Distance training, a key mode to support teachers in the integration of ICT ? Towards collaborative conception of living pedagogical resources

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DISTANCE TRAINING, A KEY MODE TO SUPPORT TEACHERS IN THE INTEGRATION OF ICT?

Towards collaborative conception of living pedagogical resources

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Abstract: The integration of ICT into the teaching and learning of school subjects remains still rather weak, even in highschools. Changes in users' practices required by such integration have probably been underestimated: teachers are obliged to question and change their professional practices. It turns out that standard training sessions towards ICT have been found to be unsuited for supporting teachers in overcoming their difficulties with this integration. This document describes a specific distance, in-service training organization, as well as its implementation and difficulties encountered in the process. A structure of resources has emerged from this collaborative virtual workshop towards the conception of pedagogical resources. Such long-term organizations could turn into efficient supports for teachers using ICT in classrooms.

1. Towards integration of ICT

This paper is intended to focus on several aspects linked to the integration of ICT into the teaching and learning of mathematics. To focus on the problem of integrating technology into classroom practice requires theoretical and empirical research towards what can be an efficient use of technology: specifically this requires devising *situations* (Brousseau 1997), implementing them in classrooms and modifying them in order to be efficient and viable in these classrooms. It also requires conditions which would allow these situations to be *reproduced more widely* and training strategies which could favor the integration of ICT into teachers' practices. Both could be realized through a collaborative conception of living pedagogical resources in teachers'*communities of practice* (Wenger 1998), communities already existing or to be built.

In spite of many institutional actions and the enthusiasm of pioneering teachers, integration of ICT into teaching mathematics in secondary school is only slowly increasing in France, despite the rapid evolution of technological tools and equipment (Trouche, in Guin & al 2004). Similarly, a survey in Catalonia and France in 2003 (§4.4) gives evidence that more than 50% of mathematics' teachers *never use ICT* (including internet and calculators) *with students*. This situation, which seems to be worldwide and not specific to secondary school teaching (Jones & Lagrange 2003), recently incited researchers to find reasons for this lack of computers use.

A collaborative research project lead by 4 French research teams (Lagrange & al 2003) studied a comprehensive corpus of 662 published work: it was found that most papers were essentially focused on epistemological issues and on the learner.

Only 5% of studied papers were related to conditions of integration in every day practice, in terms of the *viability* of technology within schooling institutions. Consequently, few papers have taken into account the conditions of viability of ICT in classrooms and the influence of the teacher. As turns out, initially, most researches were focused on *potentialities* of tools in mathematics education and has often underestimated radical changes in users community practice (students, but also teachers) that this integration requires. Nevertheless, we have noticed a *progressive awareness* of the complexity of teaching with ICT, as more recent studies on teachers in real teaching, under traditional norms, closely related to our "French" approach (Kendal & Stacey 2001; Monaghan 2001).

Moreover, the diversity of theoretical frameworks and software technologies presented in thematic group 9 of CERME 3 allows us to question more deeply what is at stake in computer use. In order to tackle the complexity of technology use in classroom settings, our approach has attempted to combine several theoretical frameworks towards the *instrumental approach* (§2). Long-term analyses of students in classrooms have brought out the *complexity of activity* in computerized environments and consequently the difficulty for a teacher to overcome this complexity in classroom (§2).

Artigue (1998) pointed out other obstacles in ICT integration and that common training strategies in France do not help teachers to overcome. Standard training sessions towards ICT are rarely designed out of teachers' practices, and training strategies are essentially based on the transmission of « expert resources ». Moreover, its short period (about 3 days), isolated from school practice, does not allow a *continuous* support to be provided during the necessary adaptation of resources to each teacher's usage context. *Therefore, which type of resources and training organization would favor the integration of ICT?*

2. Towards instrumental approach

The main features of Rabardel's theory will be briefly evoked in this section because they are, in our opinion, crucial not only to tackle issues related to student's activity with artifacts, but they are also related to teacher training and conception of pedagogical resources with ICT. This theory lies within the field of cognitive ergonomics, which is linked to an ecological view of human activity with artifacts. Rabardel's theory is based on the *theory of activity* and the idea of *mediation* due to Vygotsky.

