A Teacher-dedicated Tool Supporting Personalization of Activities

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Abstract: Personalization of learning is a complex task which objectives are manifold. One of them is to provide teachers with tools allowing them to personalize activities assigned to learners. The PERLEA project takes a step in this direction by proposing a system enabling teachers to manage learners profiles. Within this system, the Adapte module is responsible for the creation of activities adapted to a given learner. This task is performed according to the information available in the learner profile and in collaboration with teachers. Created activities are either paper and pencil worksheets or ILE-related activities. This paper describes the mechanism of the Adapte module and demonstrates how it helps teachers to personalize better learning activities.

Introduction

Personalization of teaching and learning activities is widely considered as a topical issue in the field of research in educational technologies. Personalization of activities, i.e., their adaptation to the individuality of each learner, is an efficient mean of improving teaching. However, due to the diversity of learners, the variety of situations and subjects under study, personalization is often a complex and time-consuming task. For that reason, and because of a lack of adequate tools, teachers do not efficiently personalize pedagogical activities. Therefore, developing software to assist teachers in this personalization task can turn out to be very helpful.

Personalization is a multi-faceted research question. It can concern paper and pencil activities, Interactive Learning Environments (ILEs), interactions between teachers (or interactive environments) and students, etc. In any case, the personalization process has to rely on specific information about the context, the activities, and, most of all, about learners. Usually, information about a given learner is gathered into "learners profiles", containing elements characterizing knowledge, skills, perceptions, and/or behaviour. These elements are either collected or deduced from pedagogical activities, computerized or not (Jean-Daubias & Eyssautier-Bavay 2005).

In this paper, we describe Adapte, a generic tool aimed at personalizing pedagogical activities of any kind (paper and pencil or ILE-based) based on learner profiles. Adapte provides two ways of personalizing pedagogical activities: the first involves using an embedded knowledge-based system that generates pedagogical activities adapted to a given profile and the other involves providing teachers with easy-to-use tools allowing them to interactively define sequences of personalized pedagogical activities. The paper is organized as follows. The next section presents a case study of a situation where a teacher wants to personalize some of his pedagogical activities and shows how Adapte can be helpful in such a situation. Next, the personalization issue tackled in Adapte is analyzed from two reciprocal views: (i) how Adapte can help a teacher during a personalization task? and (ii) what does Adapte need in order to work? This cross analysis leads us to define the technical requirements of the module. Next, we describe the mechanism of Adapte with a specific focus on the knowledge bases used by the processes of the module. We then discuss validation and evaluation of the approach and ends with concluding remarks.

Personalization of Pedagogical Activities in a Classroom: a Case-study

Throughout this paper, we will refer to the following example. In an eight-year-old pupils classroom, a teacher uses an ILE of the geography domain. After each learning session, this ILE generates a profile per learner. In addition, all the pupils have made national assessments in mathematics and French. The teacher has gathered the results (information on achievements, mistakes and difficulties) for each student. Thus, for each pupil, he has a numeric profile coming from the geographic ILE and a paper and pencil profile coming from the assessment for mathematics and French. The teacher wants to exploit these profiles for the elaboration of personalized exercises sheets (called *worksheets*) for each student. Therefore, for a given student and for a given subject (geometry for

instance) he is going to take into account not only the student's skills in this subject, but also in French, in order to vary the language complexity of the statements. In the same way, the teacher is able to define the parameters of the geographic ILE in order to design learning sessions that are well suited to learners depending on their profiles.

In practice, performing such a personalization is not an easy task for the teacher, for two reasons. The first one is the lack of time to process all the information available to design personalized activities. The second one is the absence of tools helping teachers in their personalization tasks. For example, as far as we know, no tool allows a teacher to easily re-use profiles coming from an ILE or to link them to hand-managed paper and pencil profiles. Producing personalized worksheets is a complex task as well. If teachers do not create exercises themselves, they have not only to find reusable existing exercises but also to adjust them to their needs. They also have to choose, for each student, the exercises to be put in the worksheet. In any case, this work requires a great involvement.

