# Adapte, a tool for the teacher to personalize activities

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**Abstract.** In the context of the personalization of learning, we want to provide teachers with generic tools enabling them to personalize activities they offer learners. The PERLEA project aims at conceiving a system enabling teachers to manage existing learners' profiles. In this system, the Adapte module proposes activities suited to the abilities highlighted in their profiles. Theses activities are either paper and pencil worksheets or activities on an ILE. This paper presents the principles of the Adapte module, its architecture and the implementation which we have done.

**Keywords:** Personalization of learning, learner's profile, generation of activities, teacher's tool, system architecture, knowledge bases.

## 1 Introduction

One of the issues at stake in the research on Interactive Learning Environments (ILE) is the personalization of learning. This personalization uses in particular learners' profiles assembling information about the learners, thus allowing us to characterize their knowledge, skills, perceptions and/or their behaviors. These data are collected or deduced from one or several pedagogical activities, computerized or not. [4].

The personalization of learning, whether in the context of classic teaching or in the context of the ILE, can relate to the interactions between the teacher / the environment and the learner as well as pedagogical activities assigned to the learner. In our research as presented here, we will focus on the second point.

In order to personalize pedagogical activities offered to the learner using a learner's profile, we can either use knowledge based systems to generate pedagogical activities best-suited to the profile, or provide the teachers with tools enabling them to perform this task themselves. Our wish is to link these two options in Adapte, a module of the PERLEA project.

After the presentation of a scenario of utilization of Adapte, we will present the PERLEA project and its software environment. Then we will describe more precisely the Adapte module showing that it can help teachers and how. We will detail its architecture and then present the implemented version of the software. We will conclude with our research perspectives on this work and more generally on the PERLEA project.

## 1.1 Scenario of utilization

A teacher uses in his classroom an ILE on geography with his eight-year-old pupils. At the end of the learning session, this ILE generates a profile for each learner. In addition, the teacher organized for all his students the national assessments due in the beginning of year. These assessments have generated a diagnostic on the achievements, mistakes and difficulties of each pupil in mathematics and French.

Thus, the teacher has for each pupil several profiles from different sources, ILE and pencil and paper, and for several disciplines. He or she wants to use these profiles globally so as to provide, for each pupil, personalized exercise sheets. These sheets enable learners to be self-reliant when working and this in several disciplines. The teacher also wants to define parameters of the ILE on geography so that it proposes sessions suited to each learner's profile.

Currently teachers cannot follow this pattern easily. Actually, there is no existing tool that would enable teachers to use data from ILE externalizing their learners' profiles, or to link this data to the pencil and paper profiles they themselves managed. Moreover, teachers can produce personalized exercise sheets but they then have to either create exercises themselves, or take existing exercises and manually adjust to their needs and their working methods. They also have to decide, for each student, which exercises to put in his sheets. This work requires a great involvement from the teacher. Finally, ILEs are customizable either through the model of learner they contain [1], [5], [7], [8], or through an administrator interface [3] ,[6]. In the first case, ILE offer sessions suited to each learner's profile but the teacher cannot step in the choice process of the system. In the second case, the teacher himself (or herself) defines the parameters of the sessions proposed to the whole class or to each student. As when creating worksheets, when the teacher personalizes an ILE session, he or she has to decide what kind of activity should be provided to each student. Therefore, we can observe that depending on the ILE, either the teacher cannot step in the proposed sessions, or he or she has to produce an important work to personalize them.

## 1.2 The PERLEA project

The PERLEA project aims at improving the integration of ILEs in education by providing links between the use of ILEs and teachers' everyday practices. In order to do so, we are interested, in a generic way, in the profiles of learners and their use *a posteriori* for the management of learners and the personalization of learning [4].

Hence, we want to develop an environment that would enable teachers to manipulate existing profiles. This environment consists of two phases: the integration of existing profiles and the management of thus restructured profiles.

In order to explain this mechanism, let us take the example of our teacher with profiles from the ILE on geography and profiles from national assessments of mathematics and French. Reusing profiles requires knowing their structure. The teacher then defines a unique frame of profiles describing the information contained in the two types of profiles. This profile frame contains information on the three disciplines. Next, the teacher specifies to the system how to automatically convert ILE profiles to get the geography data, and includes information on the mathematics

and French. At the end of the integration phase, the teacher has a unique profile for each of his students.

The second phase of the environment proposes rich uses of thus created profiles. One of these uses is made by the Adapte module offering learners activities adapted to their profiles. These activities can be worksheets generated by the system or computerized activities managed by an external ILE.

