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Textbooks and numerical publishing: an instrumental point of view

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Introduction

Confronted with a growing digitization of contents and internet spreading, it is easy to imagine that textbooks will evolve. But it remains difficult to characterise and foresee such an evolution. Following the ecotone metaphor of Horsley (2001), we can make the hypothesis of an hybridation of book and numerical technology.

> 'Biologists use the term 'ecotone' to describe an area where two adjacent ecosystems overlap – for example where a forest gradually turns into grassland. The ecotone has an ecology of its own. It can support forms of life not found in either of the adjacent systems. Today, there exists the educational equivalent of an ecotone between traditional learning environments and the emergence of new learning environments designed around student centred interaction and the internet and technology based learning tools.' (Horsley, 2001, p.38)

Evolution factors are manifold, at least in France: growing decentralisation of education management, new economical models, repeated discourses towards new (old?) pedagogical philosophies (socio constructivism), extension of home schooling, re-definition of relationships between the school space and the private space... But such different trends do not provide a clear direction of movement.

Concerning electronic devices, first examples of electronic textbooks are far from being convincing. Nevertheless, we can predict transformations linked to a new instrumentation now available via technology offered by computer science.

As a researcher, I am interested by the complex relationship between textbooks and electronic resources and I try to find fruitful ways to approaching this question. I think we need on the one hand to get a good understanding of textbooks, their history and their current situation, and on the other hand, to know the possibilities of new technologies and the complex game they can play with textbooks.

In this text, my aim will be to analyze the influence of instrumentation upon classroom activities and upon teaching contents, notably due to modalities of exercises. I shall try to demonstrate the great influence of available instrumentation on school activities and therefore on textbooks. On the other hand, learning and teaching take place in institutions in charge of assessing the progress of students. So, evaluation plays a crucial role. In this respect, ICT currently has an influence on its evolution. So far, multiple choice questionnaires have been seldom used (in France). But such a modality of evaluation is so easy with ICT that it can become more commonplace (I am not sure it is good news for our school system).

To make it clear, a small detour through textbooks history is proposed. Then I shall describe some current trends linked to ICT and some communities (for example Wikipedia) and give some concluding remarks.

Instrumentation and textbooks: area notion through textbooks

The notion of area is interesting because area is a measurable size but linked to no effective measure, no direct reading via an appropriate instrument. Measuring an area requires some work, and some material and intellectual instruments. Which evolution of educative activities (situations) related to available and used instruments can be noticed?

Some historical landmarks

Exploring mathematical textbooks of XIXth century, measuring an area leads to a geometrical activity. You need to know classical formulas concerning specific plane figures (square, rectangle, triangle, trapeze and so on), and with more complicate figures, you have to draw lines to split the initial figure in simpler figures for which you know the formula to calculate the area. For example, the analogue of figure 1 can be found in every mathematical textbook at the end of the XIXth and the beginning of the XXth century.

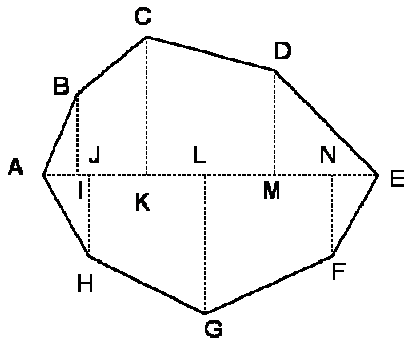


Figure 1. Area of a polygon. Cours moyen d'arithmétique,
A.-F. Patissier (1896), Arithmétique du CEP

The figure 2 can be found at the same period and relies on the same idea for area calculation.