However, researches on the field of educational technologies make significant contributions in relation with personalization issues. For example, ILEs are often customizable either through the model of learner they contain (Burton 1982), (Vu Minh et al. 2006), or through an administrator interface (Duclosson et al. 2005), (Nicaud et al. 2003). In the first case, ILE offer sessions suited to each learner but the teacher is not involved in the decision process of the system. In the second case, the teacher himself defines the parameters of the sessions proposed. As when creating worksheets, when the teacher personalizes an ILE session, he 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 is not involved in the proposed sessions, or has to produce an important work to personalize them.

Tools aiming at providing teachers with a support for personalization have to face several difficulties. On the one hand, they have to adapt themselves to teachers' habits, without trying to replace them. On the other hand, in order to be truly helpful, they have to cope with the heterogeneity of pedagogical situations and to the numerous pedagogical tools that can be used in a classroom context. Adapte takes a step in this direction by enabling teachers to easily personalize a wide range of external ILEs as well as paper and pencil activities.

Adapte, a Tool for Supporting Personalization of Pedagogical Activities

Adapte is a tool dedicated to the personalization of various kinds of pedagogical activities based on information available on students profiles. Even if it can be run as a standalone application, Adapte is mainly designed as a module of the EPROFILEA environment. On that account, it benefits from the overall infrastructure of the PERLEA project for integrating, managing and reusing profiles (Jean-Daubias & Eyssautier-Bavay 2005).

In order to illustrate EPROFILEA's mechanism, let us go back to our running example. Whatever the final objective is, reusing profiles from several source (here, national assessments in mathematics and French, and ILE in geography) requires a good knowledge of their structures. With EPROFILEA, the teacher defines a unique profiles structure describing the information contained in the two main types of profiles. This profiles structure 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 covering various subjects for each student.

The second phase of the environment offers rich uses of these profiles such as visualization or exploitation. One of these uses is provided by the Adapte module which provides teachers with activities adapted to learners profiles. These activities can be worksheets generated by the system or computerized activities managed by an external ILE.

The EPROFILEA environment is still under development but the critical parts are already completed and several experimentations have already been conducted. The development of the Adapte module, which is described in this paper, has been completed recently.

Challenges Addressed by Adapte

During the conception of Adapte, our main challenge was to make a component that was at the same time usable and useful for teachers. Hence, in order to clearly identify the particular needs of teachers, we have organized several interviews with a group of teachers. After this first phase, we had the basics to better understand what help does a teacher need during a personalization process. The next step was to design the module grounded on the results of this preliminary analysis. Several aspects of these two conception phases are discussed hereafter.

What help for the teacher? The role of Adapte 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 is able to generate worksheets 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 activity. It can also provide the teacher with answers to the exercises contained in the sheet. In order to generate exercises, Adapte relies on its embedded exercises generators. In the case of computerized activities, three personalization scenarios are possible, depending on how ILE are customizable. Either Adapte provides the parameters of the ILE, or it defines an instruction sheet for the teacher to set ILE through an administrator interface or, if the ILE is not customizable at all, it provides the teacher with a list of exercises that the student will have to do on the ILE. In any case, Adapte sets personalized sessions on the ILE according to the learner profile and determines the number of exercises, the order in which they should appear and the duration of the session. Depending on the situations, Adapte is able to use external ILE exercise generators or to pick up exercises in the ILE database.