## 2 Principles of the Adapte module

### 2.1 What help for the teacher?

The role of the Adapte module is to provide learners with activities suited to their profiles. These activities can be paper and pencil exercises or computerized activities managed by an external ILE.

In the case of paper and pencil activities, Adapte generates a worksheet matching the profile of each learner. To do so, it creates tailor-made exercises to be included in the sheet and determines the size and/or duration of the worksheet. It also provides the teacher with answers to the exercises contained in the sheet.

In the case of computerized activities, there are three scenarios depending on how the ILE is customizable: definition of the parameters of ILE by Adapte when possible; definition of an instruction sheet by Adapte, for the teacher to set ILE through an administrator interface; definition of an instruction sheet by Adapte, containing a list of exercises that the student will have to do on the ILE, if this ILE is not customizable. In all cases, Adapte sets personalized sessions on the ILE according to the learner's profile. To do so, it uses ILE exercise generators or chooses exercises in the ILE database. It also determines the order in which the exercises appear, their number and the duration of the session.

### 2.2 What sort of expertise does the teacher provide to Adapte?

In order to assign worksheets to a student, we have to help the teacher in his pedagogical work and then to acquire his expertise to integrate it into the system, but without taking his place as a teacher in the classroom. So we worked with teachers to be consistent with their teaching practices and we identified with them the rules they use to assign a type of exercise to an element of the profile.

Thus, in Adapte, the teacher specifies his own teaching strategies. In this purpose, the teacher creates activity frames containing a set of constraints allowing to generate or to select an activity (paper and pencil activity or computerized activity). After creating an activity frame, the teacher defines constraints on part of the learner's profile. The link between a part of the profile and one or more activity frames is called the assignment *criterion*. The teacher defines a teaching strategy for a given teaching situation by organizing these assignment *criteria* into a hierarchy according to their importance.

Let us go back to our teacher example. The teaching strategy, that he or she will define to create paper and pencil worksheets, will contain all the assignment *criteria* referring to the three sections of learners' profile (mathematics, French, geography). Thus, the teacher specifies, in mathematics for example, that if a student has difficulties with additive word problems, then he or she will have to solve additive word problems with small numbers and short sentences. However, if a student has good results with additive word problems, then he or she will have to solve exercises with larger numbers, with calculations requiring the use of carry over and with sentences unnecessary to the resolution of the exercise. These *criteria* really do link up the learners' profiles (command of such competence) and an activity frame (all the constraints allowing to generate exercises on the additive word problems). The assignment *criteria* enabling to personalize the ILE on geography will contain activity frames. Constraints on these activity frames will enable to choose, within the exercise database of ILE, which exercise to propose to pupils. These activity frames can also contain constraints allowing to generate new exercises thanks to the generator integrated to the ILE on geography. These assignment *criteria* refer to the data on geography in the profile, but also to the data on mathematics and French in order to consider, for example, some students' difficulties in reading or calculating.

After defining his teaching strategies, the teacher specifies his teaching situation by defining constraints which generally enable him to get worksheets corresponding to his needs for the whole class. For instance, he or she can specify to the system that he or she would like worksheets for an hour study, or that he or she wants sheets containing three exercises.

Finally, when Adapte has generated worksheets, the teacher can modify them either by requesting a new version of an exercise, if the proposed values do not satisfy him or her, or by deleting or adding exercises. Likewise, he or she can change the personalization proposed for the ILE.

### 2.3 What are the theoretical and technical needs of Adapte?

Adapte must be able to create or select activities appropriate to each learner to be added in the worksheet or in the session proposed by an ILE.

Concerning paper and pencil activities, it is necessary to generate them rather than choose them in a database, in order to have enough variety of problems and to have questions specifically thought for each learner. We therefore listed the exercises that teachers from primary and secondary schools give to learners, for all disciplines, and we identified a typology of exercises. From this typology, we proposed a set of semi-automatic generators that can generate exercises with or without the intervention of the teacher [2].

To personalize an ILE, Adapte requires a set of didactic knowledge (discipline, level, competences involved …), as well as a set of technical knowledge (position of files, existence and use of an exercise generator…) on this ILE. This knowledge is specific to each ILE and must be provided by an expert or by the ILE designer.

