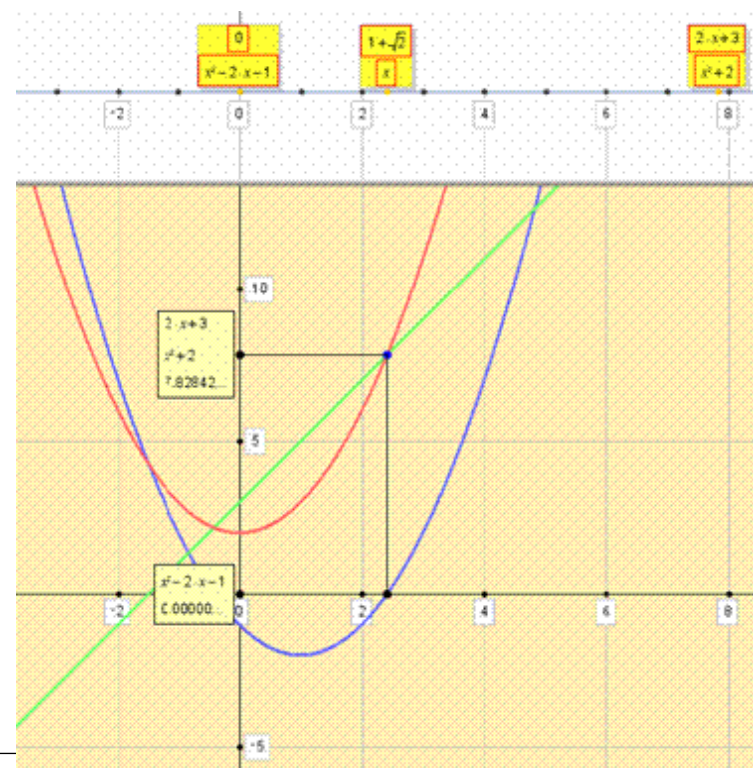
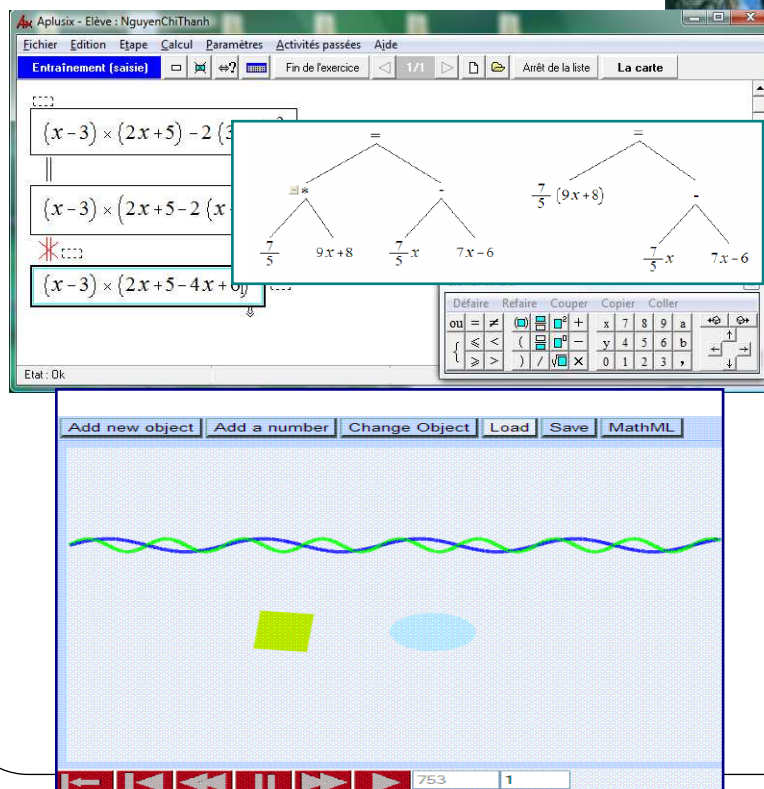
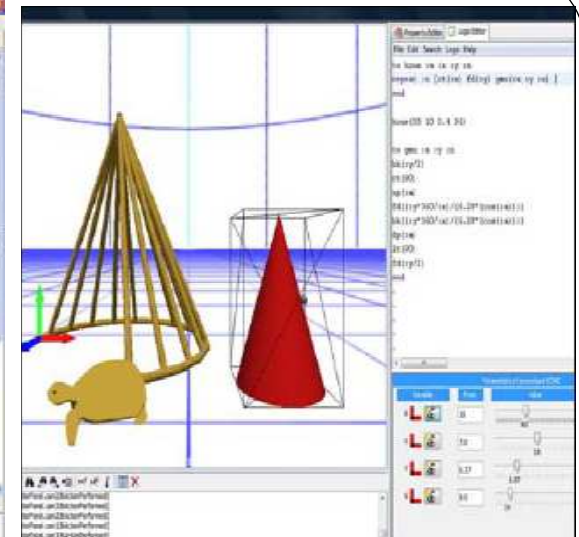
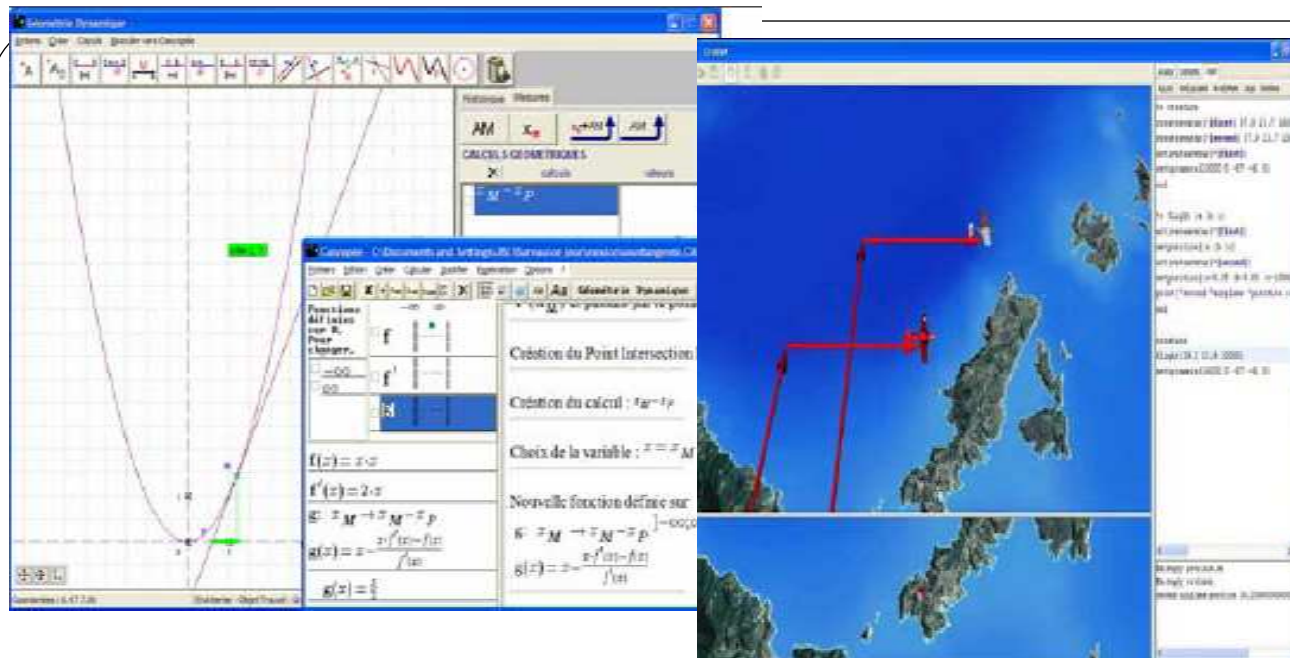
- Six Dynamic Digital Artifacts** in Algebra, Geometry and Mathematics in Science and Geography,
- 13 Pedagogical Plans** addressed to **Researchers** showing how theory drives practice,
- The same **13 Pedagogical Plans** addressed to **Teachers** showing the potential of using digital media for mathematical teaching and learning – each one in English, French, Italian and Greek,
- An academic description of **cross-case studies** of classroom activity emerging from the implementation of the Pedagogical Plans,
- An academic description of how the **above experience** can help in making sense of theory in **learning mathematics with digital media**.