What sort of expertise does Adapte need? In order to efficiently assist teachers in their pedagogical tasks a system must have a certain amount of knowledge and expertise. Knowledge and expertise have to be acquired from domain experts, i.e. teachers. For that reason, during the design of Adapte, we have spent time with teachers in order to learn about their teaching practices, the rules they use to assign exercises depending on pieces of information available in profiles, etc. We have also provided Adapte with the ability to acquire additional knowledge when it is used by teachers. As a result, Adapte is better able to improve with time and to adapt itself the teacher's habits and practices. In Adapte, a teacher can specify his own teaching strategies. For that purpose, he creates activities structures containing a set of constraints for generating or selecting an activity (paper and pencil or computerized activity). After creating activities structures, the teacher defines constraints on the learner profile. A link between a part of a profile and one or more activities structures is called an assignment rule. The teacher defines a teaching strategy for a given teaching situation by organizing these assignment rules into a hierarchy according to their respective importance. In our running example, the teaching strategy that is defined to create paper and pencil worksheets contains all the assignment rules referring to the three sections of learners profiles (mathematics, French, geography). Thus, the teacher specifies, in mathematics for example, that if a student has difficulties with additive word problems, then he will have to solve such problems with small numbers and short sentences (in order to focus on the main difficulty). However, if a student has good results with additive word problems, then he 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 rules really do link up learners profiles (mastery of a competence) and an activities structure (all the constraints allowing generating exercises on the additive word problems). The assignment rules enabling to personalize the ILE on geography contains activities structures. Constraints on these activities structures enable one to choose, within the exercises database of ILE, which exercises can be proposed to pupils. These activities structures can also contain constraints allowing generating new exercises using the generator integrated to the ILE on geography. These assignment rules refer to the data on geography in the profile, but also to the data on French in order to consider, for example, some students' difficulties in reading. 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 can specify to the system that would like worksheets for an hour study, or that he wants worksheets containing three exercises. At any time, teachers can modify worksheets generated by Adapte by adding, deleting or modifying exercises. For example, if the values of an exercise are not satisfactory, they can modify them by requesting a new version of the exercise. Likewise, they can change the personalization proposed for a given ILE.

What are the Theoretical and Technical Needs of Adapte?

Several requirements have to be satisfied in order to make Adapte able to create or select activities appropriate to each learner and to add them in the worksheet or in the session proposed for an ILE.

Concerning paper and pencil activities, it is better 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 have listed the exercises that teachers from primary and secondary schools give to learners, for all disciplines, and we have identified a typology of exercises. From this typology, we have proposed a set of semi-automatic generators that can generate exercises with or without the intervention of the teacher. In order to personalize an ILE, Adapte requires a set of pedagogical knowledge (parameters impacting the personalization, competences involved, etc.), as well as a set of technical knowledge (location of configuration files, existence and use of an exercise generator, etc.) on this ILE. This knowledge is specific to each ILE and must be provided by an expert or by the ILE designer. Adapte also requires knowledge on the teaching strategies specific to each teacher and referring to a profile with a

given structure. Hence, we have to define a 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 rules contained in the strategies according to each profile. Thanks to this knowledge, Adapte can create consistent paper and pencil worksheets from generated or selected exercises, with respect to time constraints, page format settings, etc. Finally, this knowledge enables the personalization of an ILE by creating valid sessions. All this knowledge is independent of the domain of the work provided to the learner and is also independent of the external ILE that the teacher wants to personalize.