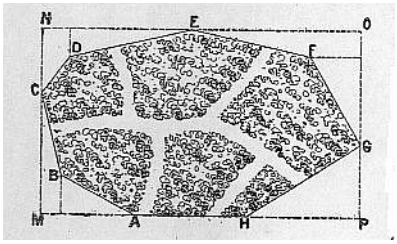


Figure 2. Find the area of the wood ABCDEFGH in which you cannot penetrate. M.P. Leyssene (1885)

Calculating an area has a direct application in agriculture and measuring fields seems to be dominant in the lesson part and exercise part of textbooks of this time. Methods and instruments are dependent of what you have to measure. Progressively, an evolution has occurred. In an elementary arithmetical textbook (Arithmétique, Leconte et Itard, 1938) a new method is proposed, called measuring areas by weighing.

> "Imagine that we cut up areas to be measured in perfectly regular cardboard and that we weigh these areas… This measuring process allows, in particular, evaluating areas of any shape. However, it is not a current process for measuring areas because it is not always convenient and cannot be practically used for measuring a room, a garden and so on…"

So a concrete activity that can be performed in classrooms is proposed, but the authors draw the reader's attention to the fact that this cannot be generalised.

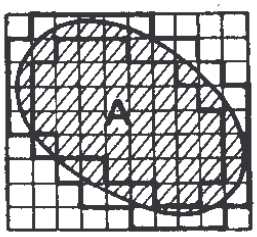


Figure 3. Introduction des quadrillages (exercice 333, page 129), Leconte et Itard (1938)

In the same textbook, an exercise (figure 3), gives a new way for measuring an area that will soon be adopted in most subsequent textbooks. One key evolution seems to be the use of graduated paper and square pattern. This new instrumentation will allow new kind of activities. Filling an area with small squares and then counting the number of squares to obtain the measure of the area. This approach will progressively be generalized in mathematical textbooks in the sixties.

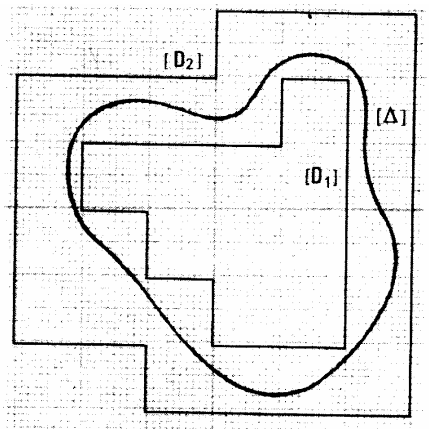


Figure 4. Mathématique sixième, Brédif Livre, 1969

A classical chapter of a textbook for grade six, in the seventies or eighties, includes considerations about square patterns, graduated paper. You have to know how to use a square pattern to surround the measure of an area. If manipulations (cut and drag part of figures) still exists in textbooks, they only intervene for the first discovery of the area notion, to give pupils an idea, but they are not used in the core of the text.

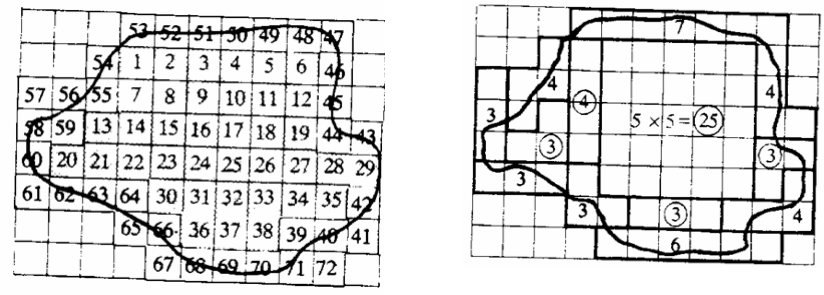


Figure 5. Faire des mathématiques, Cédic, 1981 (grade 6)

What has changed?

Several changes have occurred.

First, the activity nature is completely different and has moved from geometry (identifying standard geometrical figures, measuring length followed by calculation) to tiles counting.

Secondly, the kind of areas to considerer has also changed, switching from grounds, i.e. from big areas linked to agricultural activities, to small pictures printed in textbooks (the image in a book is not representing another object, like a field, but only itself).

