

LINGOT Project: Monitoring the Learning of Algebra according to Students' Cognitive Profiles

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Research objectives

➤ **To model**

- ◆ Algebraic tasks
- ◆ Algebraic competence at a specific school level
- ◆ Students' personal competence
- ◆ Stereotypes of algebraic competence

➤ **To design software that supports teachers' activity**

- ◆ when monitoring learning in a classroom context
- ◆ taking into account the cognitive diversity of their students

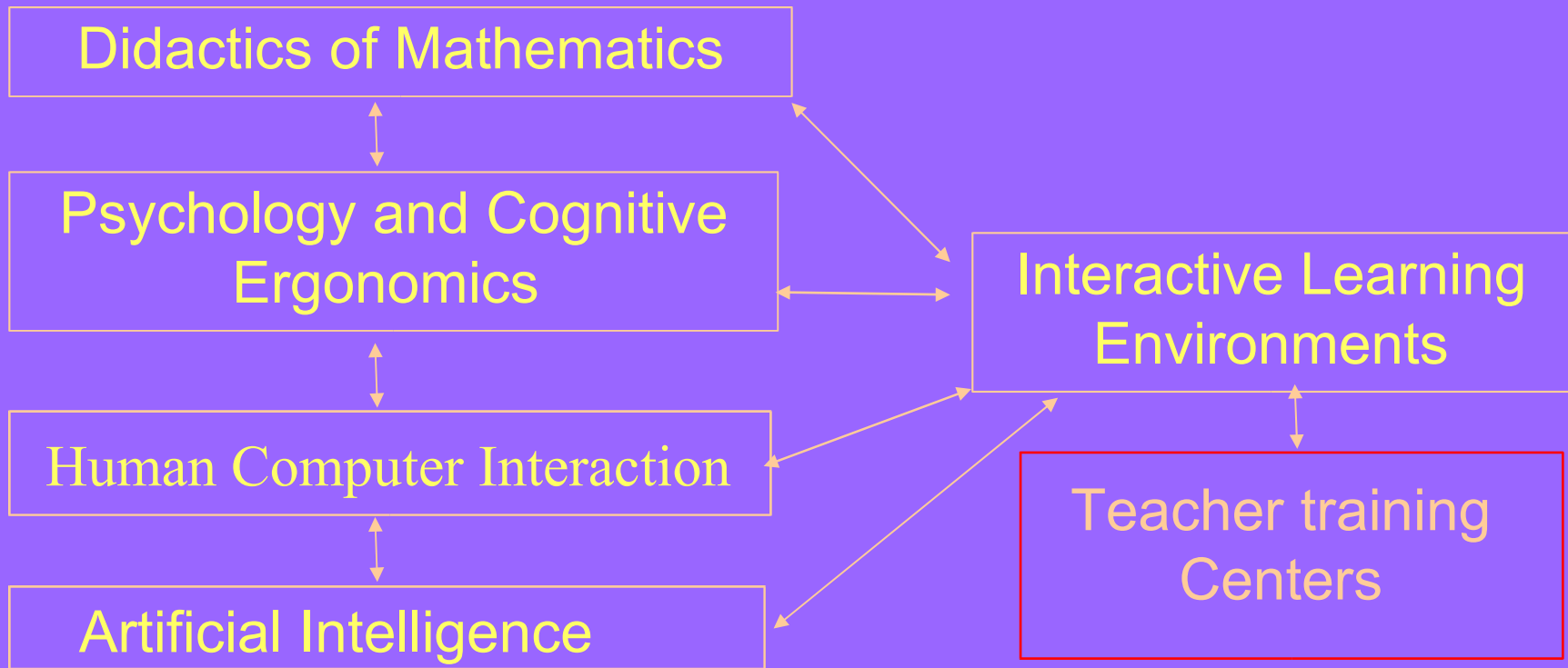
➤ **Related work**

- ◆ Koedinger et al (Algebra Tutor), Nicaud et al (Aplusix)
- ◆ Stacey et al (Decimals), Melis & al (LeActiveMath), Graesser & al (Andes)

