ICT evolutions: which consequences for mathematics teaching?

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Outline

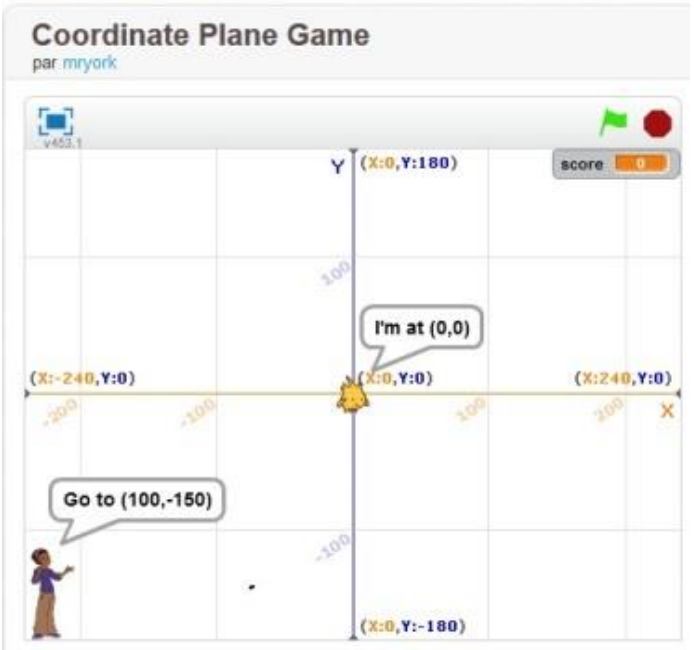
1) ICT evolutions, research with the instrumental/documentational approach
2) Digital resources for the teaching of numbers: example of a project at primary school
3) Living resources for teaching and learning: example of a project at secondary school
4) Further questions

ICT evolutions and mathematics education

ICT resources and communication in class:

new possibilities for collecting and sharing students' contributions

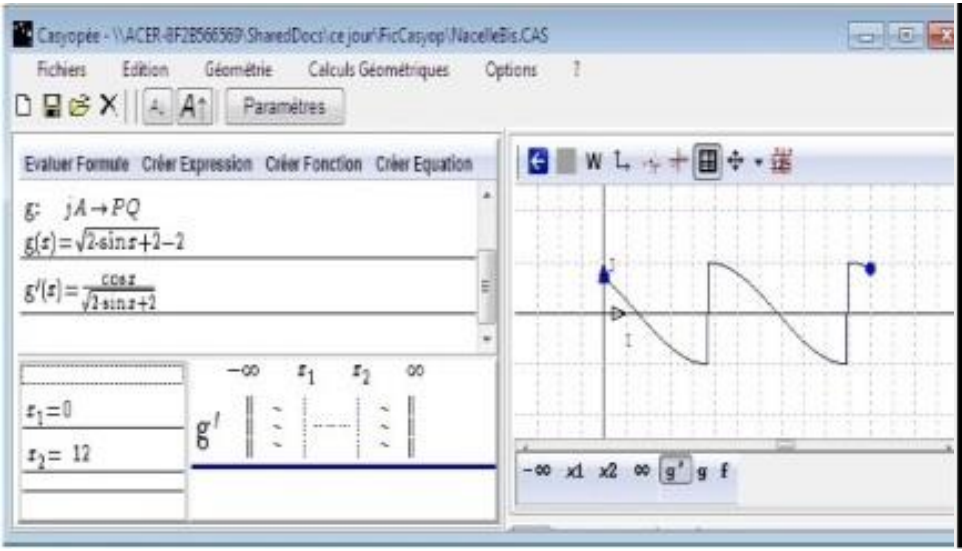
ICT evolutions and mathematics education

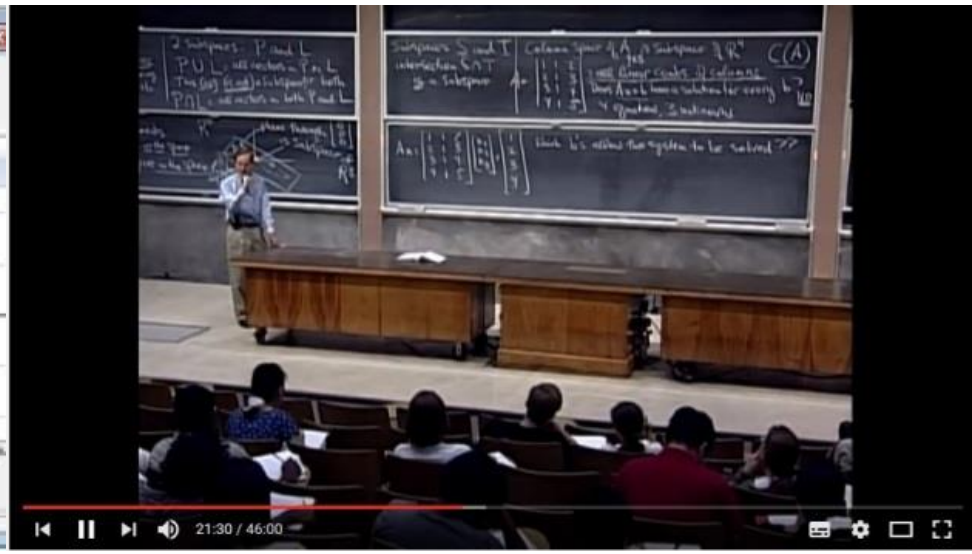


ICT resources initially designed for different aims and used for the teaching of mathematics (material, software):

New possibilities for the students' mathematical activity, new (?) links between mathematics and programming