If we take into account a constructive view of learning, what is learned relies on (situated) activities experienced by learners, and to be more precise, upon possible actions performed and upon what you can see. A notion cannot be seen independently of situations in which it has some significance. So, we can say that the notion of area itself has changed.

Of course, it is not only instruments that have changed, also the purpose of education, links to practical activities, even the theory of measure in the mathematical field and so on. For example, there is a greater focus upon learner activity: pupils can use graduated paper, be active and remain seated!

So school activities acquire a new status (objectives, instruments). Browsing through a list of mathematical textbook, we can observe the change of status of figure 1, corresponding to the problem of finding the area of a non-regular polygon. Such a polygon appears in the introduction, then clearly in the pages devoted to the knowledge to acquire and step by step is associated with some complementary knowledge and then disappears. It appears again in exercises (deepening exercises) in new textbooks reintroducing geometrical activities.

What can be observed in the evolution of the notion of area is that, progressively, the required technical skills diminish and the distance with real objects grows. Available instrumentation plays a key role in that change and in the evolution of the school notion of area.

Consequently, school situations have to be reinvented…without being under cover of mistakes. The calculation of the area of a circle is a good illustration of possible pedagogical regression.

Area of circle: from geometry to prestidigitation

A very classical way for calculating the circle area is to make a link with the area of regular polygons.

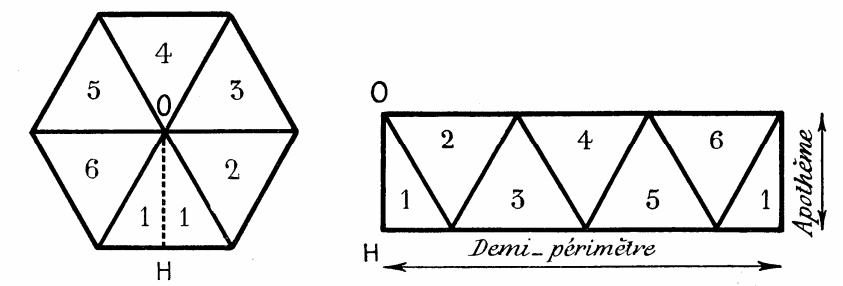


Figure 6. Area of a hexagon

With a hexagon, you jut cut it in several triangles and rearrange them to get a rectangle, whose area formula is known.

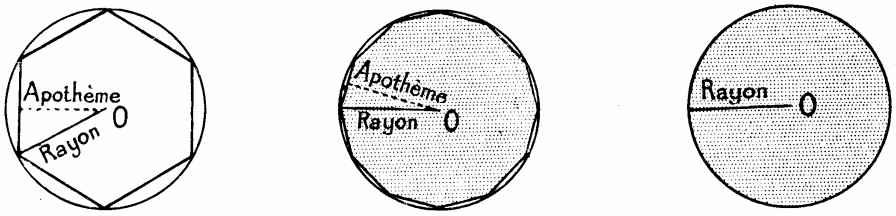


Figure 7. From the area of a regular polygon to the area of a circle

The formula for the circle is then straightforward: Area = semi-perimeter x radius

So a very simple activity and a picture showing that when a regular polygon has a lot of sides it fills nearly completely the circle, appear convincing. The approximation appears to be relevant; the formula to calculate the area of the polygon remains exactly the same.

Such an elegant and easy process is not possible with the new notion of computing an area by counting of a number of unit squares. The figure 8 and the quotation below show the rhetorical trick that has to be used to find the same formula.

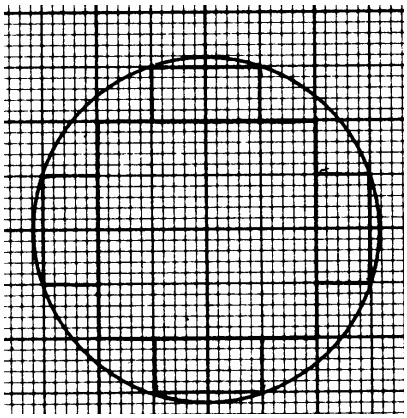


Figure 8. Mathématiques 6e, Bordas, 1977

> We notice that A (the area) is a bit superior to the triple of r^2. In reality, if we could have more precision, we should have found a number near 8.04, that is to say the product of Pi by 2.56.