So that Adapte can propose activities adapted to the learners' profiles, we have just seen that the system needs to know the teaching strategies specific to each teacher and referring to a profile with a given structure and to know how to generate or to choose

activities to propose to learners. We also have to define the mechanism enabling Adapte to apply these teaching strategies to each profile. So Adapte has been fitted up with a set of knowledge to evaluate the assignment *criteria* contained in the strategies according to each profile. Thanks to this knowledge, Adapte can also create consistent paper and pencil worksheets, i.e. to create worksheets, from generated or selected exercises, respecting the constraints of time, page setting… Finally, this knowledge enables to personalize an ILE by creating valid sessions. All of this knowledge is independent of the domain of the work provided to the learner and is also independent of the ILE the teacher wishes to personalize.

## 3 Architecture of Adapte

Now that we have clarified what Adapte needs in order to operate, we will present its architecture (see Fig. 1). Adapte has several knowledge bases on which we will focus in order to explain their contents.
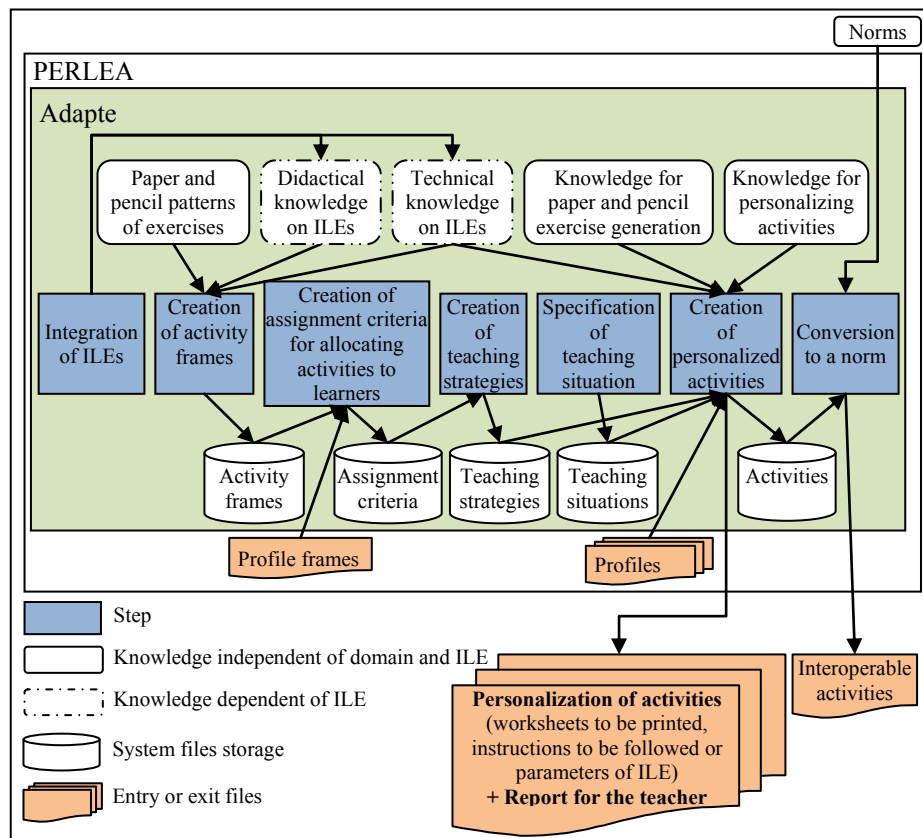


**Fig. 1.** Architecture of the Adapte module.

**Paper and pencil exercise patterns.** An exercise pattern contains the theoretical definition of a class of exercise frames. An exercise frame contains all the constraints to create an exercise of a particular type. Currently, we have identified eight exercise patterns. These exercise patterns are independent of the domain for which we want to generate an exercise. They can be used to generate exercise frames that are dependent on the domain.

**Knowledge for paper and pencil exercise generation.** This knowledge includes the eight semi-automatic generators used to create paper and pencil exercises. These generators use exercise patterns in order to know the structure of exercises that can be generated. Each generator contains knowledge of the domain of the generated exercise (e.g. knowledge of calculation for math exercises) and general knowledge independent of the exercise domain (e.g. a dictionary of synonyms for varying exercises or grammatical rules to generate exercises formulated in natural language).

**Didactical and technical knowledge on ILEs.** This knowledge is different for each ILE and thus for each domain. The didactic knowledge contains everything related to what is taught in the ILE (discipline, practiced competences…). The technical knowledge specifies how to act on the ILE to personalize it (position of files, available generators, exercise bases…). There is a link between these two types of knowledge used, for example, to link an exercise from a database to the competences that this exercise puts into practice. All the knowledge about the ILE to personalize should be provided to Adapte by an expert or by the designer of the ILE.