HOME  
OBJECTIVES  
PARTNERS  
DOCUMENTS  
TECHNOLOGIES  
SCENARIOS  
MEMBERS AREA  
PUBLIC FORUM  
CONTACT US

++ En ligne

Terminé





# 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...

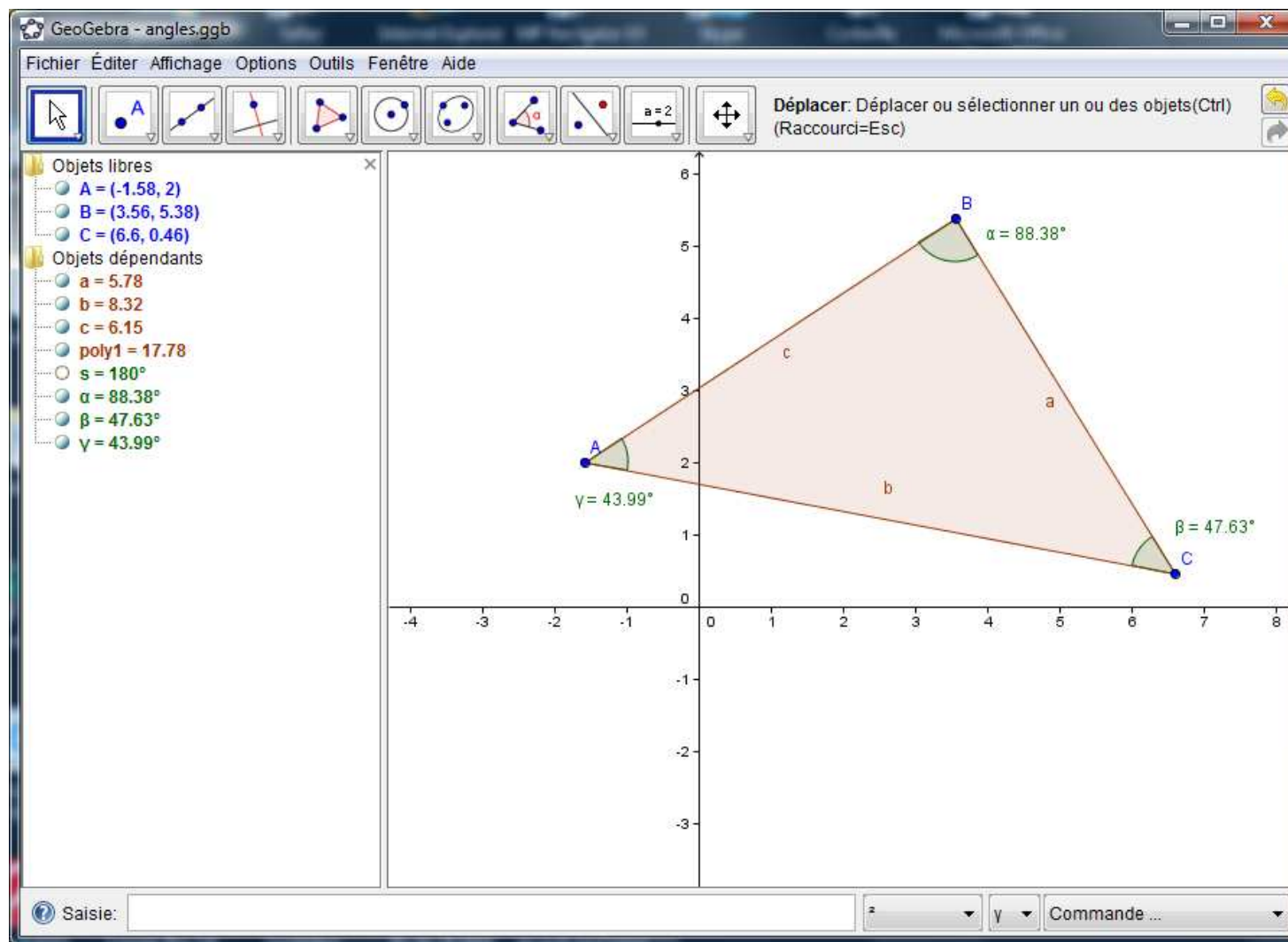
1. The attractiveness of ostensive and pseudo inquiry-based practices.
2. The under-estimation of instrumental issues.
3. The specific ecology of most successful experiments.
4. The diversity of educational cultures and contexts.
5. The connection between maths and sciences.