It seems to be more prestidigitation than mathematics! It is difficult to believe than a pupil can understand and accept such manipulation. However, we can find such a process and an explanation in many textbooks, in France and in other countries.

What about information technology?

With information technology, new instruments can be considered. Then, of course, new examples and new activities will be given.

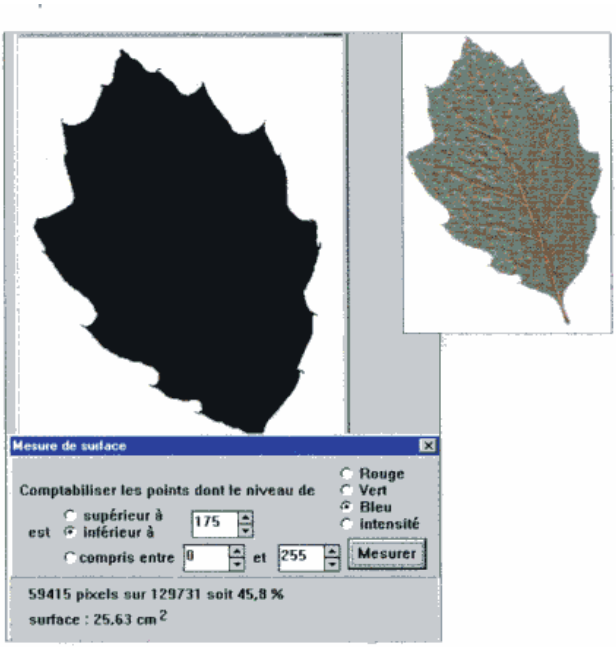
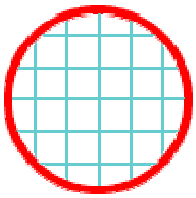


Figure 9. Outil de mesure de surface, Jean-François Madre, Dossiers de l'ingénierie éducative n°30

The example figure 9 shows that it is now possible to get an instrument directly giving the area of a surface (counting the number of pixel of an image). Of course, such tools and activities are designed for older students, but this illustrates the connection with images and the emergence of virtual tools operating on virtual objects giving *real* results.

Quick search on the Internet gives access to mathematical websites for beginners. Not a surprise, we can easily find similar examples about circle area.



> The area of a circle is the number of square units inside that circle. If each square in the circle to the left has an area of 1 cm^2, you could count the total number of squares to get the area of this circle. Thus, if there were a total of 28.26 squares, the area of this circle would be 28.26 cm^2 However, it is easier to use one of the following formulas…[1]

According to the new cut and paste culture, we find also an old manipulation:

> A circle's area is found using the formula: $A = \pi r^2$
> But where does this formula come from? Let's find out ...
> What we're going to do is break up a circle into little pieces, and then reassemble it into a shape that we know the area formula for ... the rectangle.[2]

Some interactive animations are also proposed giving the same manipulation[3], for example with the use of *JavaSketchpad*[4]

> Magical trick: change the size of a circle radius and area are given and calculate the ration A ÷ r2?

These examples illustrate the old idea of computers as meta-instruments (Kay, 1990), i.e. able to simulate any instrument. In that sense, computers can offer a range of activities far more extended than before, and even all the activities, … but with which coherence? To what extend each animation will be coherent with the notion of area introduced in classrooms? It is not clear that in interacting with different animations, underlying different views of the area notion, young students will construct a solid knowledge… or be completely lost.

To summarize what we have just discussed, we can observe long term evolutions (methods, knowledge and teaching contents) with some connection with available instruments, a process of schoolarization of instruments with sometimes unexpected effects (as for example the calculus of the circle area).