First, artifacts are necessary mediators in human activity and the activity mediated by instruments is always *situated* (Rabardel 2001; Trouche 2004). Second, there is a clear distinction between the technological *artifact* and the *instrument* that a human being is able to build out of this artifact. It goes through user's activity worked out in a given context and through a complex process, named the *instrumental genesis*. Consequently, an instrument consists, on the one hand, of a part of an artifact and, on the other hand, of schemes which are psychological structures organizing the subject's instrumented activity aiming to accomplish a given task.

Instruments are both *private* and *social* entities, as schemes are social because they have characteristics that are both shared and widespread in communities. Therefore, Rabardel considers designing instruments as an *activity distributed by designers and users*, evoking the idea of *conception in use.*

We analyzed students' activity with symbolic[1] calculators according to the meta study previously mentioned (Lagrange & al 2003). We brought out the necessity of a plurality of approaches: Rabardel's theory was combined by Artigue, Lagrange & Trouche (in Guin & al 2004) with other French didactical theories, especially, the *anthropological* approach of Chevallard (1999) and Vergnaud's theory (1996) on mathematical conceptualization. In the same way, Drijvers & Gravemeijer (in Guin & al 2004) argued for a relationship between instrumental approach and other theoretical perspectives on learning such as the *semiotic*, *symbolization* and *modeling* perspective.

These papers based on experiments in real classrooms show evidence of the *complexity* and *diversity* of instrumental geneses (complexity increasing with the complexity of artifacts). Moreover, Kendal, Stacey & Pierce (in Guin & al 2004) have pointed out the diversity of *teaching styles* with CAS, depending strongly on their conception of mathematics. They described the different methods of organizing the classroom and of devoting time to technology or mathematics. These papers also outline the *crucial role* of the teacher in dealing with scenarios aiming to build *coherent systems of instruments* from the diversity of students' instrumental geneses. Based on the evidence of these experiments, the success depends on *precise piloting* by the teacher beyond the careful choice of a didactical engineering. First scenarios designed by researchers required serious *reorganizations* to be viable even in experimental classes, with expert teachers. Consequently, the theoretical instrumental approach has been developed (Guin & Trouche 2002) to describe the place of didactic intervention: *instrumental orchestrations* defined by their *configurations (*i.e. specific arrangements of the artifactual environment), and *exploitation modes* of these configurations, aiming to reinforce the *social* dimension of instrumented action and to oriente the construction of *instruments' systems* (Trouche, in Guin & al 2004). Then, an instrumental orchestration must be designed for each situation, allowing a *didactical exploitation scenario* to be defined.

Although computing competencies are necessary for an instrumented practice, these theoretical researches point out that integrating ICT into classrooms requires other teachers' competences. *The implementation* of situations and scenarios by teachers for their own use in given classrooms is another unavoidable step which is far from being obvious. Consequently, the integration of ICT has created serious difficulties for teachers involving a profound *questioning* of professional practices and requires radical changes in teachers' practices. The question is, which training organizations could favor the transition to pedagogical action and the conception of

[1] Calculators capable of formal computation.

pedagogical resources that could be *reused* more widely in communities of teachers? According to Rabardel's theory, we will consider pedagogical resources as artefacts becoming *instruments* when integrated by teachers in their own practice. *Which type of pedagogical resources could facilitate their implementation in a given classroom, as well as their evolution within communities of practice?*

3. SFoDEM, a distance training organization

The integration of ICT calls for new mechanisms of professional development which provide *continuous* long-term support for teachers in their efforts of pedagogical action. In this way, an *evolving network* of teachers was introduced in the USA to develop *usage scenarios* for geometry software, even before the means fully existed (Allen 1996). The relevant idea of these usage scenarios (Vivet 1991) acknowledges the necessity of taking into account the pedagogical organization of a class and the role of the teacher. Such usage scenarios may be considered as a first approach of didactical exploitation scenarios (§2). For example, usage scenarios have been developed to produce teaching units integrating CABRI-Geometry (Laborde 1999) and including supporting notes for teachers to help *put* the unit *in practice*. Another training organization has been developed around units integrating usage scenarios and *accounts* of classroom exploitations of these units by teachers in training (Guin, Delgoulet & Salles 2000).

