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► To cite this version:

Stéphanie Jean, Pierre Jacoboni, Elisabeth Delozanne, Brigitte Grugeon, Martial Vivet. Design, implementation and evaluation of an interface in a Computer Based Learning Environments: the example of PÉPITE. AIED 97, 1997, Kobe, Japan. pp.598-600. hal-01437186

HAL Id: hal-01437186

<https://hal.science/hal-01437186>

Submitted on 17 Jan 2017

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Design, implementation and evaluation of an interface in a Computer Based Learning Environment : the example of PÉPITE.

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Abstract: The work presented here is part of a multidisciplinary project, called the PÉPITE project. Its aim is to set up a system to build student cognitive profiles to evaluate their competences in elementary algebra. We consider here the problems linked to using didactic know-how related to pencil & paper tasks and in particular how to transfer these tasks to a data processing system.

1. Introduction

Studies in relation with Human-Computer Interaction draw attention to the fact that the user of a technical device faces a double problem : first, transferring his knowledge of the task and second, learning how to use the system. In Computer Based Learning Environments, these meaning transfer problems for the students are called by the didacticians *computational transposition*: technical and physical limitations interfere with the student's knowledge both at the representation level and at the action level. These limitations thus modify the perception of the effects of the actions.

First we describe the basis of the project : the didactical analysis and the pencil & paper diagnosis tools. After, we present the general architecture of the PÉPITE project.

2. The basis of the PÉPITE project

This project involves in computer science, Martial Vivet, Élisabeth Delozanne, Pierre Jacoboni and Stéphanie Jean from the LIUM (Laboratoire d'Informatique de l'Université du Maine) and, in didactics of mathematics, Michèle Artigue and Brigitte Grugeon from the DIDIREM laboratory of Paris VII. The aim of the PÉPITE project is to build a computerised environment able to *modelise* the reasoning process of the students of French secondary schools (the year before the GCSE) in elementary algebra. The LINGOT project which will follow the PÉPITE project will use this *modélisation* to give the students appropriate learning situations likely to help the evolution of their knowledge. The idea is to seek out, in the student's way of functioning, the « grains » of knowledge (in French, the « pépites ») to use as a basis to build some new knowledge.

The general problem of automatic diagnosis in an ITS [1] is to infer the information of the learner's model from what is noticed of his behaviour, which means making an analysis and an interpretation of the data collected during the interaction. In the PÉPITE project, we base our work on a rigorous didactic and cognitive study which has been validated academically, institutionally and experimentally [2].

2.1. The didactical analysis

This research in the didactics of mathematics starts from the hypothesis of knowledge building: The students have built up pieces of knowledge sometimes different from the reference knowledge. Consequently, the productions of the students present coherences and regularities which correspond to their personal knowledge. One of the results of this study is a tool enabling us to interpret the students' productions in order to find the starting point to modify their knowledge. This tool combines a series of pencil & paper tasks with a multidimensional analysis grid allowing us to interpret the student's production to establish their profile in elementary algebra.