We derive one conclusion: Textbooks are instruments or meta-instruments, orienting the use of instruments in specific activities supposed to help student and textbooks cannot be analysed apart from their possible use. In the context of ICT and Internet spreading, what will change with textbooks?

Impact of ICT on Textbooks

According to several authors (see Bruillard, 2005 for a review), the textbook appears as a worn model? Tool of standardizsation in the past, it is now supposed to be a tool for every student in very heterogeneous classes, proposing appropriate paths for each one, helping teachers to organize effective school collective activities… Paper format seems to be unable to provide all these possibilities, requiring ICT for help.

Different forces push for an evolution of the model of textbooks. We can briefly quote:

- growing decentralisation of education management, giving new responsibilities to regional authorities
- new economical models,
- repeated discourses towards new (old?) pedagogical ways (socio constructivism)
- extension of home schooling,
- new definition of relationships between school space and private space...

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[1] http://www.mathgoodies.com/lessons/vol2/circle_area.html (retrieved 11 January 2007)
[2] http://www.worsleyschool.net/science/files/circle/area.html (retrieved 11 January 2007)
[3] http://www.wku.edu/~tom.richmond/Pir2.html (retrieved 11 January 2007)
[4] http://illuminations.nctm.org/ActivityDetail.aspx?ID=116 (retrieved 11 January 2007)

It is not possible to discuss all these issues in this paper. I will just raise one important issue. There are lots of discourses concerning the extraordinary potential of ICT for education and it is difficult to filter or select the more realistic ones. How to consider all these wonderful promises? What is sure is that instrumentation spreads out in a specific context. This context, and all the forces that constitutes this context, gives the significance of instrumentation. This question appears clear for example with digital portfolio (in the context of accountability for each institution, see Baron and Bruillard, 2003).

But which model? Concerning this question in taking into account school culture, we will try to make a balance between promises and current obstacles.

A first tendency is linked to learning objects and learning objects repositories (for example see Lornet project[5]) with world wide efforts towards normalization (control, management), interoperating computer programs and scenarios. It is important to notice that numerical resources can include educational scenarios (LOM, SCORM, IMS-LD…). A second tendency, with freeware inspiration, concerns the collective design of resources. We will just have a rough overview of these two new approaches and their possible impact in the design of a new model of textbook.

Personnalizable textbook

Some computer scientists and educational managers have a dream: a maximal individualisation thanks to a world-wide offer. Giving to each student the right resource at the right moment (just in time), dreaming of a sort of zero defect education. In computer science, a subject that can be considered exactly the same in each part of the planet, in which no particular culture or local features are involved, it is yet possible and effective to rely on standard resources. It works, but for computer science training (for example learning XML, it is easy to find a lot of good resources on the Internet).

But many problems remain for subjects who keep specificities and are not really part of the "global culture". Issues of culture, minorities and so on are at stake.

Some people imagine that learning can be reduced to simple access to resources, which can be described by norms (for example LOM) and can be rearranged dynamically to fit to one's person needs. But that view ignores the social aspect of learning and for the moment the collective organisation of teaching.

Furthermore, there are strong limits of Meccano-like models, even to biological metaphor (see Paquette & Rosca, 2002). It is well known, for example, in hypermedia research: to understand connected resources, some rhetorical aspects are required to help users to find some significance (Nanard, 1995).

Free (freeware) textbook

Another possible future can follow the free software example (Linux for example). Free documents raise an interesting issue and may be a good alternative from an economical point of view. But is it working in the same way? Producing collectively has certainly a learning effect for contributors. But to what extent consensus among many people can lead to the "best"? Are we sure that it will lead to really innovative resources and methods?

Analysing the Wikipedia phenomena can provide good hints.

Wikipedia case

Wikipedia is a multilingual, Web-based, free-content encyclopedia project[6]. It has more than six million articles in many languages. Wikipedia is an important phenomenon with a very spectacular and rather unexpected success. No one seems to have a whole understanding of this phenomenon, but some recent works and papers give many useful explanations (Denning *et al*., 2005; Meyer, 2006; Endrizzi, 2006; Rosensweig, 2006).