ICT evolutions and mathematics education

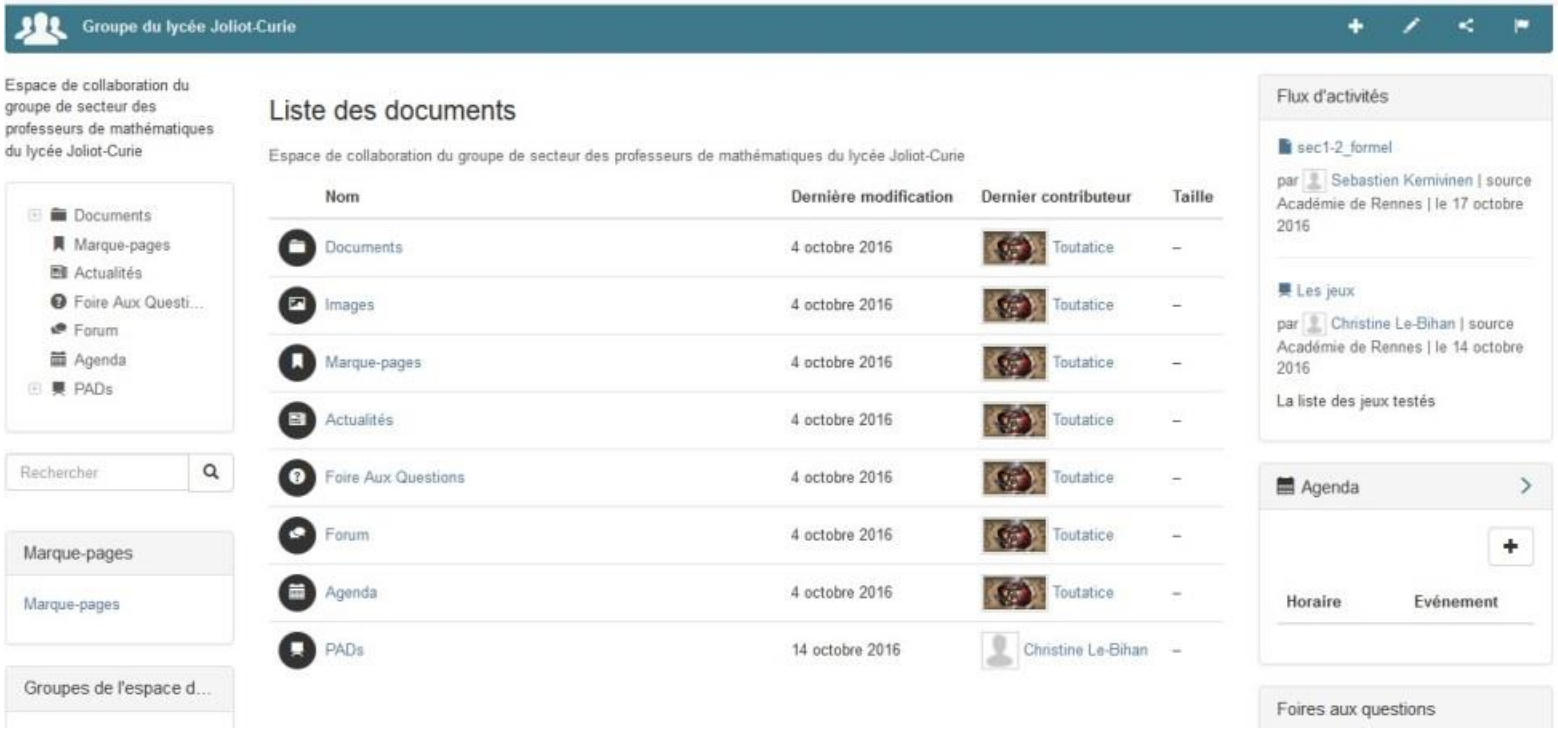




Resources designed for the teaching of mathematics (Software, Videos etc.)

Modification of the students' mathematical activity, modification of the teachers' work.

ICT evolutions and mathematics education



New possibilities for the design by teachers, individually and collectively

Design by teachers of resources for their own teaching; of resources for other teachers. Collective design of Open Educational Resources (OERs).

Two directions for research

- Investigating the consequences of the use of digital resources designed for the teaching of mathematics in terms of students' learning

- Investigating the consequences of the new possibilities offered by digital means for individual and collective design of resources in terms of teachers' work

The instrumental approach perspective

In the instrumental approach (Rabardel 1995), an essential distinction between an artefact and an instrument:

- An *artefact*: produced by the human activity, designed for a human activity with a particular aim.
- An *instrument*: developed by a subject (student, teacher) using the artefact with a special aim.

An instrument is a mixed entity, comprising the artefact and a scheme of use of this artefact (Vergnaud 1996).

ICT in mathematics education research: the instrumental approach perspective

Instrument = Artefact + Scheme

A scheme of use comprises the aim; rules of actions; knowledge developed in action.

Using the same artefact with the same aim, two subjects can develop different instruments.

The aim of the subject can coincide, or not, with the initial aim chosen by the designer of the artefact.

The artefact can be modified by the user: design-in-use.

ICT in mathematics education research and the instrumental approach perspective

Research in mathematics education used the instrumental approach to investigate:

- How students learn mathematics with calculators (Guin, Ruthven & Trouche 2005)

- How teachers use the spreadsheet in class (Haspekian 2005): artefacts for the teacher

The documentational approach perspective

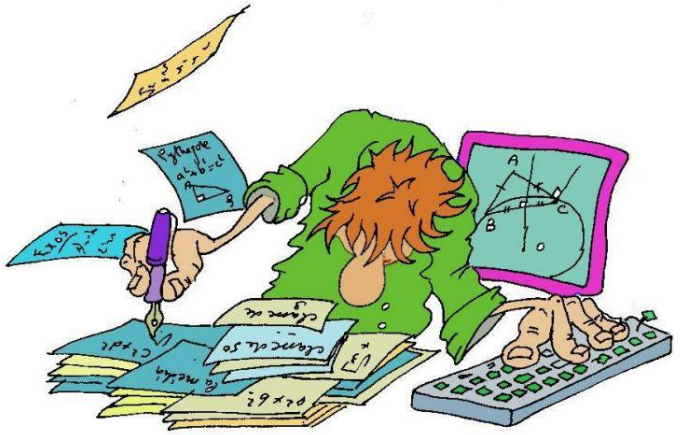
From artefacts to all kinds of resources: textbooks, students' productions, discussions with colleagues…

Teachers interact with resources to design their own teaching

Document= Resources + Scheme

Teachers develop structured resources systems

(Gueudet & Trouche 2009)



« Digital resources for the teaching of numbers »

A research and design project for Kindergarten and Primary School

http://python.espe-bretagne.fr/blog-gri-recherche/?page_id=201

A design and research group

From 2011 to 2016

Teachers, teacher educators and researchers

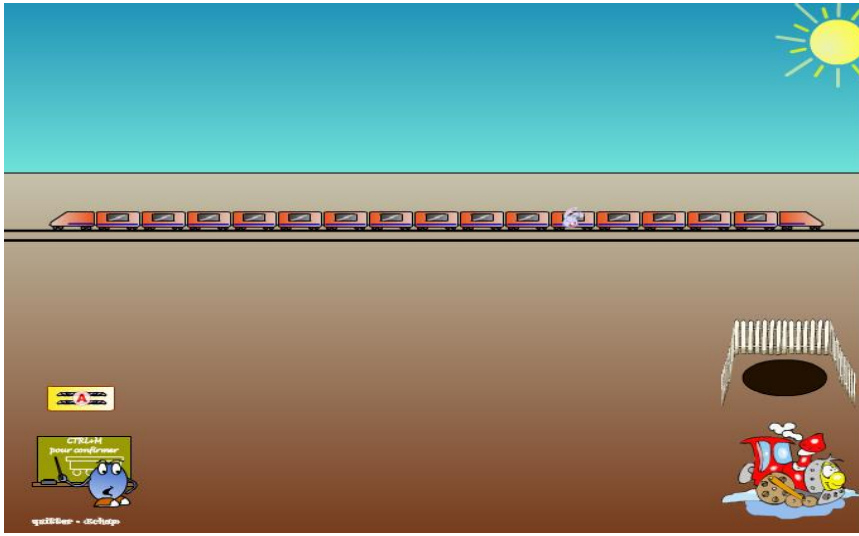
Use of existing software, development of new software

Design of lessons, tests in class, new version of the lesson.