**Knowledge for personalizing activities.** A personalization of activities contains, depending on the use of Adapte, either the worksheet to be printed, or the parameters enabling the personalization of an ILE. In addition, it contains a report for the teacher indicating what is proposed to the learner (the exercises, planned working time …). The knowledge used to create a personalization of activities contains the rules used to create a paper and pencil worksheet based on generated exercises or to create personalized sessions on an ILE. This knowledge is independent of the domain and independent of the ILE that we want to personalize.

From this knowledge, Adapte, with the help of the teacher, can propose activities adapted to the learners' profiles. In this purpose, the teacher defines its teaching strategies by creating a set of assignment *criteria*. These assignment *criteria* use the activity frames contained in the system or defined by the teacher. Then the teacher specifies his teaching situation and the system creates personalized activities. We will now go back on each step of Adapte enabling this mechanism to operate.

**Integration of ILEs.** This step is performed by an expert or by the designer of the ILE to personalize. It enables to integrate the necessary technical and didactical knowledge for each ILE. This step is compulsory so that Adapte can personalize an ILE but it is only done once.

**Creation of activity frames.** This step is performed by the teacher to define exercises corresponding to his working habits. For the paper and pencil part of Adapte, the teacher chooses an exercise pattern (i.e. a type of exercise) and defines the constraints he or she wishes so that the system can generate exercises that satisfy him or her. For the personalization of ILE, the teacher defines the constraints of exercise generation when the ILE to personalize contains a generator, or defines the constraints to select an exercise in the system databases. All these constraints are saved in an activity frame.

**Creation of assignment *criteria* for allocating activities to learners.** This step is performed by the teacher and enables him or her to link parts of learners' profiles to activity frames. The parts of profile are selected and are constrained in order to choose students with a particular problem or competence. For example, the teacher will choose in the learner's profile the competence "Command of the punctuation rules," and will provide a type of exercise for students with a success rate between 0 and 25%, another type of exercise for those with a rate between 25 and 75%, and nothing for students with a rate higher than 75%.

**Creation of teaching strategies.** This step is performed by the teacher and enables him or her to choose the assignment *criteria* he or she wishes to use. It also enables him or her to classify these *criteria* by giving them a level of importance. This level of importance is used when the system cannot choose between two exercises to provide to the learner. As a priority, the system will provide activities associated to the *criteria* with the highest level of importance.

**Specification of the teaching situation.** This step is performed by the teacher and is made up of two parts. First, the teacher specifies the learners' profiles for which he or she wishes to obtain personalized activities. Secondly, the teacher defines the constraints enabling to "limit" the worksheets or the ILE sessions. In our situation, "to limit" means to specify the duration of the working session, a maximum number of exercises, etc.

**Creation of personalized activities.** This step is performed by the system from the learners' profiles, the teaching strategies defined by the teacher and the knowledge related to either the creation of a paper and pencil worksheet, or to the creation of a session on an ILE. After Adapte has proposed its selection of personalized activities, the teacher can validate or modify the choices of the system.

**Conversion to a norm.** This step is optional in the mechanism of Adapte. It enables anybody to convert paper and pencil exercises, generated by Adapte, into a given norm, thus making their exchange with other systems possible.

All these steps were defined to enable Adapte to provide paper and pencil worksheets or to personalize an ILE. In the next section, we will illustrate them introducing the part of Adapte enabling the creation of personalized paper and pencil activities.

## 4 Implementation and evaluation of the Adapte software

A first part of the software has been developed to enable teachers to fully put into practice the desired approach of Adapte. This part implements the results proposed for the paper and pencil part of the software i.e. the part which proposes worksheets to learners.

When using the software, the teacher defines his or her teaching strategies specifying his or her assignment *criteria* for allocating an exercise to one or several competences of the learner's profile. Let us go back to our teacher example. He or she defined a profile frame containing knowledge on French, mathematics and geography. Now, he or she defines in Adapte assignment *criteria* so his students can work on their weak points. We can seen on the *criterion* 1 of Fig. 2 that the teacher has selected the knowledge "France – Its main cities" and that he or she has specified that he or she wishes to make work the students whose ratings for this knowledge are "not mastered". He or she associated with this constraint on the learners' profiles the exercise frame "D14_Put_cities_in_France.xml". To do so, he or she had chosen an exercise pattern, "Work on illustration", from the eight available patterns of Adapte and defined constraints to generate an exercise matching his or her wishes. These constraints indicate that the illustration is a map of France, that the fields to be filled are the cities of France, that the exercise must contain at least ten fields of which Paris, Lyon and Marseille are compulsory, etc.