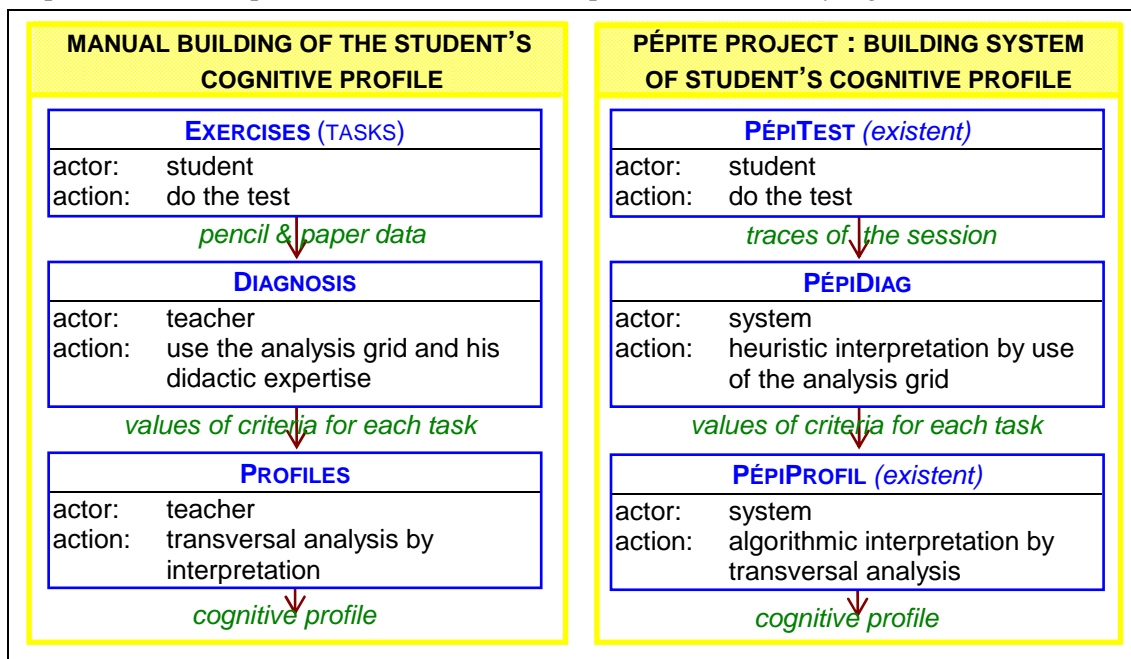


Figure 1 : The pencil & paper diagnosis tool.

Figure 2: Architecture of the PÉPITE project.

The pencil & paper tasks

Three types of pencil & paper tasks are proposed to the students during a test :

- *technical exercises* to determine numeric calculating and formal manipulating procedure,
- *recognition exercises* to determine how students identify and interpret algebraic expressions in the algebraic writings frame or linked with other semiotic frames,
- *modelling exercises* to identify which algebraic type of treatment is used, how they translate problems in the algebraic frame and how they use the tools adapted to solve the problems.

The students' answers to the exercises are, in this didactical work, analysed *by hand* by the teacher with the multidimensional analysis grid.

The multidimensional analyse grid

This grid is made of six components: arithmetic / algebra relationship, operability of formal manipulation of algebraic expressions, interpretation of semiotic representations in relation to algebra, production of semiotic representations in relation to algebra, role of algebra and rationality in algebra.

A set of criteria is associated to each of these analysis components. During the correction of the tests, for each answer given by the student the teachers award global values defined by the different criteria of the analysis grid. Certain global values are specified by local values linked to the exercise.

The student's profiles

Applying the analysis grid to the productions of a pupil on the pencil & paper tasks produces for each pupil a set of values for each task. This very fine description of the behaviour is too

detailed to be used *as it is* by the teachers (or by a computer). A transversal analysis of the grid's results enables one to establish a higher level description : the *cognitive profiles* of the students. These profiles can be used to understand and to modify the student's functioning.

These profiles have three levels of description:

- a quantitative description of algebraic competence in terms of *success rates*,
- a qualitative description of functioning coherences, in terms of *functioning modalities*,
- a description of flexibility between frames, represented by a *diagram*.

This diagnosis tool (Cf. figure 1) based on pencil & paper tasks has been tested several times. It has in particular been tested in June 1996 on 600 students of a third form class (14 years old). The students' test papers coming from this experiment have been used as a corpora for the conception of the students test software of the PÉPITE project.

2.2. The diagnosis in PÉPITE

The PÉPITE project aims to automate the pencil & paper diagnosis tool. The architecture of PÉPITE contains three modules (Cf. figure 2) :

- PÉPITEST which gives the students an adaptation of the pencil & paper tasks to the computer and which collects their answers. The difficulty resides more precisely in the transfer of the pencil & paper tasks to the computer platform.

This software has been completed, it was tested for the first time in October 1996. The first results show that the data collected with PÉPITEST are equivalent to those collected with the pencil & paper test. The most interesting result is undoubtedly that the didactician was able to apply the analysis grid and obtain cognitive profiles confirmed by the class teacher.

- PÉPIDIAG which interprets and codes the students' productions, from the data furnished by PÉPITEST according to the multidimensional analysis grid, while awarding values to criteria tested by the exercise.

- PÉPIPROFIL which, from the preceding code, establishes the students' profiles and presents them to the users (teachers or researchers). This last module has been developed.

3. Conclusion

In comparison with a learning environment, we are interested in the previous knowledge of the student, and not the knowledge built by the student during the interaction with the software.

We have presented the software PÉPITEST which collects data to diagnose the capacities of students in algebra. PÉPITEST has been completed and successfully underwent the test of experimentation in class. This concludes the first prototypage cycle for the iterative conception process. In our conception method, we laid great importance on defining the evaluation criteria of PÉPITEST which means specifying the equivalence between the data determined from the pencil & paper tasks and those of PÉPITEST. The first results presented here and in particular the achievement of a corpus from PÉPITEST tasks, make it possible to envisage the didactic study necessary for the conception of PÉPITE's module of diagnosis. Only this second phase will allow us through case-studies and a statistic study, to validate the automatic diagnosis by comparing it to the manual diagnosis established from the pencil & paper corpus.

4. References

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