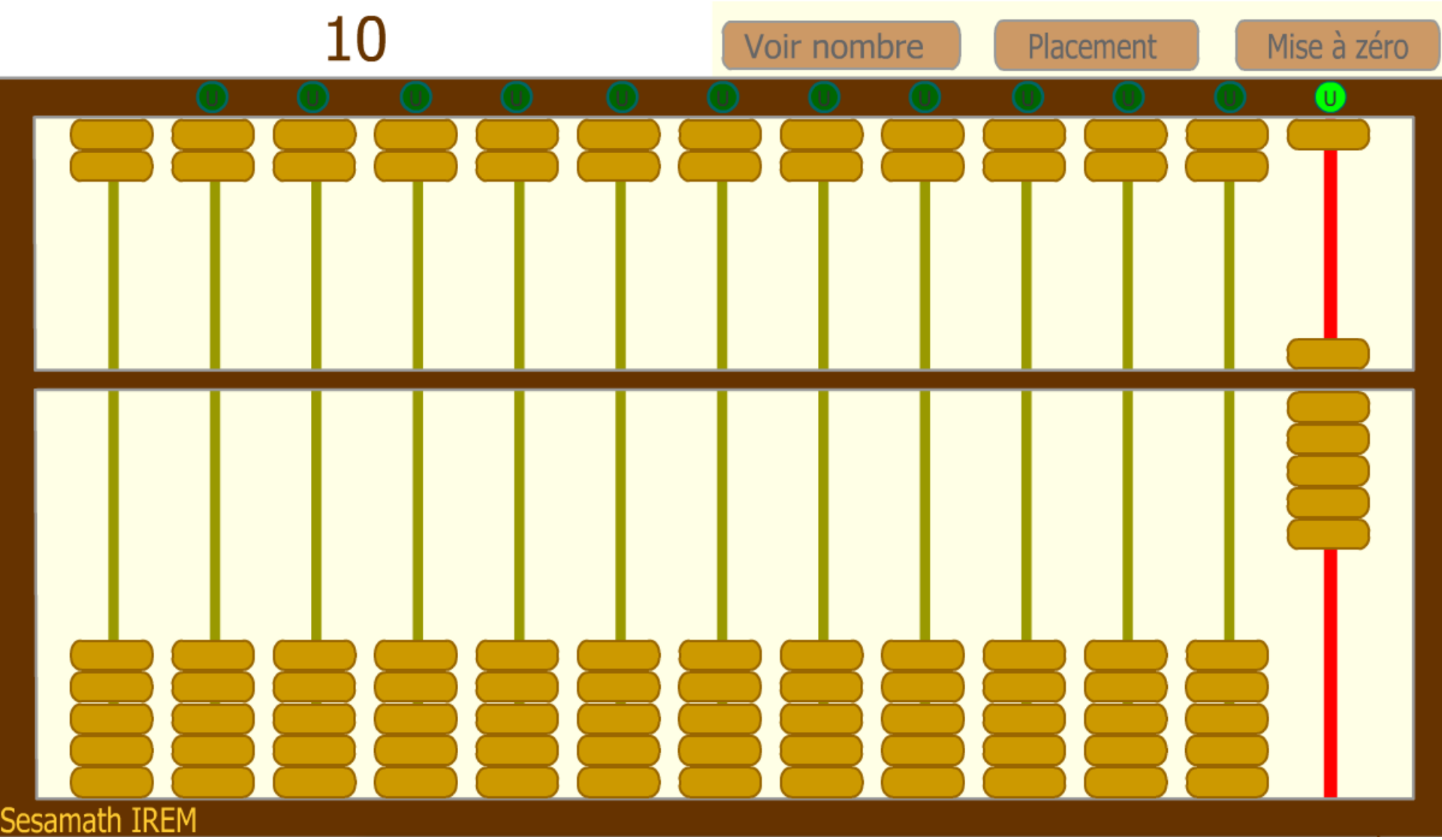
Design of resources for teachers.

Design of in-service teacher education programs.

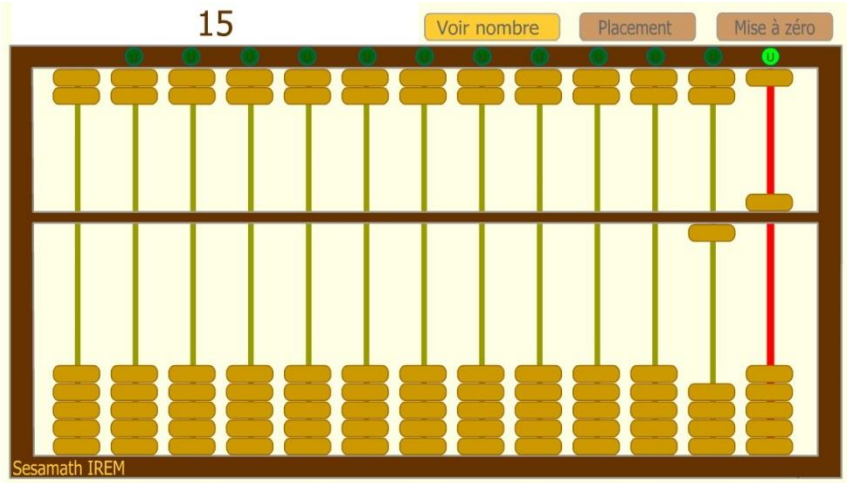
Gueudet, Bueno-Ravel & Poisard (2013)