Methodology

- **Design and implementation linking 3 topics**
 - ◆ Diagnosis (Pépité project)
 - ◆ Learning activities
 - ◆ Teachers' activity (Rabardel, Rogalski)
- **Linking design and experimentation**
 - ◆ Starting from didactical analysis
 - ◆ Building scenarios and prototypes in an iterative design approach
 - ◆ Experimenting with teachers and students from the very beginning of the design stage

Multidisciplinary project



CRIP5 (Paris 5), LIUM (U. Maine), DIDIREM (U. Paris 7),
Laboratoire C&AF (U. Paris 8-CNRS), Equipe STICE
(IUFM Créteil), IUFM d'Amiens, Equipe SASO (U. Amiens)

Overview

- **Lingot project**
- **Studies on teachers' diagnosis activity**
- **Different models of students' competencies in algebra to design software**
 - ◆ Automatic diagnostic
 - ▶ Pépite software
 - ◆ (Partial-automatic) monitoring of learning activities
 - ▶ Cime software, Aile software
- **Conclusion**

History

- **1995 (Grugeon)**
 - ◆ A model of algebraic competence for students at the end of the compulsory education (15-16)
 - ◆ Students' answers to a set of well-chosen problems show not only errors but coherences in their reasoning
 - ◆ A paper and pencil tool was developed to determine individual students' cognitive profiles
- **2000 (Jean)**
 - ◆ Automated (at least partially) this diagnostic paper and pencil tool
 - ◆ A first prototype : Pepite (<http://pepите.univ-lemans.fr>)
- **2000-2004 (Delozanne & al 2002, Rogalski & al 2004)**
 - ◆ Experiments with teachers and teachers trainers
 - ◆ Observations (classroom, training sessions), workshops, interviews
- **2002-2004 (Grugeon, Coulange & al 2003)**
 - ◆ Stereotypes
 - ◆ Families of parameterized learning situations

Pépité software

End-users:

Students

PÉPI TEST

PépiTest

Fichier Edition Outils Aide

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

ABC est un triangle rectangle en B.
BDEF est un rectangle.
AB = 10 , CD = 1 , BF = 2 , BC = x .

1ère partie 2ème partie 3ème partie

Exprimez l'aire du triangle ABC en fonction de x .

Calculs

```
aire(ABC)=(h * B) / 2
=(AB * x) / 2
=10 * x / 2
=5x
```

Résultat

Aire du triangle ABC : 5x

Teachers
Students ?

PÉPI DIAG

Grille de diagnostic:

Atteindre la source Fermer

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
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PÉPI PROF

PépiProf & PépiDiag - Florence A - D:\STEPH\PROG\PROD98\NP96_A08.PEP

Eleve Codage Définitions Options Quitter

Profil résumé Taux de réussite Modalités de fonctionnement Diagramme d'articulation

Taux de réussite global 67 %

Traitement : 53 questions

Catégorie	Pourcentage
Absence de réponse	38%
Traitement correct	36%
Traitement partiel / non attendu	6%
Traitement incorrect	21%

Exercices techniques
Exercices mettant en oeuvre l'application de procédures algébriques ou numériques enseignées (standards). **50 %** Effectuer des calculs numériques

Exercices de mathématisation
Exercices mettant en oeuvre la modélisation, la mise en équation, la recherche d'une propriété, la traduction algébrique. **50 %**

Exercices de reconnaissance
Exercices mettant en oeuvre la reconnaissance d'un objet dans deux registres ou dans un même registre. **81 %** Interpréter des expressions algébriques
Manipuler formellement des expressions (niveau 2)
Interpréter des écritures numériques

Remarque : Certains exercices appartiennent à plusieurs catégories.

Coding of the data

Coding correction

Transversal analysis

Students' profiles in Pépité

3 descriptions :

➤ **Quantitative**

◆ **Success rates on mastered skills**

➤ **Qualitative**

◆ **Meaning of letters, processing algebraic expressions, translation between representations, type of justification**

➤ **Flexibility when translating between representations**

Teachers' diagnostic activity

➤ **Diagnosis**

- ◆ Focused on the class or a group of students rather than individual students
- ◆ Often expressed in categories of students
 - ▶ Global achievement : Good & quick, average & quick, average & slow, students with many difficulties
 - ▶ Well-known errors
- ◆ Closely linked with action
 - ▶ Especially : experienced teachers

➤ **Pépite : interesting but too demanding**

- ◆ Difficulty of computer access, too much time required to administer the test, not enough support for teachers to capitalize on the results of the diagnosis

Using Pépite : What teachers asked for ?

