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Published in "La matematica e la sua didattica", Anno 21, n. 1, 2007, Special Issue, pg. 67-74. Pitagora Editrice Bologna, Italy. ISSN 1120-9968

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Summary. *This contribution deals with the work of TELMA, a European Research Team of the Kaleidoscope Network of Excellence. In particular the 'cross-experimentation' project is presented. Such project was developed by TELMA to understand the role played by theoretical frameworks in setting up experiments using Interactive Learning Environments (ILE) for mathematics. The paper focuses on the methodological dimension of this project.*

Introduction

Kaleidoscope (www.noe-kaleidoscope.org)is an initiative founded by the European Community (IST–507838) which brings together key European teams with the aim of developing new concepts and methods for exploring the future of learning with digital technologies. Within this context a European Research Team (ERT), called TELMA (Technology Enhanced Learning in Mathematics), has been established to focus on the improvements and changes that technology can bring to teaching and learning activities in Mathematics. TELMA includes six European teams (among these, two French and two Italian teams) with a strong tradition in the field[1]. TELMA aims are to favour the integration among teams through construction of a shared scientific vision, the development of common projects and the building of complementariness and common priorities. At the beginning, integration was addressed analysing the

[1] Consiglio Nazionale delle Ricerche – Istituto Tecnologie Didattiche – Italy (CNR-ITD); Università di Siena – Dipartimento di Scienze Matematiche ed Informatiche – Italy (UNISI); University of Paris VII – France (DIDIREM); Grenoble University and CNRS – Leibniz Laboratory – France (MeTAH); University of London – Institute of Education – UK (UNILON); National Kapodistrian University of Athens – Educational Technology laboratory – Greece (ETL-NKUA).

work of each team according to a number of different focuses: theoretical frameworks of reference, designed and/or employed Interactive Learning Environments (ILE), research methodologies, projects carried out, etc.
In order to find similarities and to clarify differences, it was then necessary to define perspectives under which to look at the different researches. For this reason, it was decided to concentrate the analysis on three interrelated topics: the *theoretical frameworks* employed by the different teams to face research in learning mathematics with technology, the role assigned to *representations* provided by technological tools and the way in which teams plan, and analyse the *contexts* the technology is used in. As a step toward this analysis, a methodological construct has been elaborated: the notion of "didactical functionalities" (Cerulli & al., 2005) of ICT tools (including also ILEs). This notion individuates 3 main analysis concerns: a set of *features/characteristics of the tool* employed; an *educational goal* towards which the teaching and learning activity mediated by the tool is oriented; and the specific *modalities of employment* of the tool in the teaching and learning process aiming at reaching the outlined educational goal. This construct has been used to produce an integrated analysis of teams' past studies (See the Integrated Analysis of Teams' Approaches: www.itd.cnr.it/telma). However, to better understand the role played by theoretical frameworks, representations and contexts in teams' researches, it was decided to prepare a joint short-term project based on a cross-experimentation approach: each team would experiment, in real class settings, an ILE that was developed by one of the other teams. Here we report specifically on the work of the Italian and French teams within the TELMA cross-experiment.

The cross-experimentation

The idea of cross-experimentation is a new methodological approach to collaboration, seeking to facilitate common understanding across research teams with diverse practices and cultures and to progress towards integrated views of technology use in education. The key idea was the design and the implementation by each TELMA team of a teaching experiment making use of an ILE developed by another team.
This approach aimed at developing a deeper understanding of what happens when a research experiment, involving an ILE, is planned

under theoretical frameworks and in a context that are different from those of the team that developed the ILE. In particular, we wanted to make more visible the influence of theoretical frameworks through the comparison of the didactical functionalities developed by the designers of a tool and by the experimenting teams. In table 1, the specific ILEs experimented by the different TELMA teams are indicated.

ILE	**Developer's team**	**Experimenting team(s)**
Aplusix	MeTAH	CNR-ITD, UNISI
E-Slate	ETL-NKUA	UNILON
ARI-LAB 2	CNR-ITD	MeTAH, DIDIREM, ETL-NKUA

Table 1: The ILEs employed by TELMA teams in the cross-experimentation project

From a methodological perspective, the cross-experimentation was planned to compare each team's experimentation with respect to the use of a theoretical framework different from that within which the design of the ILE was rooted. In particular, the cross-experimentation aimed at:

- Understanding what it is implied when "tuning" the use of a ILE to the specific pedagogical aims and research objectives of a team that has not developed it.
- Understanding similarities and differences in the educational context set up by each team to experiment an ILE.
- Understanding/discovering implicit aspects embedded in the used ILEs.