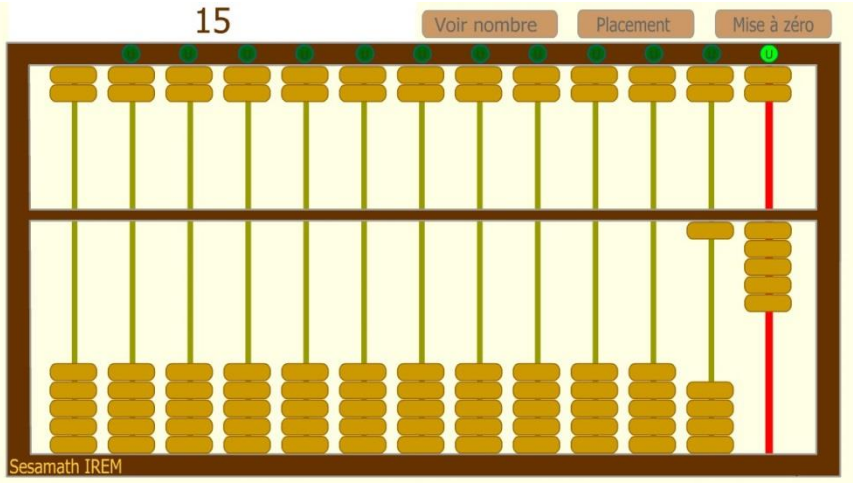


The virtual abacus



Potentialities of the abacus for the learning of numbers



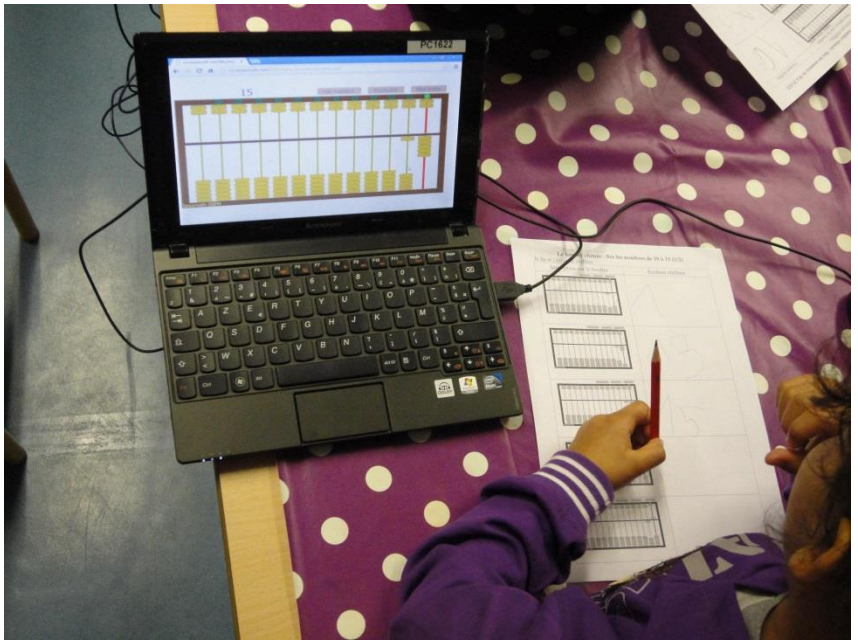


Noticing different possibilites of decomposition for the same number

Evidencing the possibilities of grouping and exchanging:
five one-unit beads correspond to one five-units bead, etc.

Designing a lesson to draw on these potentialities i.e. to lead the students to develop an instrument from the abacus artefact

Design of a lesson with the virtual abacus and other resources

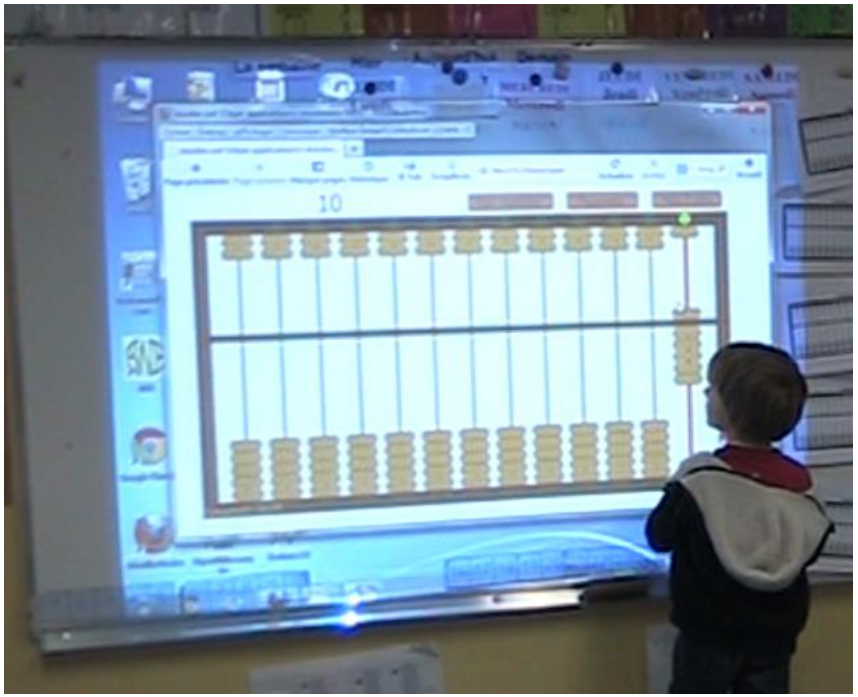


Using the Chinese abacus for a teaching of numbers and place value, within a set of resources:

- Virtual abacus
- Material abacus
- And other resources and representations of numbers…

Design of lessons with the virtual abacus

Lessons designed from Kindergarten to grade 5, tested and improved during 3 years.



Grade 2 (students 7 years old)

Investigation, to discover how the abacus works: possible with the virtual abacus function « display number »

Collective discussion about « how the abacus works », version 1 on the usual board, version 2 on the IWB

Design of lessons with the abacus

To main tasks proposed to the students:

1) inscribe a given number on the abacus;

2) write in digits a number inscribed on the abacus.

Version 1 of the lesson:

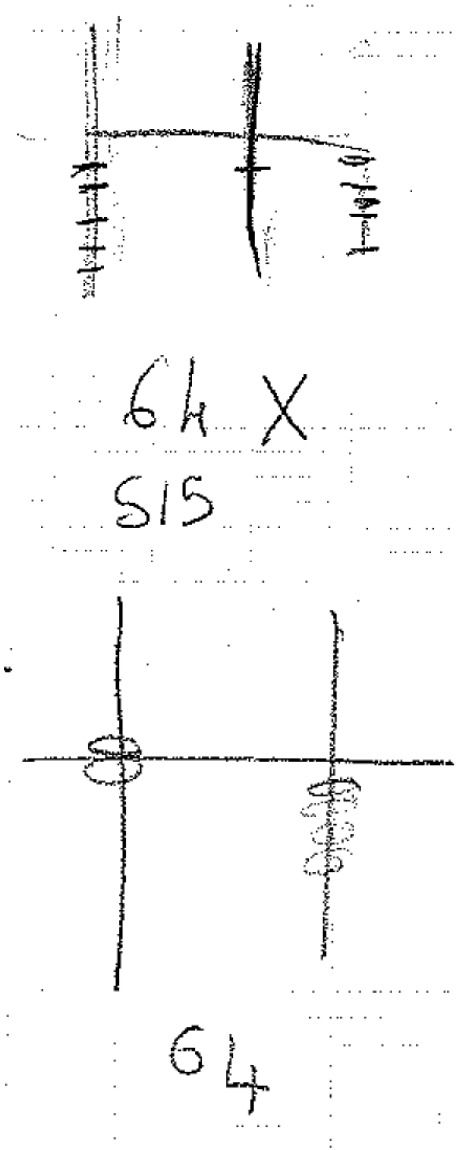
Some students use the function « display number » to work by trial and errors.