The latter approach has been extended to SFoDEM through employing a distance platform (SFoDEM is piloted by IREM[2] and supported by institutions at the regional scale and the Ministry of Education). In the region of Montpellier, teachers are rather old; therefore, implementing new methods of teaching is particularly difficult because they have practices that are deeply established. Moreover, they have very few experiences of collaborative work, whereas ICT integration requires an effective collaboration between teachers to overcome its complexity. The IREM of Montpellier had a base of pedagogical resources and a training network towards the use of ICT. However, the usual 3 days training courses organized proved to be inadequate to face ICT integration in standard classrooms. Insufficient attention has been payed to teachers'concerns on ICT use in their own environment.

Therefore, the main objective of SFoDEM was to provide a continuous support for teachers in the *conception, appropriation and experimentation* of pedagogical resources to get over the crucial transition to the pedagogical act. This requires a collaboration to be built between teachers with different teaching experiences aimed to support teachers' day-to-day practice. Various themes were chosen to find invariants in distance training viable beyond the organization and these studied themes. This type of training organization requires to deeply re-think the *structure* of pedagogical resources. Resources should be designed which can be adapted in various environments with different configurations, moreover in order to facilitate the search of resources, the appropriation of them by users, the *mutualisation* and *reuse*

[2] Institut of Research on Mathematics Teaching (http://www.univ-irem.fr/)

of resources through the possibility to adapt them. Finally, to facilitate the *implementation* in the class of various software tools such as Cabri, Géospace, Excel, DERIVE etc. and various organizations as overhead calculators; essentially, resources have to *evolve* enriched by the experience of users.

Five themes were implemented: transition from numerical to algebraic setting and ICT, graphic and symbolic calculators, experiments of teaching sequences towards dynamic geometric diagrams, simulation of random experiences and cooperative problem solving via internet. SFoDEM is piloted by a leadership team of three researchers and its platform is managed by an administrator. About 15 trainers are involved in the training network and every year since September 2000, about 100 teachers volunteer to participate in this projet. The *training comittee* manages the orchestration of the SFoDEM configuration (§ 2). It is composed of the leadership team, the administrator and the training network of trainers, whereas each trainer is involved in one specific theme. The training comittee manages the *coordination* of the five themes (Figure 1). First experiments on distance teaching have pointed out the necessity of compensating distance with an established structured and controlled organization and showed the crucial role of planning and *regulation*. The organization alternates face-to-face meetings and distance periods. That is, the trainers of each theme have a face-to-face meeting each week, the training comittee each month, and each theme (trainers and trainees) meets four times a year. Regulation is carried out at global level by the training comittee relying on a regular assessment with *barometers* based on questionnaires.