Mechanism of Adapte

The mechanism of the Adapte module is described on Fig. 1. This figure shows that the reasoning process in Adapte is decomposed in several steps that exploit the various knowledge bases. The different knowledge bases as well as the steps are detailed in this section.
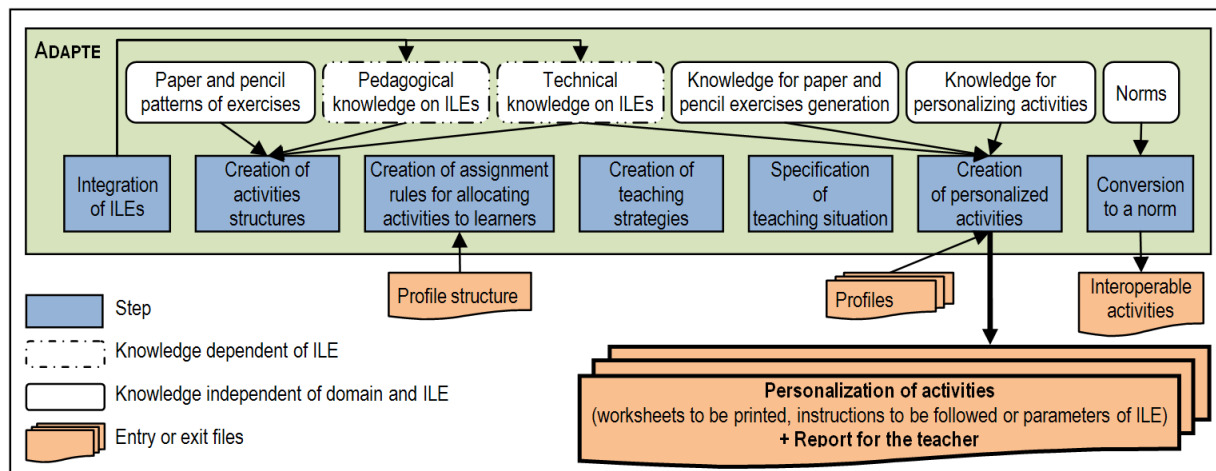

Figure 1: Mechanism of the Adapte module.

Paper and pencil exercises patterns. An exercise pattern contains the theoretical definition of a category of exercises structures. An exercises structure 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 exercises structures dependent of the domain.

Knowledge for paper and pencil exercises 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 on the domain of the generated exercise (e.g. knowledge of calculation for math exercises) and general knowledge independent of the exercise domain (e.g. grammatical rules to generate exercises formulated in natural language).

Pedagogical and technical knowledge on ILEs. This knowledge is dependant of the ILE and the domain. The pedagogical knowledge contains everything related to what is taught in the ILE (parameters impacting the personalization, associated competences, etc.). The technical knowledge specifies how to act on the ILE to personalize it (location of configuration files, available generators, exercise bases, etc.). There is a close link between these two types of knowledge. For example, both types of knowledge are required in order 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 worksheet to be printed, or parameters enabling the personalization of an ILE. In addition, it contains a report for the teacher indicating what is proposed to the learner (exercises, planned working time, etc). 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.

Based on the available knowledge and with the help of the teacher, Adapte can propose activities adapted to the learners profiles. For that purpose, the teacher defines teaching strategies by creating a set of assignment rules. These assignment rules use the activities structures 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 describe each step of the personalization process performed by Adapte. All these steps were defined to enable Adapte to build paper and pencil worksheets or to personalize an ILE.

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 pedagogical knowledge for each ILE. This step is compulsory so that Adapte can personalize an ILE. However, it is only done once.

Creation of activities structures. This step is performed by the teacher in order to define exercises corresponding to his working habits. For the paper and pencil part of Adapte, the teacher chooses an exercises pattern (i.e. a type of exercises) and defines his own constraints so that the system can generate satisfying exercises according to this pattern. For the personalization of a specific ILE, the teacher can either define the constraints of exercise generation (when the ILE contains a generator), or define the constraints to select an exercise in the system database. All these constraints are saved in an activities structure.

Creation of assignment rules for allocation of activities to learners. This step is performed by the teacher and enables him to link parts of learners profiles to activities structures. The parts of profiles are selected and are constrained in order to select students with particular problems or competences. For example, the teacher might want to select in the learner profile the competence "mastery of the punctuation rules," and to 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 to choose the assignment rules he wishes to use. It also enables him to classify these rules 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 rule 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 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, to set a maximum number of exercises, etc.

Creation of personalized activities. This step is performed by the system and by using learners profiles, teaching strategies defined by the teacher and knowledge related to the creation of paper and pencil worksheet or to the creation of sessions 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 one to convert paper and pencil exercises, generated by Adapte, into a given norm, thus making their exchange with other systems possible. Thanks to this functionality, Adapte is interoperable with other systems.