Design of lessons with the abacus

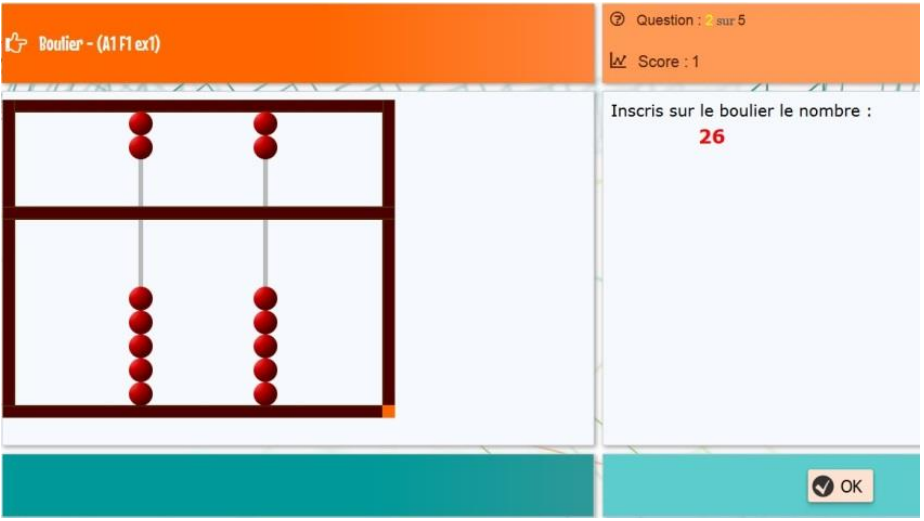
Version 2 of the lesson:

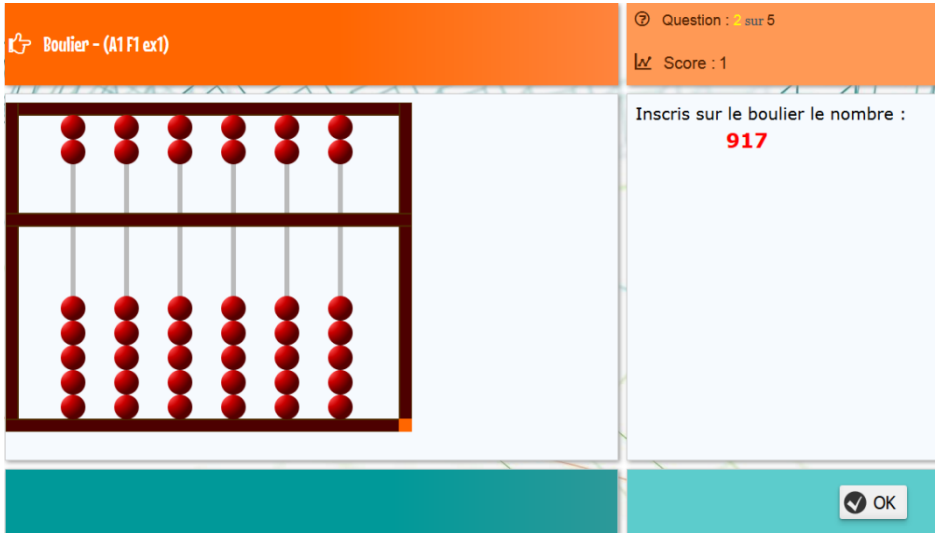
A first task is proposed on paper (draw the beads);

the students can practice on the virtual abacus;
then a second task is proposed on paper



Design of lessons with the abacus





Version 3 of the lesson:

Development of a new software, proposing interactive exercises with the abacus. Choice of parameters by the teacher; an Internet connection needed.

Design of lessons with the abacus

According to the teachers, a real improvement of the understanding of place value, especially useful to work on operations.

The abacus artefact is tranformed into an instrument, incorporating mathematical knowledge, like: « a number can have different representations », « one tenth is like one five and five units » etc.

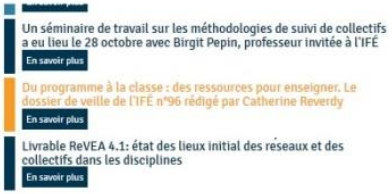
Learning mathematics with ICT

- Importance of the possibility for the students to use ICT to investigate and have a feedback
- ICT amongst other resources: paper-and-pencil work, material etc.
- ICT functionnalities diverted by some students from their initial aim
- Interest of the design of a lesson by a research group, with successive tests and improvements. Different possible versions of the lesson, depending on the available equipment or other elements of context

Design of resources for the teachers…

ReVEA

Ressources vivantes pour l'enseignement et l'apprentissage



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« Living resources for teaching and learning » (REVEA)

A research project at secondary school

Living resources for teaching and learning

A national research project in France, about the use of resources by teachers at secondary school.

From 2014 to 2018

4 subjects: English, Mathematics, Physics, Technology

- Investigating teachers' resources systems
- Investigating teachers' collective work with resources
- Investigating the evolutions (of teachers' resources systems, of teachers' collective work) linked with digital resources and the new possibilities they offer

Living resources for teaching and learning

For secondary school maths teachers in France:

- Their central “resource” is a collection of 4-6 textbooks on paper
- Generalised use of software: spreadsheet, dynamic geometry, programming and calculators
- Increasing use of websites to search for lessons (institutional, associative, individual) especially lessons using ICT
- Emerging use of videos
- More collective work in the schools than the teachers of other subjects – but limited to particular tasks.

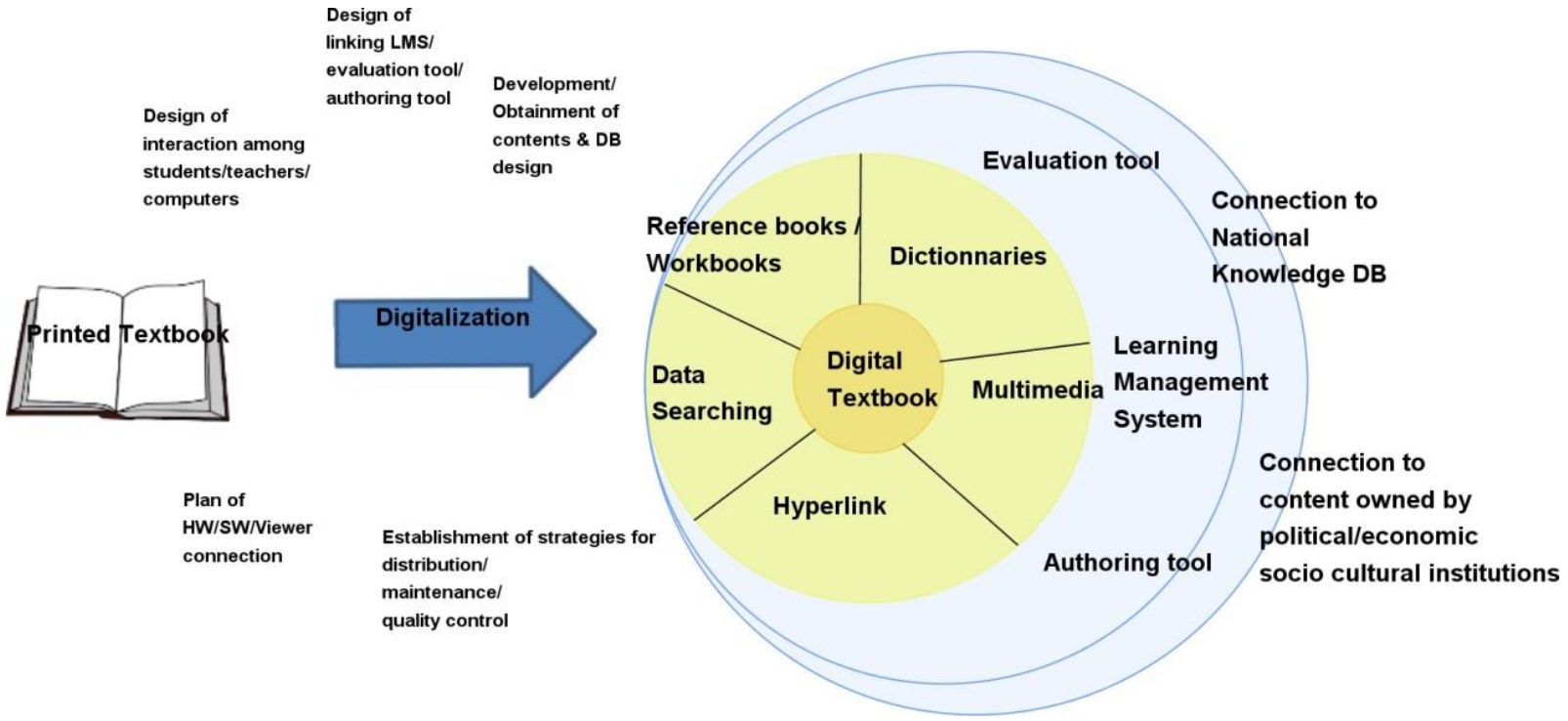
A focus on textbooks and **e-textbooks**