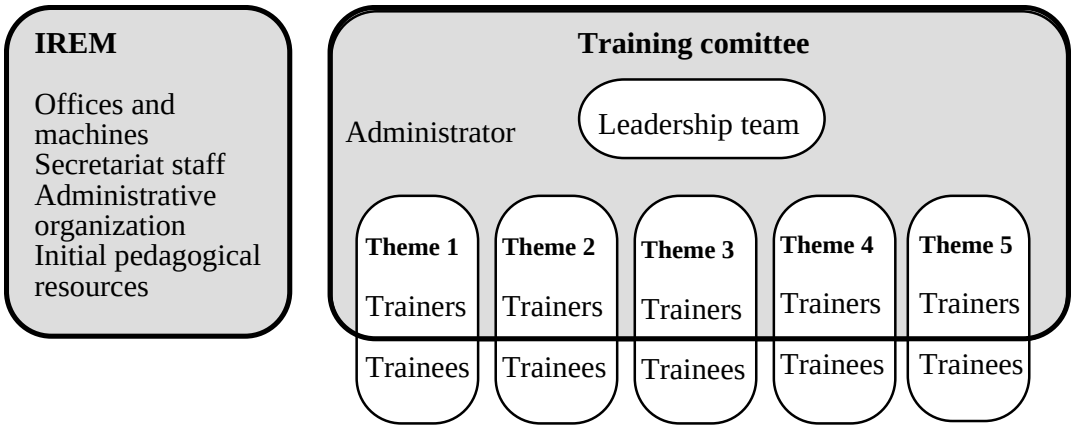

Figure 1 - Structure of SFoDEM

4. Implementation and evolution

4.1 First difficulties

First, this organization has rapidly revealed that schools equipment is frequently *inadequate* or *inaccessible*. Second, trainees were not adequately trained with the softwares involved, as required to participate in SFoDEM. But mainly, there was a *reluctance* to take an *active part* in exchanges within this controlled organization and a reluctance to fill barometers because evaluation is highly unusual in French teachers training context. Collaborative work is far from beeing spontaneous among

French teachers. Thus, the trainers are charged to find ways to create a confident atmosphere, an active participation of trainees, enhancing the value of their work and *elaborating a community of practice* within each theme. Moreover, customary working modes were also deeply questioned within the training comittee because usual trainers' strategies were essentially based on *imitation* strategies where trainees were asked to take the position of a student.

The first change was to *make explicit* rights and duties for all actors involved in the organization within *charts*. These charts are reference texts explaining in detail tasks and working modes of each community (trainers/trainees/leaders) and interacting modes with the others. Charts underline the fact that distance working modes require agreement with a strict schedule and the unavoidable act of writing down (and consequently, *making explicit) didactical choices* which usually remain tacit for teachers.

Moreover, initial resources provided by trainers, often expert resources, were too complex for an experimentation by trainees in their own class. Then, there was an evolution towards simpler resources, easier to implement and towards *virtual workshops* of trainees creating resources from initial ideas, named « germs of resources ». This evolution may be considered as an evolution from a top-down approach towards a bottom-up approach. A face-to-face final meeting on various themes was organized between trainers and trainees in order to share resources produced by trainees, and it showed the diversity of approaches for the integration of ICT. They really appreciated to have an overview on resources achieved in other themes. It was also the only way possible to *valorize* trainees' work and make it visible, because there is no institutional recognition for this type of work in France.

4.2 The model of resources

Distance working requires, on the one hand, to make explicit essential information of pedagogical type or technical-type which remains *tacit* when used in a face-to-face environment (for example, configuration of material and software tools). On the other hand, it requires us to write down the resources apart from a particular software tool, separating technological and pedagogical levels, student and teacher documents. The model of resources was elaborated within the training comittee from the available resources to adapt them for the needs of a distance organization. Moreover, this model was aimed to facilitate the evolution of resources after trainees' experimentations in their own class. Then, this model was afforded to trainees for rewriting resources to validate the model.

It is composed of *indissociable* elements which underpin the resource (Figure 2). An *identification sheet* describing the activity, its context in the syllabus, and the conditions of its implementation in the classroom (technical aspects and others). A *student sheet* describing the student's activity. A *teacher sheet*, with pedagogical objectives relating to the official syllabus and prerequisites, pointing out the pedagogical interest of ICT use for effective learning. A *technical sheet* facilitating the technical appropriation, describing software and configuration, directions for use

specific to this resource with links to *satellite files*. These files may include information, technical and mathematical knowledge shared with other resources (the idea was to « factorize » information as soon as possible); a usage scenario describing the task for each unit, its approximate length, tools and devices utilized and the teacher role in the management of this situation. Several scenarios may be described for the same activity, according to the diversity of teachers' behaviours using ICT as previously mentioned. These scenarios will be modified according to *experimentation reports* completed by trainees after experiencing the resource in their class.