# 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?

Microsoft Excel interface showing a spreadsheet titled "nombres consécutifs [Mode de compatibilité] - Microsoft Excel". The ribbon includes tabs for Insertion, Mise en page, Formules, Données, Révision, Affichage, Compléments, and PDF Suite. The ribbon is set to the "Formules" tab, showing options for "Renvoyer à la ligne automatiquement", "Fusionner et centrer", "Standard", "Mise en forme conditionnelle", "Mettre sous forme de tableau", "Styles de cellules", "Insérer", "Supprimer", and "Format".

The spreadsheet displays a table of numbers, with columns labeled A through L and rows numbered 1 through 23. The first row (row 1) is highlighted in yellow and contains the header "n/p" in column A, followed by numbers 2 through 10 in columns B through J. The subsequent rows (rows 2 through 21) are highlighted in orange and contain numbers 1 through 20 in column A, followed by their respective sums of consecutive integers in columns B through J. The sums are calculated as follows:

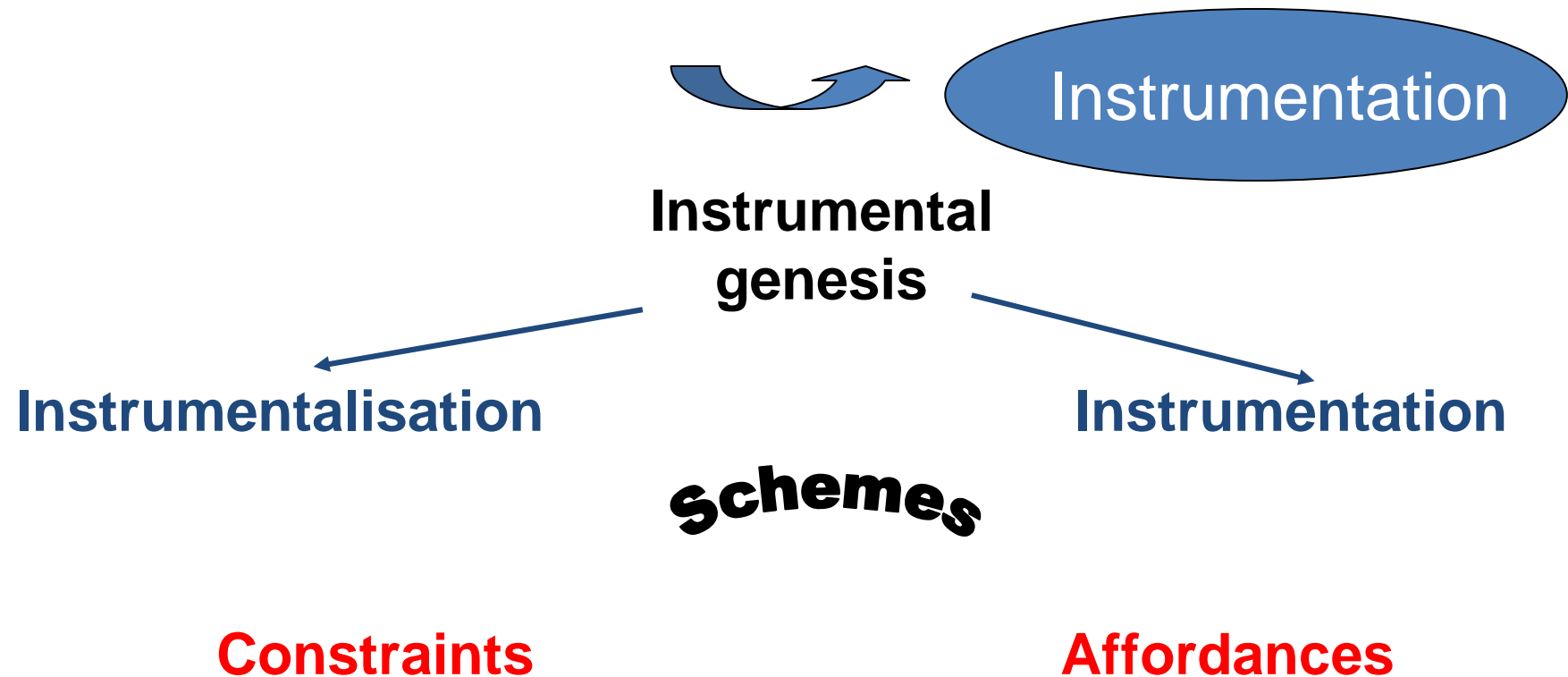
n/p	2	3	4	5	6	7	8	9	10
1	3	6	10	15	21	28	36	45	55
2	5	9	14	20	27	35	44	54	65
3	7	12	18	25	33	42	52	63	75
4	9	15	22	30	39	49	60	72	85
5	11	18	26	35	45	56	68	81	95
6	13	21	30	40	51	63	76	90	105
7	15	24	34	45	57	70	84	99	115
8	17	27	38	50	63	77	92	108	125
9	19	30	42	55	69	84	100	117	135
10	21	33	46	60	75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