Analysing the possibilities offered by digital resources for teachers: The example of the e-textbook

The e-textbook: a recent evolution

From a static pdf version of the paper textbook

To a rich network of resources



Three types of e-textbooks

(Pepin et al. 2015)

1. the *integrative e-textbook*: digital version of a (traditional) textbook connected to other learning objects;
2. the *evolving or 'living' e-textbook*: authored by a community and permanently developing due to the input of other practicing members/teachers;
3. the *interactive e-textbook*: a 'toolkit' model based upon a set of learning objects (tasks and interactive diagrams and tools) that can be linked and combined

Connectivity of an e-textbook

A need to take into account:

- “practical connections”: between different kinds of resources, between different users etc. (panel ICMI 17, Hoyles & Lagrange 2010)
- “cognitive connections”: between different concepts, different representations etc. (Hiebert and Carpenter 1992)

The connectivity of an e-textbook is defined as:

“*Its connecting potential for a given user (student or teacher) both practically as well as cognitively*”

A classical distinction, in textbooks analysis: *Macro-level* (the textbook as whole in the educational system) and *Micro-level* (for a given content).

Connectivity of an e-textbook, macro-level

Examining the existence of links (external) between the e-textbook and:

- The official curriculum,
- Other textbooks (other levels, other disciplines), a teacher's guide,
- Websites: from the publisher, other websites
- Software,
- Students assessment sytems,
- Teacher's and students resources system: possibility to download and modify parts of the e-textbook, to integrate their own resources in the e-textbook
- Possibility of establishing links between different users (teachers, students, a teacher and his/her students), between users and designers

Connectivity of an e-textbook, micro-level

For a given mathematical theme (e.g. functions)

Examining the existence of links within the e-textbook:

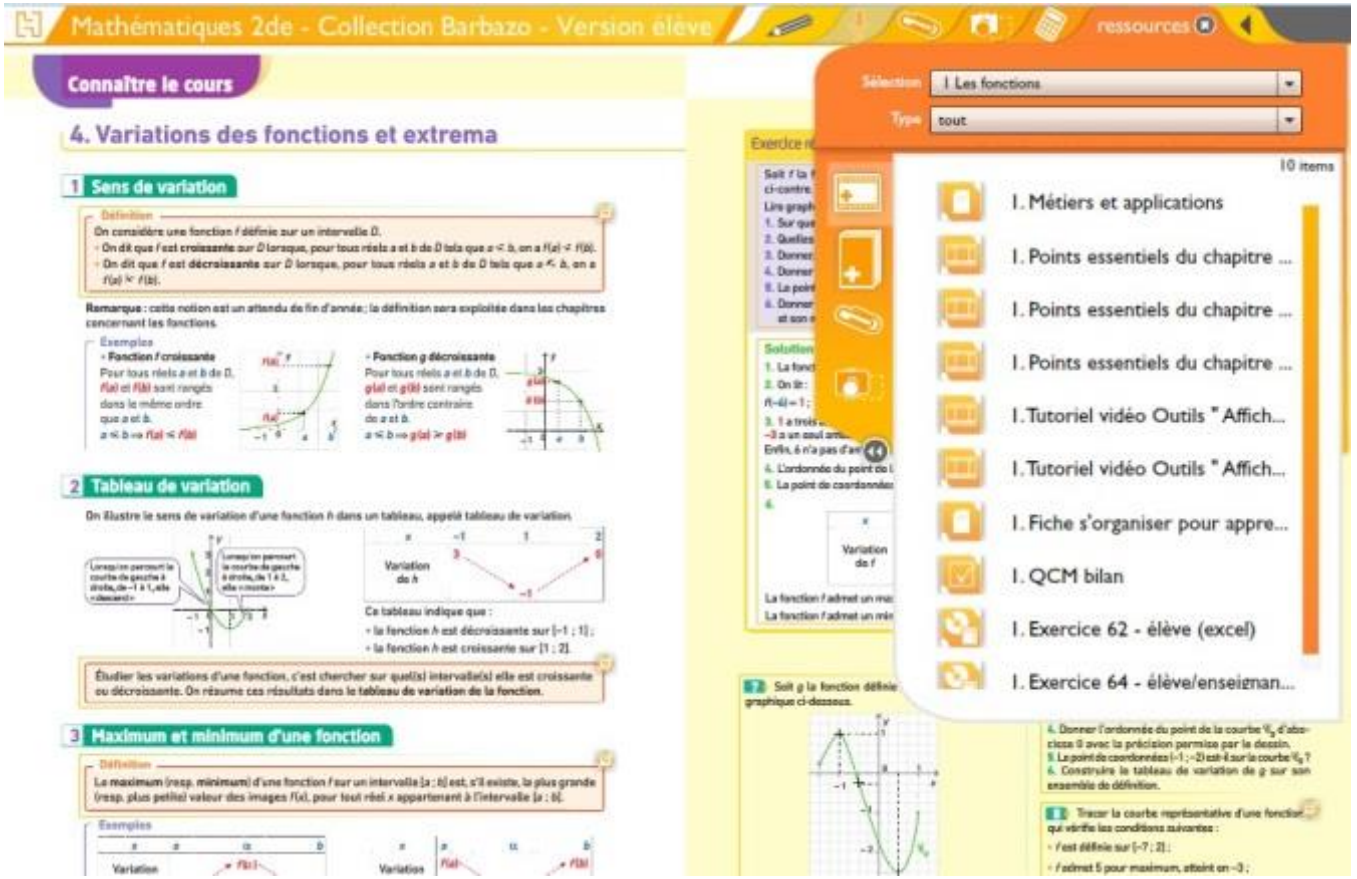
- Between concepts, between different levels of appropriation of the same concept;
- Between different representation registers, links with dynamical representations;
- Between different mathematical domains, with other subjects, with real-life contexts;
- Links with software and calculators;
- Propositions for a differentiated teaching, taking into account different needs;
- Links with students' assessment tools.