This way, the teacher defines several constraints illustrating his pedagogical objectives. These constraints constitute his or her teaching strategy. A part of this strategy is provided in Fig. 2.

```
Criterion 1: Lack of command of French cities
   -   Knowledge: Geography - France – Its main cities
   -   Values: not mastered
   -   Exercise frame: D14_Put_cities_in_France.xml
Criterion 2: Lack of command of additive word problems
   -   Knowledge: Mathematics – Exploitation of numeric data – Additive
       word problems
   -   Values: X between 0% and 50%
   -   Exercise frame: F18_Additive_word_problems_Low_level.xml
Criterion 3: Command of additive word problems
   -   Knowledge: Mathematics – Exploitation of numeric data – Additive
       word problems
   -   Values: X between 50% and 100%
   -   Exercise frame: F19_Additive_word_problems_Hard_level.xml
```

**Fig. 2.** Teaching strategy defined in Adapte

Then, the teacher chooses a set of learners' profiles, and specifies that he or she wants for each student a worksheet containing two exercises. The system produces as many personalized worksheets as existing profiles. In order to do so, the system will evaluate the assignment *criteria* according to each student's profile data. For example, look at the case of Boris and Charles whose profiles are provided in Fig. 3. We can see that Boris does not master the placement of main cities in France on a map and has a success rate of 45% to additive word problems. According to the teaching strategy in Fig. 2, the system will provide a worksheet containing an exercise generated through the exercise frame "D14_Put_cities_in_France.xml" and an exercise generated through the exercises frame "F18_Additive_word_problems _Low_level.xml". We can also see that Charles knows the cities of France and has a success rate of 95% to additive word problems. His worksheet will contain two different exercises generated through the same exercise frame "F19_ Additive_word_problems_Hard_level.xml".

```
<profile name="Boris">                   <profile name="Charles">

<brick name="Geography">                 <brick name="Geography">
 <component name="France">                <component name="France">
 <subcomponent name="Its situation       <subcomponent name="Its situation
in a map">                               in a map">
 <value>Mastered</value>                  <value>Mastered</value>
   </subcomponent >                         </subcomponent >
 <subcomponent nom="Its main              <subcomponent nom="Its main
cities">                                 cities">
 <value>Not mastered</value>              <value>Mastered</value>
 </subcomponent>                          </subcomponent>
 </ component >                           </ component >
…                                        …
</brick>                                 </brick>
< brick name="Mathematics">              < brick name="Mathematics">
 < component name="Exploitation of        < component name="Exploitation of
numeric data">                           numeric data">
 <subcomponent name="Additive word        <subcomponent name="Additive word
problems">                               problems">
 <value>45</value>                        <value>95</value>
   </subcomponent>                          </subcomponent>
…                                        …
 </ component >                           </ component >
…                                        …
</ brick >                               </ brick >
  </profile>                               </profile>
```

**Fig. 3.** Boris and Charles's profiles.

Finally Adapte gives the teacher the worksheets assigned to each of his students. The teacher can modify them by deleting or adding exercises, or else by requesting another version of one of the exercises. Then, he or she can print them to hand out to his students.

The conception of the Adapte module has been made in partnership with teachers and as the software is now usable, we have submitted it to these teachers. Then a teacher outside the PERLEA project has tried the software. Their feedbacks seem to validate the software and the defined architecture.

# 5 Prospects

We presented in this paper the conception work that we have undertaken on the Adapte module. This module offers learners activities suited to their profiles. A first version of the software implements the results suggested for the generation and assignment of paper and pencil activities. This software enables teachers to achieve the full approach proposed by Adapte. However, only three fully developed generators are included. Before finishing its implementation, we would like to work with experts from education sciences to validate our typology of exercises and therefore all the exercise generators.

In our work, we are currently focusing on the part of Adapte offering sessions adapted to the competences of the learner on an external ILE.

When Adapte is fully implemented, we will set up more rigorous evaluations of our results. This will be done through experiments with many teachers unrelated to the conception of the module. These experiments will involve all related modules of the PERLEA project environment, and will range from the definition of a profile frame by the teacher to the effective use of personalized activities by learners.

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