An approach for unified personalization of learning

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Abstract. To assist teachers in the task of personalization, we propose a tool that enables them to customize both working sessions on paper and working sessions on educational software. This tool is based on the PERSUA2 model for unified personalization of learning activities. This article describes the principles of the model and we illustrate how to exploit this model.

Keywords: Personalization of learning, tool for teachers, unified approach.

1 Introduction

Personalization of learning consists in modifying activities proposed to learners according to a given teaching situation. This situation includes the learner's specificities, the teacher's pedagogical goals and the learning context. Personalization of learning activities is a complex and lengthy task for two main reasons. Firstly, there is a great variety of paper activities, as well as educational software focusing on different subjects; and secondly, pedagogical situations are very diverse. To assist teachers in the task of personalization, it seems relevant to provide them with a tool for personalization of both working sessions on paper and using educational software. This tool should take into account the specificities of each learner, and the goals and pedagogical habits of teachers. Building such a tool implies then to know how to exploit the available information on learners to take into account their individualities; to be able to adapt an activity according to needs and teaching habits of teachers; and to identify the necessary knowledge to select activities to be addressed to learners.

Section 2 illustrates the difficulties encountered by teachers during their work towards personalization. Section 3 presents the strengths and weaknesses of existing approaches to help them and describes our approach for building a tool to support personalization. Section 4 presents the principles of the PERSUA2 model on which our tool relies. Our propositions are discussed in the concluding section.

2 Usage scenario

We present a scenario showing the challenges for teachers while performing personalization of learning activities for students. Let's consider the example of Joey, teacher of eight-year-old French pupils. At the beginning of the school year, he gets the results of national assessments in French and Mathematics performed by his

students at the end of the previous year. Besides, Joey's students work in autonomy with AMBRE-add [1], an ITS for additive word problems. In Joey's school, personalized support is available to underachieving students. Each concerned student receives two hours of extra teaching. To prepare the content of these extra teaching sessions, teachers meet one hour per week. Thus, each teacher sets the objectives for his students and provides his colleagues with a list of exercises to do, extracted from exercises books. Joey would like to rely on all the information available on the knowledge of his students (data from national assessments and learners profiles created by AMBRE-add) to propose remedial sessions either on paper, or with learning software, suited to each student.

This scenario show the complexity of the teacher's work for designing sessions in the light of the information he has on his students: he must parse the information himself, and learn how to handle various tools (generators and / or interface setting tools) to get resources adapted to his students and to his educational goals.

3 Approaches related to personalization of teaching

In the context of learning, researches on personalization try to meet several needs. Proposed approaches can be considered according to three analysis criteria [4]. **Considering individualities of learners** can be done through the use of stereotypes [5] or learners' profiles [6]. In both cases, the difficulty consist in capturing relevant data about learners, and in enabling the teacher or the system implementing personalization to easily access to these data. **Considering the pedagogical needs and habits of teachers** is possible when they use authoring tools [7], when they define learning scenarios [8] or when they configure educational software by themselves [7]. But the heterogeneity of systems is a limit for teachers. Indeed, to adapt activities issued from various sources (produced by generators, described in scenarios, embedded in educational software) to their educational goals, teachers must learn how to use the interfaces of many tools. **Assigning an activity to a learner** can be done automatically by the system [6], or manually either by the learner [9] or by the teacher [10]. In general, the pedagogical choices involved in personalization, and thus the assignment of an activity to a learner, must be made by the teacher if one wants the personalization to reflect pedagogical goals. However, systems that fulfill these requirements are infrequent.

Our analysis of current researches did not enable us to find any approach providing a unique tool supporting personalization of educational activities offered to learners, exploiting their profiles, while respecting the specificity of the educational context. However, this study enabled us to underline the limits of current approaches for personalization of learning. Firstly, to exploit information on learners coming from different sources (paper evaluations, teacher observations, profiles extracted from educational software) a teacher must currently process information himself, for each learner. Secondly, to generate paper exercises or to define the parameters of educational software, teachers must learn to manipulate various tools (generators or setting interfaces). Finally, it is currently impossible to automatically customize software that does not have a dedicated module managing this customization.