Example of an integrative e-textbook

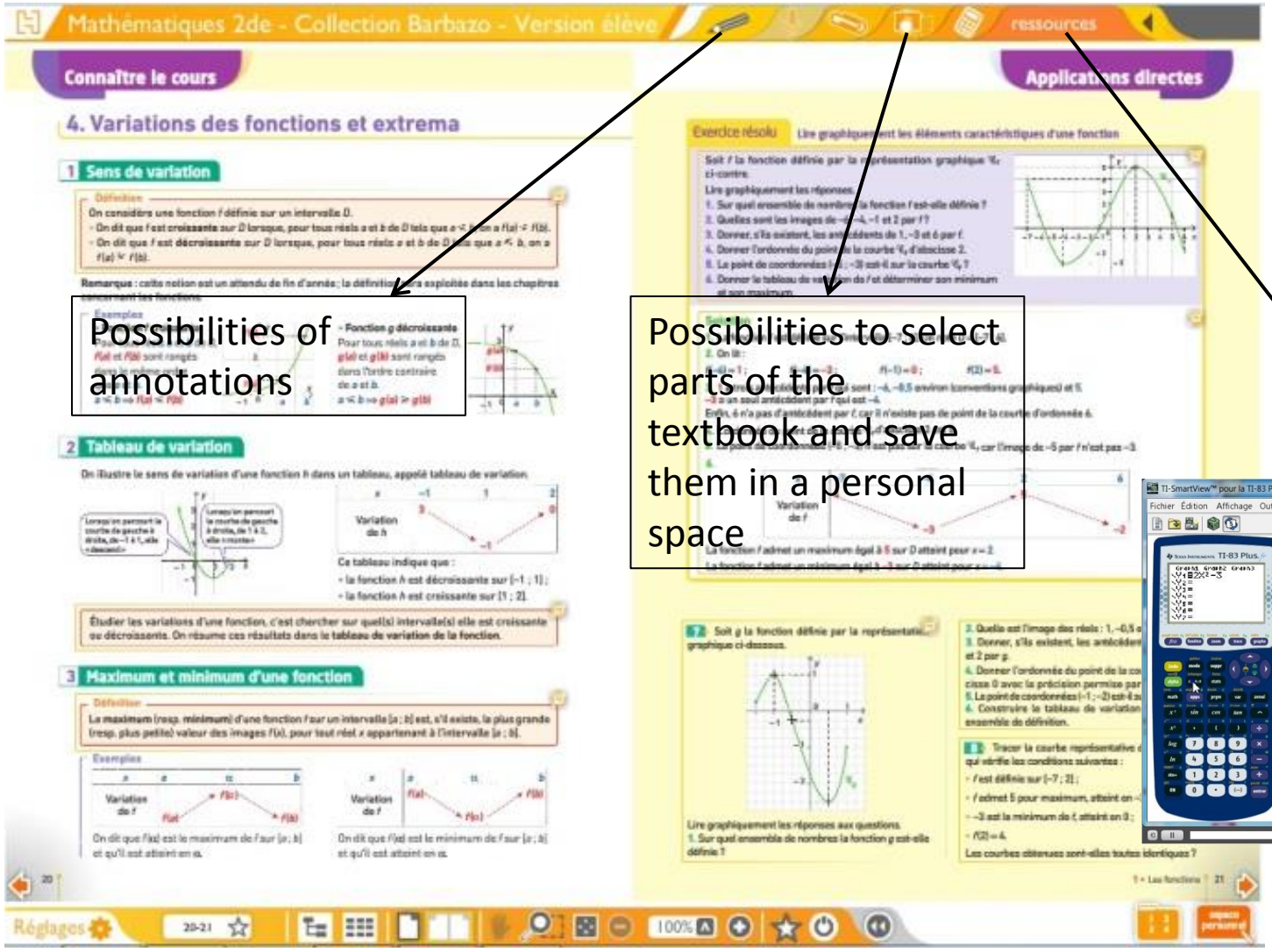
Hachette Barbazo
Grade 10
2014

The e-textbook is accessible via an annual subscription

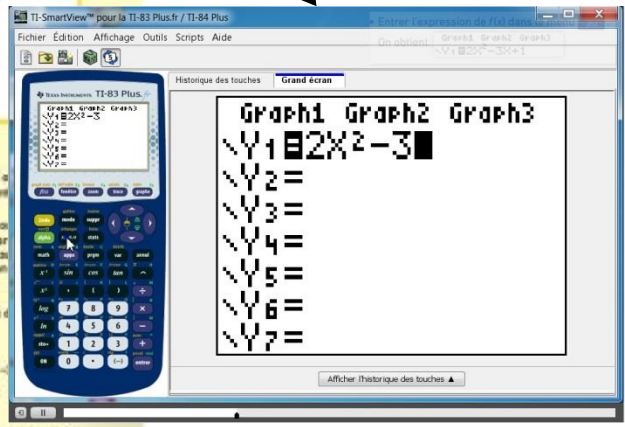
Associated with a textbook on paper



Example of an integrative e-textbook



Additional resources



Example of an *evolving* e-textbook

Sesamath

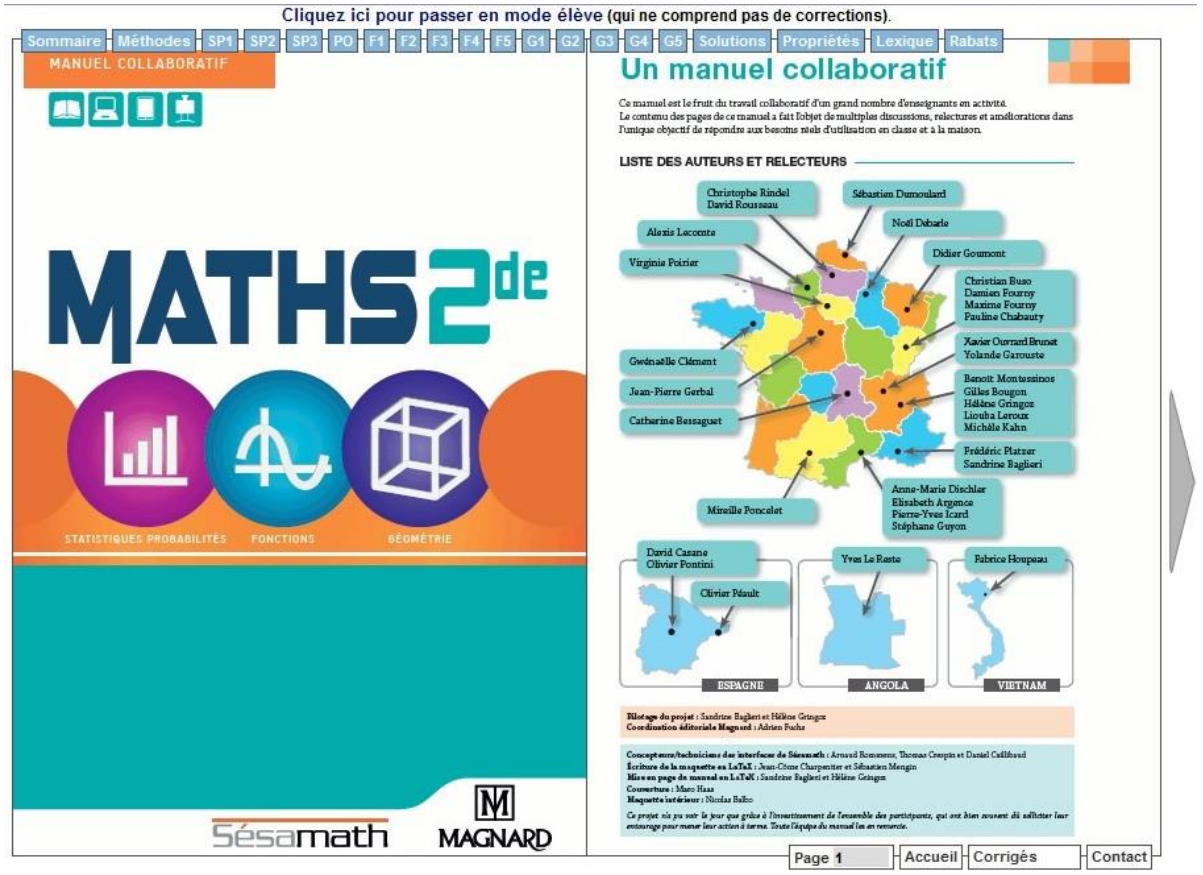
Grade 10

2014

Designed by an association of teachers

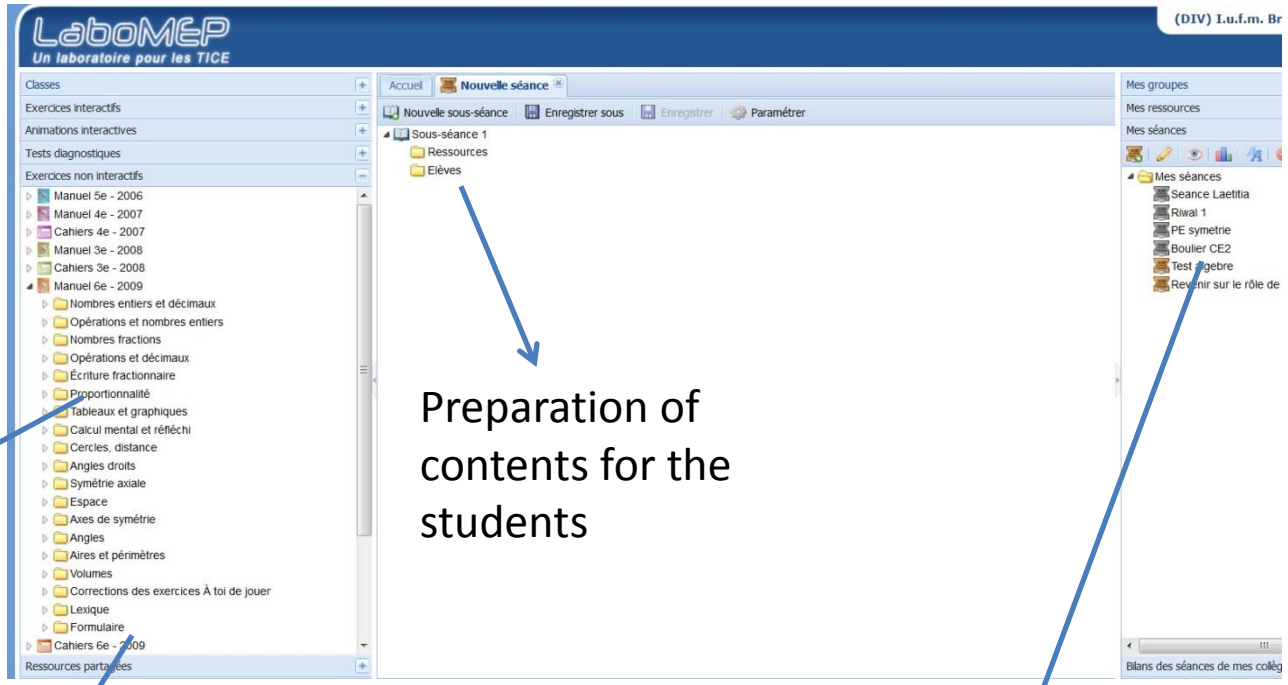
Free access to the e-textbook

Associated with a textbook on paper



Example of an evolving e-textbook

Inserted in a virtual environment, LaboMEP



Sésamath resources: e-textbooks, interactive exercises

Preparation of contents for the students

Resources shared with colleagues

Resources selected by the teacher

Comparison, in terms of macro-level connectivity

Integrative e-textbook

A rich resources system from the publisher (Hachette).

Possibility to create a personal space in the e-textbook, but:

Not possible to download parts of the e-textbook

Not possible to contact directly other users or the authors to suggest modifications

The e-textbook is connected with the publisher's resource system

The user can buy a space in it, but cannot insert parts of the e-textbook in his/her own resource system, and cannot communicate with the authors (no design-in-use).

Evolutive e-textbook

No possibilities for direct annotation of the e-textbook, but all the e-textbooks parts can be downloaded and modified.

The e-textbook, or parts of it, can be inserted in the user's resource system.

Possibility of direct contact between the user and the team of designers. Permanent design-in-use

Comparison in terms of micro-level connectivity
Theme: functions

Integrative e-textbook

Many connections between concepts: functions, variations, equations

Many connections between different representations: algebraic, table, graphic

Many connections with other subjects: economics, physics, biology

Reduced use of dynamic representations

No differenciation possibilities

Evolutive e-textbook

Many connections between concepts: functions, variations, equations