# 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-based 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 ?

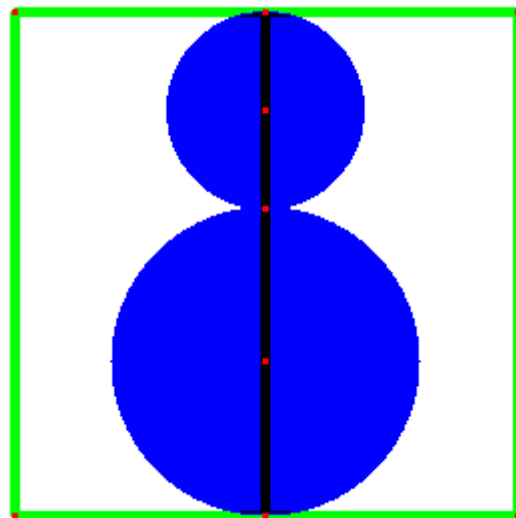
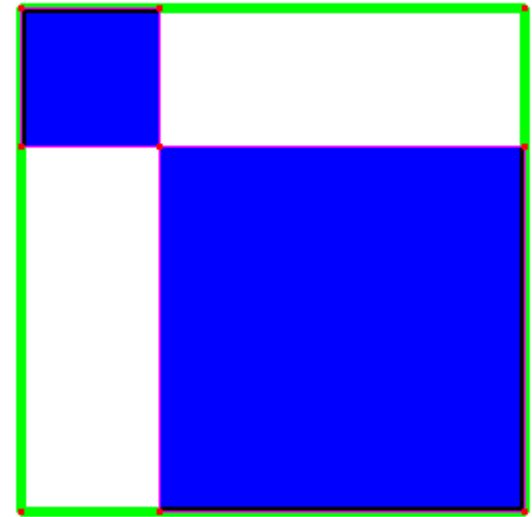
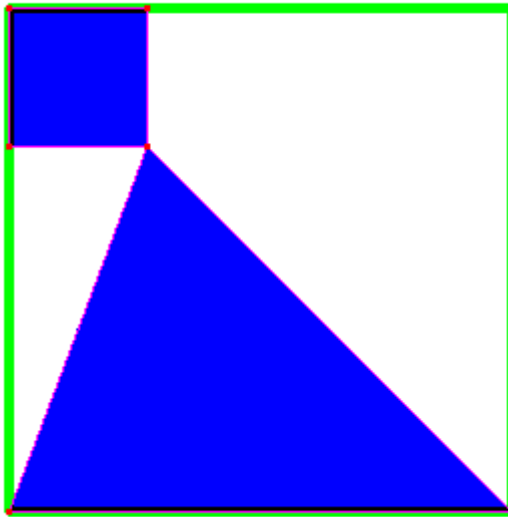
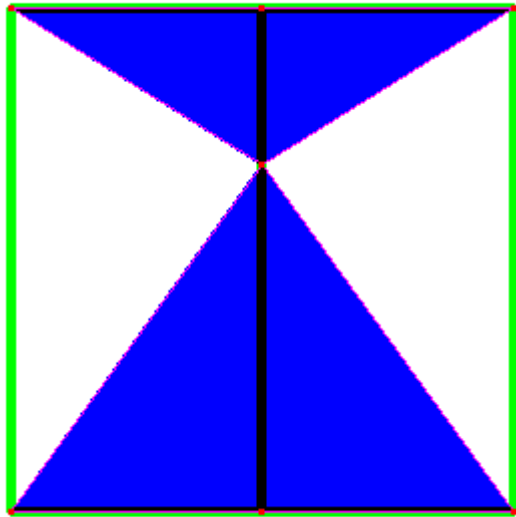
## ~~ANOTHER FACET OF CURRENT INQUIRY-~~ based practices to take into consideration