Discussion and conclusion

Evaluation issues. From a software engineering point of view, Adapte fulfills all the requirements for such a tool. It has the ability to exploit profiles, to create paper and pencil worksheets, to generate configuration files for configurable ILEs, to produce procedures guiding teachers during the configuration of external ILEs, etc. Besides, it is equipped with knowledge acquisition facilities that make it able of evolving and improving itself with time.

In order to validate the internal process of the module, we have tried to re-generate existing worksheets (manually created by secondary school teachers in mathematics, biology, history and English) only by using the knowledge available in the system. The results of this experimentation were fully satisfactory as we were able to re-generate all the worksheets. We have also checked that Adapte was able to configure external ILEs by using it to configure five new ILEs that were not part of the initial study.

Now that Adapte is fully implemented, several experimentations can be envisioned to provide an evaluation of the usability of the tool by teachers in real situations. For a first experimentation currently conducted with a teacher, we focus on interaction issues, interface ergonomics issues and we question the easiness of appropriation of the tool.

Another point in our experimentation agenda is to validate our exercises structures and, as a consequence, our exercises generators, from a pedagogical viewpoint. This evaluation requires collaboration with educational sciences researchers and constitutes an important future work.

However, in order to evaluate in depth the benefits of the Adapte module, real-size experimentations in situation are required. Such experimentations will imply to deploy not only Adapte, but the full EPROFILEA environment in the context of a classroom or a school and to involve several teachers, possibly not related to the project so far. Setting up such experimentation is a complex task, but it will enable us to study in depth the global relevance of our approach as well as the specific efficiency of each component of the mechanism.

Strengths and Weaknesses of the approach. Several issues related to the design choices of Adapte are currently under investigation. First, the international community has defined a certain number of norms and standards (for example SCORM and LOM) for educational tools (Koper 2001). Norms and standards improve the interoperability of systems using them. However, they do not provide us with any support to make interoperate two applications not using them. A major strength of Adapte is that it is able to cope with any application, even if it is not developed according to a specific norm. Adapte has not been designed with respect to a specific norm; however it has a functionality enabling the exportation of its generated pedagogical activities in any standard.

We are also concerned about the issue of the usability of Adapte within the context of a classroom. Even if the tool is easy to use for a teacher, setting it up raises several technical issues and requires several skills and a little involvement from the teacher. A simple example is the automatic configuration of an ILE. For an automatic configuration, Adapte and the ILE that has to be configured have to be installed on the same computer. Otherwise, the teacher will have to manually copy the configuration files on the right place, which can turn out to be complicated. In order to tackle this issue, we think about developing a distributed version of the system based on a web application principle. However, this solution has numerous technical impediments. Besides, we wonder if all teachers will have time and the will to involve themselves in the implementation of the tool in their classrooms. A distributed application facilitating a collaborative work might be starting point to solve this issue if it alleviates the load of work of each participant.

Conclusion. In this paper, we have presented Adapte, a module of the PERLEA project dedicated to assist teachers in the process of building activities suited to learners by using learners profiles. All the functionalities are fully implemented. Only five exercises generators are missing. Hence, Adapte now allows teachers either to build personalized paper and pencil worksheets or to configure external ILEs to personalize learning sessions. The mechanism of Adapte has been validated by several tests and several facets of the module are currently evaluated.

Open research issues are numerous for Adapte as well as for the PERLEA project. For Adapte, in addition to the technical improvements that are already planned, a major issue is to study how it can be extended to other kinds of pedagogical activities such as collaborative teaching or collaborative learning for example. Our main focus is to design a framework able to adapt itself, to evolve and to cope with a large range of other pedagogical tools. Indeed, we believe that these features are necessary in any tools aiming at truly helping its users.

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