[5] http://www.lornet.org/

[6] http://en.wikipedia.org/wiki/Wikipedia (retrieved, January 20, 2007)

Contents can be produced with a good quality, comparable to renowned encyclopaedias (error rate, Giles, 2005), but two strong limitations can be found:

- A pedagogical reduction, in order to be better understood
- A dependence upon a consensus based upon evidence or facts (due to the so-called Neutrality principle).

This neutrality principle and the collective production of Wikipedia have been strongly criticized by some observers (as Lanier, 2006). Knowledge is certainly not an accumulation of facts and the lack of personal involvement, a possible convergence towards a kind of politically correct view, can be a major problem. For example, Rosensweig (2006) raises the issue of writing history without historians.

Which innovation can occur (apart the availability and many contributors shares), as it cannot be new (and the new parts are more like journalism), and no specific rhetoric to facilitate learning is really present.

Certainly this project provides easy access for a lot of people to many different facts, but is it sufficient? It is certainly a good resource to get factual information, a good start to get some hints about a new domain, some high quality resources, but a questionable resource for education.

One thing is important to underline with this new kind of collective design. As no authority validates its content, we have to find new ways to evaluate its quality. Within an article, one can have access to a record of the dynamical processes of elaboration, including the possibility of comparing two different versions of the same article. This functionality is useful to study the process (conflicts for example) and to have a clearer view of the contributions. Thus, Swartz (2006) has proved the great importance of anonymous authors for Wikipedia. To get better visualisations of the design process is a key point for assessing quality of an article. We can mention History flows (Viégas *et al*., 2004) as an interesting step in that direction (see figure 10, I will not explain this figure, somehow impressive).

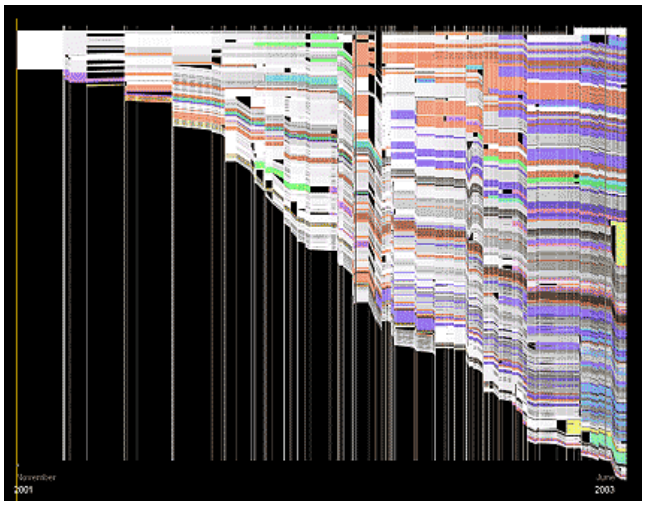

Figure 10. History of contribution of a Wikipedia article (Viégas *et al*., 2004).

To what extend Wikipedia collective design process gives new ideas for textbooks? A quick look to Sesamath will provide some interesting reflections.

Sesamath textbook

Sesamath[7] is a French association of teachers whose main goal is to freely provide, via the Internet, pedagogical resources and professional tools to be used for mathematical teaching and learning. Its work is inscribed in a public service approach and the association has a commitment to the free

[7] http://www.sesamath.net/

software movement. Sesamath has recently produced a mathematical textbook for 7th graders (see figure 11).