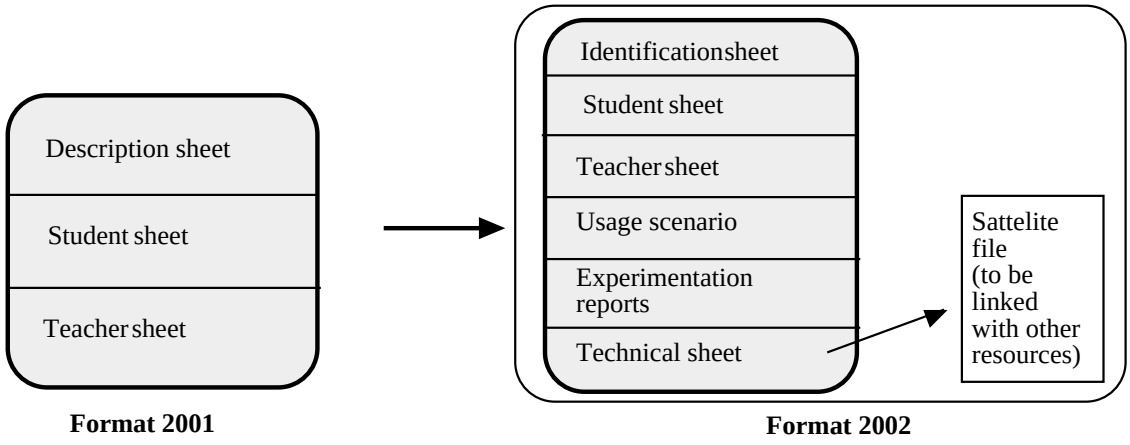

Figure 2 – The model of pedagogical resources

Thus, the designing process of resources is iterative, combining top-down (from a given model) and bottom-up (from users'experiences and experiments) approaches. The idea of *conception in use* (§ 2) is at the center of this process where resources are considered as instruments built by trainers and trainees in the SFoDEM communities of practice. In this perspective, a usage scenario may be considered as a *scenario in use*. Such scenarios may become *germs* for future didactical exploitation scenarios (§2).

4.3 Some results

The results of the *experimental phase* of SFoDEM are available in a CD-Rom (Guin, Joab & Trouche 2003) composed of examples with animated resources produced by trainers and trainees within each theme. This CD-Rom includes a presentation of assessment tools (essentially barometers, end of § 3), collected data, and trainers and trainees reactions to these experiences.

Through these barometers, the trainees were questioned about their interest in this distance training organization, their personal equipment, the facility for loading resources, their prior (before experimentation) analysis of these resources, and a posteriori analysis.

Mainly, it turns out from the analysis of these barometers that SFoDEM can be considered as a first answer to teachers' interests and needs (Figure 3): interest for ICT integration and need for a continuous support and a collaborative work.

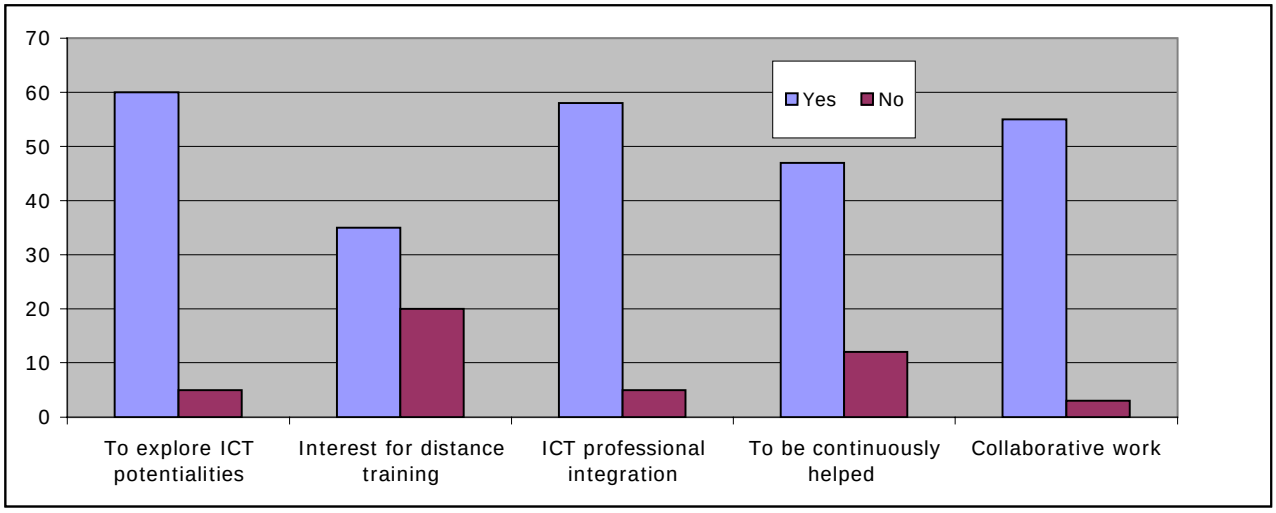

Figure 3 – Trainees's reasons (2001) for choosing SFoDEM (76 answers among 121 trainees)

Most teachers have easily loaded resources and they consider that the content of the provided resources is clear, complete and useful for the class. However, there are still many who do not dare to use these resources in the classroom.