In order to facilitate communication and comparison among teams, the experiments were planned according to a set of common constraints: short-term experiments carried out with 5^{th} to 8^{th} grade pupils, involving arithmetic problem solving, fractions or algebraic expressions.

The first phase of the cross-experimentation was dedicated to the joint construction, carried out through an on-line collaborative activity, of a common set of guidelines expressing questions to be answered and goals to be addressed by each experimenting team. This activity was planned to frame the process of cross-team communication and to support the a-priori and the a-posteriori analysis of the experiments. In the second phase of the project, the specific class experiments were planned and carried out by each team independently but according to the elaborated guidelines. The third phase was concerned with an analysis of the results of each experiment and with a reflection on the methodology employed.

Even if the analysis of the cross-experimentation and the discussion of similarities and differences among teams are currently under progress, some preliminary comparisons of team's results have been already made highlighting interesting issues and indicating directions for future investigations. In the following section we briefly outline some of these results focusing in particular on methodological aspects and findings.

Discussing some preliminary results

Researchers involved in the cross-experimentation project acknowledged the importance of referring to a common set of guidelines expressing research questions and issues to be addressed. It has been also pointed out the appropriateness of using a common methodological construct, that of "didactical functionalities", for analyzing the ILEs employed by each team. Such construct facilitated the comparison between what the experimenting team has perceived and what the team, which had developed the ILE under consideration, has affirmed.
Moreover, the request to communicate to the other teams the way in which each guidelines issue influenced the design, implementation, and analysis of the classroom experiments, forced each team to address each issue explicitly, leaving as less implicit choices as possible. This resulted in a very useful effort both in terms of refining teams' modality of investigation on the use of ILEs in maths education, and in terms of making the descriptions of each classroom experiments comparable with the others. In general, the cross-experimentation methodology has been considered useful as an help to make explicit the relationship between theoretical assumptions made by a research team and the set up of the experimental investigations. In the following some examples are provided to illustrate these aspects. In particular we focus on the comparison between the Italian and the French teams.

Making the implicit explicit

Nowadays most of the approaches to technology enhanced learning in mathematics acknowledge the necessity of focusing not only on the specific characteristics of the technology employed but of adopting a more integrated perspective where importance is assigned to aspects such as, for example, theoretical and epistemological choices, contexts of use, social interactions, educational strategies, role assigned to the teachers (Bottino, 2004). This is true also for the approaches adopted by

TELMA research teams. Nevertheless, the teams do not address the above-mentioned aspects in the same way, and the cross-experiment revealed differences in goals and focuses of attention. The observed differences depend on cultural backgrounds, on the adopted theoretical frameworks, and on different ways of approaching and conceiving research in maths education. In other words, there is a set of assumptions which often remain hidden, and which are made explicit only at a reflective theoretical level. The TELMA cross-experimentation approach required researchers to put in practice their views, but also to compare their own approach with that of the other teams. In this way, differences among the teams could be made explicit, increasing teams' awareness of their priorities and assumptions. For instance, in the experiment carried out by the DIDIREM team (France), main reference was made to the Theory of Didactic Situations (Brousseau, 1997) and to the anthropological approach (Chevallard 1992). As a result, in the pedagogical design of the experiment, priority was given on the one hand, to the characteristics of the 'a-didactic milieu'[2] and, on the other hand, to institutional values and constraints. The pedagogical design was asked to maximize the cognitive potential offered by the milieu, seen as an antagonist system with respect to the student. This made the researchers especially sensitive to the feedback offered by the ILE used. The design was also asked to be manageable in an ordinary classroom. This made the researchers especially sensitive to the distance with the usual institutional context, and to the necessity to keep this distance manageable by the teacher. Other aspects, even if considered interesting, were less emphasized (e.g., collaborative work among students, teacher's role). On the contrary, the CNR-ITD team (Italy), mainly referring to socio-constructivism and Activity Theory (Cole & Engestrom, 1991; Engestrom, 1991; Vygotsky, 1978) assigned a priority to social construction of knowledge and to the role of the teacher. Therefore, the experiment carried out by this team was mainly focused at investigating these issues while less attention was paid to other aspects (e.g. the detailed organization of the milieu within which learning is expected). Many choices (e.g. tasks to be faced during the classroom activities and explicit orchestration of the work) were not detailed by the

[2] In the Theory of Didactics Situations, a situation is modeled as a game and the "milieu" was initially defined as the system opposing the student in this game.

experimenting team, as done by the French ones, but left to the teachers while carrying out the classroom activities.