- Remediation proposals according to profiles
- A “cognitive geography” for the whole class
- Feedback for the students
- Possibility to modify the test, to adapt it
- Printing facilities for paper and pencil work
- An editor for algebraic expressions
- Training in using the model of competence and algebra teaching



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Monitoring learning activities for the whole class

- ▶ **Problem: an articulation between**
 - ◆ Cater for individual students
 - ◆ Whole class management
- ▶ **Objective: Grouping of students**
 - ◆ Based on an accurate didactical analysis of the algebraic competence
 - ◆ Supported by technology
- ▶ **How to do it?**
 - ◆ Stereotypes of students' profiles
 - ◆ Families of parameterized learning situations

Stereotypes

➤ Objective

- ◆ Conceptual tool to articulate personalization and whole class management

➤ Definition

- ◆ Stereotype = a class of personal students' cognitive profiles

➤ How are they used in the project?

- ◆ To present a single student's diagnosis:

- ▶ The stereotype it belongs to
- ▶ The personal student's features

- ◆ To propose adapted learning situations

- ▶ Stereotypes:

- teachers choose learning activities to work on by priority

- ▶ Student's personal features:

- software tunes parameters in activities

Stereotype & Personal features

Usage of Algebra Level 3	Few Uses of Algebra Some algebraic justifications	<i>Success rate</i> (Modelling exercises) : 7 % Algebraic justifications, explanations in natural language, by giving examples
Translation Level 3	Low ability in translating between algebraic and other representations Few reformulations	<i>Success rate</i> (Recognition exercises) : 25% <i>Weakness</i> Uses of symbolic writing to abbreviate <i>Levers</i> : Some links : (algebraic \leftrightarrow geometric) and (algebraic \rightarrow natural language)
Algebraic calculus Level 3	Low ability in algebraic calculus Use of incorrect rules to form or to transform expressions	<i>Success rate</i> (Technical exercises) : 24% <i>Weakness</i> Incorrect rules : gathering : $3 + a \rightarrow 3 a$; parenthesis : $3 a^2 = (3a)^2$; wrong-linearity : $a^2 a^3 = a^6$ <i>Lever</i> : Some interpretations of algebraic expressions

Parameterized Learning Situations

- ▶ **Defined by**
 - ◆ Learning objective
 - ◆ Task
 - ◆ Parameters
- ▶ **A set of given parameters values**
 - ◆ To generate numerous exercises
 - ◆ To adapt to a given stereotype

Interactively fill up equations and word problem (CIME)

- Statement : There are _____ marbles in Mary's bag than in Peter's one. Yet Mary has _____ marbles than Peter.
How many marbles has each child ?

Énoncé

Il y a de billes dans le sac de Marie que dans celui de Pierre.
Or Marie en a que Pierre.
Combien chaque enfant a-t-il de billes ?

Équations

$$\begin{cases} x = 4y \\ y = x - 36 \end{cases}$$

Complète l'énoncé, en étudiant les équations



1	2	3	4	5
6	7	8	9	0

fois	moins
de	plus

(some) parameters :

- Problem type :
 - ◆ Unequal sharing
 - ◆ ratio and difference
- Statement type :
 - ◆ not congruent
- 2 equations
- 2 unknowns
- 2 blanks in statement
- feedback

On going work

- ▶ **Teaching strategies adapted to stereotypes**
 - ◆ How to choose a family of situations ?
- ▶ **Monitoring the student's progress**
 - ◆ How to move within a family of situations ?
- ▶ **More flexible diagnostic system**
 - ◆ Adaptive testing

Overview

➤ Objectives

- ◆ Providing conceptual and software tools for teachers to monitor individual learning and whole class management
- ◆ Automating most of the diagnosis and the capitalization on it

➤ Results

- ◆ Stereotypes
- ◆ Families of Parameterized Learning Situations
- ◆ Some prototypes to implement and test the different models
 - ▶ Pepite
 - ▶ Aile
 - ▶ Cime

Web sites

Software and research documents download
<http://pepите.univ-lemans.fr>

Documents for teachers (in french)
<http://maths.creteil.iufm>
**(formation continue, la compétence
algébrique du collège au lycée)**