Finally the analysis of the questionnaires essentially points out that the implementation of new working modes requires a deep individual involvement of trainers and trainees which cannot be expected in the short term. Furthermore, *working memory update* within each theme still remains at an embryonic state, despite the fact that it is essential for distance working. Nevertheless, the emergence of a common structure had positive effects on the evolution of resources (Figure 4).

The *operational phase* began in September 2002 to test the organization efficiency, modified according to the evaluation results: a *technical comittee* of two people was added in order to relieve trainers from technical problems and from the mediatization of resources, allowing them to focus mainly on didactical aspects of resources. Due to the progressive awareness of the *coordination* central role in this type of distance organization, another person was also added to coordinate the three themes retained for the operational phase. From collected data in this new phase, one may notice a significant improvement: less retirement, a more important trainees' involvement, a better management within each theme of the working memory. Usage scenarios play a central role for resources implementation in classrooms while including supporting notes to help teachers put the unit into practice. Separation between pedagogical and technical levels ensures the resource *more independence* as regard to the technical environment. Experimentation accounts are essential to have resources *evolve* among teachers' communities. This evokes the idea of *living pedagogical resources* (Figure 4). Nevertheless, compared to the deep involvement required from teachers, the *lack of institutional validation* and *certification* of ICT-based teaching skills remains the main obstacle to the success of this training organization.