- 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 inadequacy 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.

# References

- Artigue M. (2002). Learning mathematics in a CAS environment: the genesis of a reflection about instrumentation and the dialectics between technical and conceptual work. *International Journal of Computers for Mathematics Learning*, n°7, 245-274.
- Barbeau E.J., Taylor P.J. (2009). Challenging Mathematics In and Beyond the Classroom. *The 16<sup>th</sup> ICMI Study*. Springer.
- Brousseau, G. (1997). *Theory of Didactical Situations in Mathematics*. Dordrecht: Kluwer Academic Publishers.
- Chevallard Y. (2002) Organiser l'étude. In Dorier J.L., Artaud M., Artigue M., Berthelot R., Floris R. (Eds.), *Actes de la Xème Ecole d'été de didactique des mathématiques* (pp. 3–22, 41–56). Grenoble : La Pensée Sauvage.
- Chevallard, Y. (2006). Steps towards a new epistemology in mathematics education. In Bosch, M. (Ed.) *Proceedings of the 4<sup>th</sup> Conference of the European Society for Research in Mathematics Education (CERME 4)*. (pp. 21-30). Barcelona: FUNDEMI-IQS.
- Cornu B. & Ralston A. (Eds) (1992). *The influence of computers and informatics on mathematics and its teaching*. Science and Technology Education. Document Series 44. Paris: UNESCO.

# References

- Haspekian, M. (2005). An “instrumental approach” to study the integration of a computer tool into mathematics teaching: the case of spreadsheets. *International Journal of Computers for Mathematical Learning*, vol 10, n°2, 2005, p.109-141.
- Hoyles C, Lagrange J.B. (Eds.) (2010). *Mathematics Education and Technology – Rethinking the Terrain. The 17<sup>th</sup> ICMI Study*. Springer.
- Haspekian M. & Artigue M. (2007). L'intégration d'artefacts informatiques professionnels à l'enseignement dans une perspective instrumentale : le cas des tableurs. In, M. Baron, D. Guin, L. Trouche (Eds), *Environnements informatisés et ressources numériques pour l'apprentissage*, pp.37-63. Paris : Editions Hermès.
- Guin D, Ruthven K. & Trouche K. (Eds). (2004). *The didactic challenge of symbolic calculators*. Dordrecht : Kluwer Academic Publishers.
- Laborde C. (2001). Integration of technology in the design of geometry tasks with Cabry-geometry. *International Journal of Computers for Mathematical Learning*, 6/ 3, 283-317.

# References

- Miller D. & al. (2005). From technology to professional development: how can the use of an interactive whiteboard enhance the nature of teaching and learning secondary mathematics and modern foreign languages? Report for the Training and Development Agency. Agency, [www.ttrb.ac.uk/attachments/0d65acf3-488a-4fca-8536-918d6dafd694.pdf](http://www.ttrb.ac.uk/attachments/0d65acf3-488a-4fca-8536-918d6dafd694.pdf)
- Restrepo A.M. (2008). *Genèse instrumentale du déplacement en géométrie dynamique chez des élèves de sixième*. Thèse de doctorat. Université Joseph Fourier, Grenoble.
- Tapan S. (2006) *Différents types de savoirs mis en oeuvre dans la formation initiale des enseignants de mathématiques à l'intégration de technologies de géométrie dynamique*, Thèse de doctorat. Université Joseph Fourier. Grenoble.
- Vérillon P., Rabardel P. (1995). Cognition and artifacts: a contribution to the study of thought in relation to instrumented activity. *European Journal of Psychology of Education* vol.X(1), 1995, p.77-101.