Many connections between different representations: algebraic, table, graphic

Many connections with dynamic representations

Reduced connections with other subjects

Possibility for the teacher to plan different exercises for different students (but no indication concerning the difficulty of the exercises).

ICT and evolutions of teachers' resources

Choppin, Carson, Borys, Cerosaletti & Gillis (2014): a study about digital curricula in the US. Results:

- few changes to the underlying opportunities for teaching and learning
- the use of multimedia in particular lacked interactivity

Coherent with our analyses of e-textbooks!

Recommendations for digital curricula designers:

- Communication features should be more extensively and more widely used within the programs;

- More embedded mechanisms for differentiated instruction should be offered

ICT and evolutions of teachers' resources

Concerning curriculum resources, two opposite models:

- Resources designed by experts, applied by the teachers with only local modifications;
- Teachers working collectively to design and share resources.

ICT evolutions reinforce the tension between these two models (an increased offer of ready-made resources / increased possibilities for teachers' collective work)

Conclusion and further questions

Concerning the consequences of the use of digital resources designed for the teaching of mathematics in terms of students' learning

Possibilities for the improvement of learning with software allowing investigation, offering feedback.

Further work needed about the links between mathematics and algorithmics (with or without computers).

For the teacher: a complex work of didactical analysis, design of lessons.

Conclusion and further questions

Investigating the consequences of the new possibilities for individual and collective design of resources in terms of teachers' work

Possibilities for the collective design of resources

Further research needed on the quality of a digital resource; how a teacher can choose a resource; which features support the appropriation of a resource by a teacher etc.

Thank you!

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