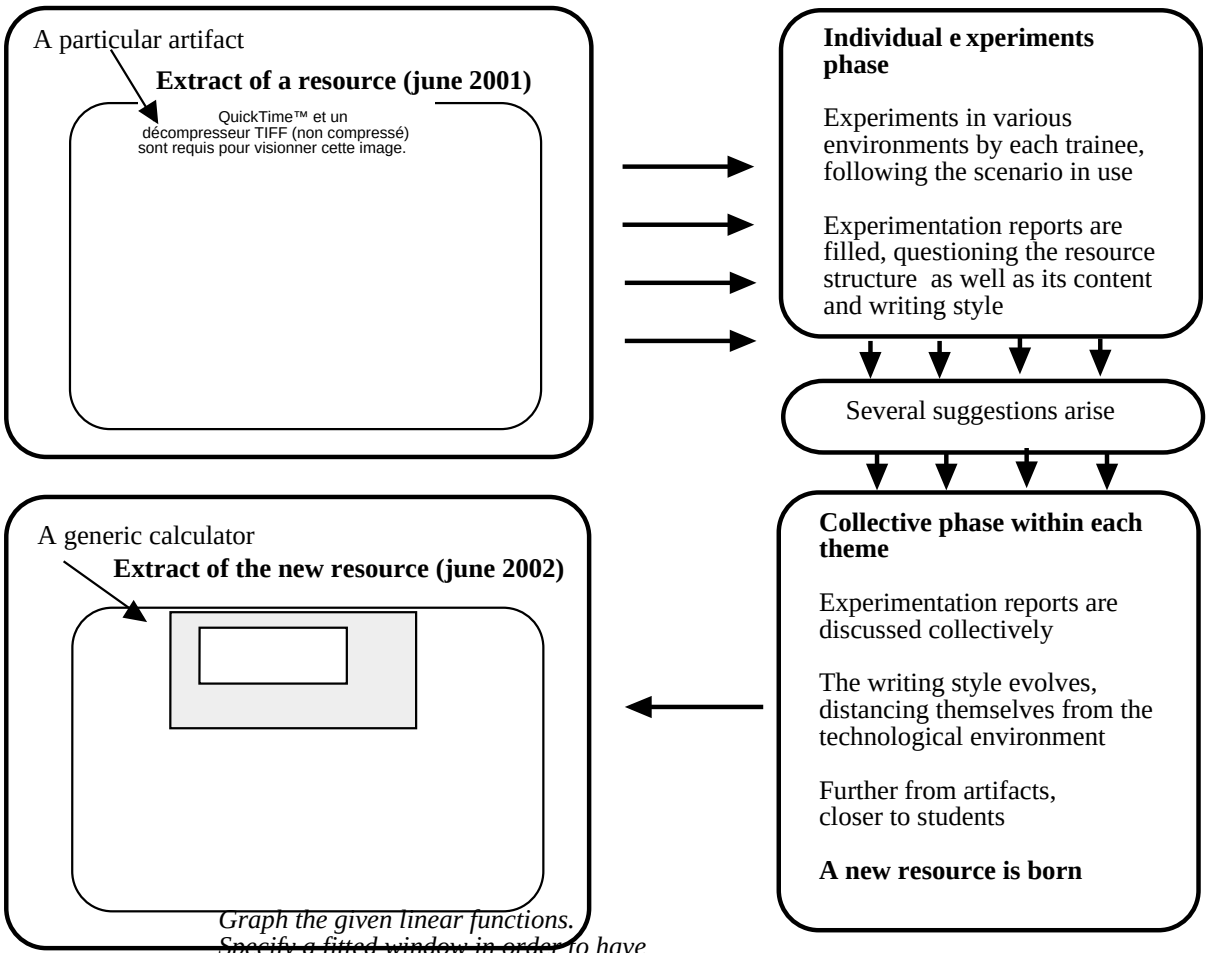

Figure 4 – Extracts from "birth and life processes" of a resource in a SFoDEM community

4.4 Other projects

In the same way, the specificity of the European project INTERREGIII lies on a *comparative study* of two European border regions (Catalonia in Spain and Languedoc in France). This study lies on a survey on mathematics teachers'needs towards ICT training in each region based on a common questionnaire (2003). This study has proved two main points: the first one is that all mathematics' teachers have a computer at home, but still more than 50% of them never use ICT (including internet and all types of calculators) in their own class. The second one is that 75% are interested in being involved in a distance training organization with *collaborative work*, even if it is completely new for them (http://www.uoc.edu/in3/transforma/fr). Therefore, two *pilot projects* were designed with a common outline, while still taking into account the specificities of each region. The French project began in June 2004. The main objective was to bring teachers to use ICT as a mode of distance communication through creating a *virtual class* involving teachers and students in open problem solving processes. A conference will close this project in December 2004. It will present and compare the Catalan and French experiments results and will pose a possible extension of this project to other countries.

Another project of the IREM of Montpellier, named AccESSIT (http://www.irem.univ-montp2.fr), is also devoted to mathematics teachers' support in ICT integration, but at the university level: two themes are implemented (computer algebra systems and statistics), which work separately until now. The computer algebra theme is beginning an experimentation of current resources at a large scale. A new theme (linked to the development of Géoplan and Géospace, two dynamic geometry systems) began in September 2004. The collaborative work for these three themes aims for a *common process* to conceive and experiment resources, eventually with the same resource structure.

5. Discussion

This paper describes some ways explored in professional development to help teachers who deal with technology-rich learning environments (theme 2 of WG9). All these experiments show the complexity of this task, but the *conception in use* approach gives some possibilities to overcome various difficulties, essentially because these are *not underestimated*. Starting from teachers' practices, designers of training organizations nedd to consider *configurations* that would favour a collaborative reflection:

- on affordances and constraints of available artifacts and on the designing of mathematical situations taking into account the educational context;

- on pedagogical resources characteristics required to *share* resources.

Each community will have its own response. These conditions are not easily met, but they are necessary to an environment where resources can be *alive* and where professional practices may evolve in the medium term. The usage scenarios, through the description of a precise piloting of a teacher, and experimentation reports are in *the very heart of the evolution process*.

Finally, the necessity of a real involvement from our community of practice (researchers in mathematics education and practicing teachers) in the e-learning current will be discussed.

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