Clarifying the relationship between theoretical assumptions and experimental choices

In the above-mentioned example, the CNR-ITD team set up its classroom experiment giving priority to the role of the teacher in the social construction of knowledge (consistently with the socio-constructivist approach and Vygotskyan theories).
Setting up the actual classroom experiment, the ITD researchers faced the necessity of finding a way to precise, in practice, the role that the teacher had to assume, since the theoretical frameworks of reference gave only some general indications but did not provide a method to define it. In general, a theoretical framework can influence an experiment at a global level, but when going into details, there are issues that need to be directly addressed by the researchers. In other words, there is a sort of gap between what it is offered by a theoretical framework, and what it is needed by the researchers when planning a classroom experiment. Such gap is determined by the steps (often implicit) that a research team has to undertake to move from theoretical reflections to experimental practice. The cross-experimentation helped TELMA teams to articulate some of these implicit steps by means of a comparison among the different experiments. A team referring to a given framework may view the work of another team under a different perspective, helping the individuation of gaps between a theoretical position and the experimental practice. In this sense, we report the case of the DIDIREM team which is particularly familiar with addressing the roles played in learning processes by "ruptures" and "obstacles", as they are key elements of the theory of didactic situation which this team refers to. During the cross experimentation, the DIDIREM team observed how the Siena team assumed Vygotsky's framework (Vygotsky, 1978) which describes the importance of "ruptures" and "obstacles" but which does not provide explicit methodological tools for putting these ideas in practice; nevertheless, as observed by the DIDIREM team, the Siena team successfully set up an experiment where "ruptures" and "obstacles" were exploited as means for achieving a specific educational goal. The DIDIREM team expressed the will to understand how the Siena team put in practice such a principle, which

started a discussion to clarify (at least partially) the gap between the Siena team's theoretical assumptions and how they put them into practice (which is certainly an original part of the team's work).

Adapting tools to new cultural and institutional contexts

One of the issue addressed by the TELMA cross experimentation, is the way in which the teams addressed the task of adapting an ILE to a context different from that for which such tool was designed. With this respect let us cite the two French experiments involving the use of ARI-LAB2 an ILE for arithmetic problem solving and for introducing algebra (Bottino & Chiappini, 2002) developed by the CNR-ITD[3]. One of the microworlds which ARI-LAB2 is composed of is the "Fraction" microworld. Such microworld provides a graphical representation of fractions on a line: representations of constructions of (and operation between) fractions are based on Thales theorem. Because Thales theorem is usually introduced in the French curriculum later than fractions, French teams met difficulties in using this microworld in their school context. In fact, on the one hand the MeTAH team tried to use it as a "black box" but found this caused problems when pupils needed to make sense of feedback. On the other hand, foreseeing this difficulties the DIDIREM team decided not to use that microworld at all. On the contrary from ITD perspective this curricular issue was in a sense a minor concern: the teacher was assumed to be able (and in charge) to manage also situations where not everything is explicitly explained, freely exploiting pupils' relationship with the ILEs and their feedbacks.

These different theoretical positions, supporting the design of the tool and of the experiment, were made explicit during the TELMA cross experiment, by means of comparisons of teams' experiments and answers to the guidelines questions. As a consequence, after the first analysis and comparison of classroom experiments, the DIDIREM team hypothesised more clearly that even within their scholastic context it could be possible to experiment ARI-LAB2, but under certain conditions, such as switching to long term experiments instead of short term ones.

In conclusion, the cross experimentation, centred on the comparison

[3] There are many cultural and institutional differences between Italian and French School (e.g. different curricular constraints and school praxis) and research approaches

between developing and experimenting teams helped making explicit each team's assumptions and led to two main results. On the one hand, the assumptions lying behind the design of the tool were made clearer, and, on the other hand, the developers were provided with new ways of employing their tool.

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