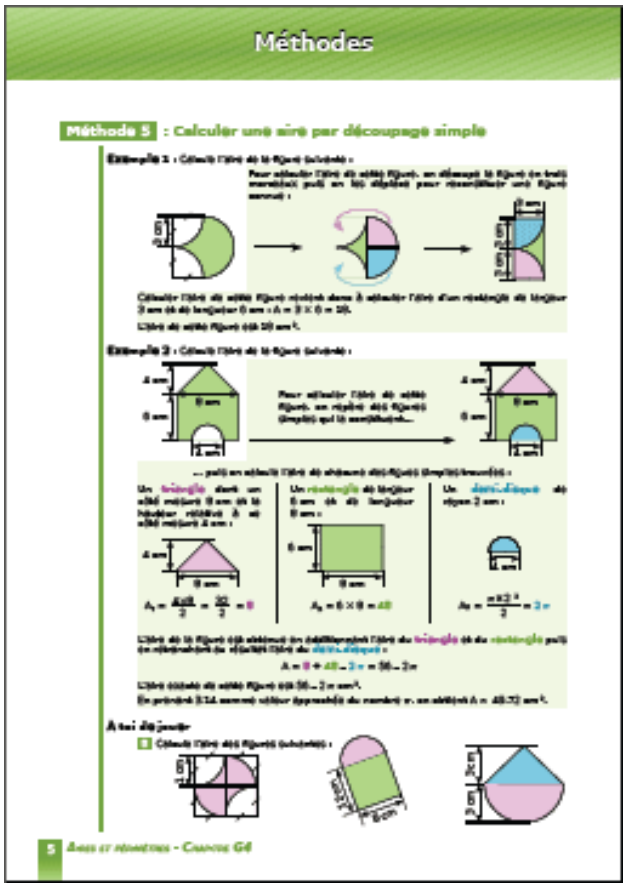

Figure 11. A page of the Sesamath textbook (area calculus)

> "*Sésamath 5e is a complete textbook, in accordance with new prescribed curricula for 7th graders, rather classical in its organization (in chapters, and in each chapter, in sections: methods, activities, exercises...) and in its editing quality (quality of the cover, of the setting and of the printing)*" designers' discourse

The page (figure 11) is obviously a textbook page and we can underline the fact that, even if the design process (collaboration of a community of mathematical teacher) and the economic model are quite new and unusual, the result looks quite classical. Even more, this classical feature is claimed by the authors. Is it due to the great resonance of a sort of textbook archetype? Is it the felt necessity of the Sesamath community to show that they can produce the same thing as private publishers?

Innovation is certainly not the goal, and, except recommended usage of computer instruments (and ICT tools provided by Sesamath), nothing is really new, and no link made to educational research. It is not surprising that the first new *free* textbook is a mathematical textbook, as this subject matter is very stable and has a unique reference. It is clearly a kind of *By the people to the people* product, as the PlanetMath encyclopaedia[8]. Such resources allow a reinforcement of control of the teachers, as explained many years ago by Cuban (1986). Is the quality really improved? Not sure.

Perspectives

Our initial question was connected to possible future for the textbook. We certainly have not answered this question, but we have discussed some recent trends.

[8] http://planetmath.org/?method=12h&from=collab&id=35&op=getobj

A first trend, characterized by educational resources normalisation (learning objects, LOM, IMS-LD…), leads to the end of the book model substituted by a growing offer of carefully described and inter operating resources. If it is currently happening in domains rather near computer science for an adult audience, i.e. for contents which are already the same all around the world, it will not be the case in the near future for more cultural contents. This fragmented approach (databases of learning objects) and then re-organization (scenarios) illustrates a tension between book and database, reinforced by competence based approaches and didactics blinds concerning instruments.

The free software movement has many supporters in education, but if it will facilitate acceptance of technologies, giving more control to teachers, it is not clear that theses approaches will lead to better textbooks (but theses movements are too young and we can expect many evolutions).

Another trend, which can be analysed via activity theory and relationships with instrumentation, associates paper and numerical supports, each of them providing specific instruments leading to transform pedagogical methods and even contents themselves, due to the importance of exercises given to students in school subjects (this has been verified in mathematics in the domain of area calculus). But the possible forms of hybridation (ecotone milieu), and evolution of instrumentation role are still difficult to foresee.

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