4 PERSUA2: a model for a unified personalization of activities

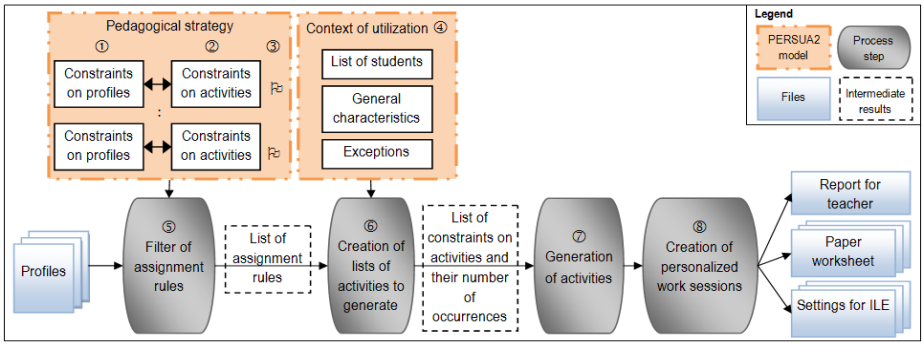

Fig. 1. *Principe of the PERSUA2 model and its exploitation process*

We propose a unified personalization of learning, supported by a single tool used by the teacher. This tool integrates a wide variety of information on learners and is able to adapt activities while taking into account the pedagogical needs of teachers. This tool exploits the PERSUA2 model, formalized in [4], allowing the teacher to define a pedagogical strategy and a context for using this strategy (see Fig. 1). A **pedagogical strategy** defines how to assign activities for learners. This assignment is described using a set of links organized into a hierarchy ③. Links are called assignment rules. An *assignment rule* associates constraints on learners' profiles to one or more constraints on educational activities. *Constraints on profiles* ①, formalized in the cPMDL model [4], enable to select values of the learners' profiles. *Constraints on activities* ②, following the GEPPETO approach [11, 12] enable to select or to generate an activity corresponding to the pedagogical strategy to be implemented. An activity can be a set of exercises to print or activities requiring external educational software associated with the environment configuration. A **context of utilization** ④ defines a set of information to characterize the situation in which the learner is when he carries out the work session. Information concerns, among others, the list of learners for who personalized sessions are required, their profiles, but also more general features on the sequence of activities (number of activities, time, material available…). The context may comprise, in addition to general information for all learners, exceptions for some of them. These exceptions enable one to take into account characteristics of some learners that do not appear in their profiles. The independence of the two parts of the personalization model enables associating the same pedagogical strategy in several contexts of utilization and *vice versa*. In addition, teachers can define as many strategies as they want, each of which can reflect different pedagogical goals. PERSUA2 is associated with an exploitation process. Firstly, teacher defines *pedagogical strategy* and the *context* of personalized sessions. Using this personalization model, the system filters assignment rules given the profile of each learner ⑤, filters activities to generate depending on the rules activated by profiles and context of utilization ⑥, and generates activities according to lists of activities to be generated ⑦. Ultimately, the system provides as many personalized sequences as learners' profiles, and produces a report for the teachers ⑧.

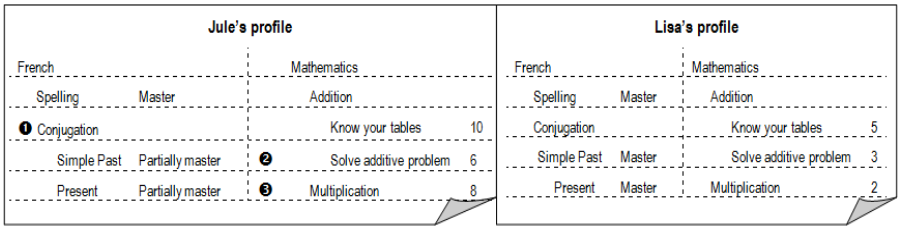

Fig. 2. *Examples of profiles for two students: Jules and Lisa*

We illustrate this exploitation process by the scenario presented in Section 2. To prepare these sessions, Joey creates, for each student, a profile containing information about their skills in French and Mathematics (see Fig. 2). During the support sessions, Joey wants to have the students who have not mastered the skills of conjugation work on a A-type paper exercise and those who partially master this skill on two paper exercises (one B-type and one C-type). For this purpose, we have to look for the value of "French - Conjugation" in the student's profile ❶. This element is the average of its sub-elements. The scale associated with this value is the enumerated list "not mastered, partially mastered, mastered". If the value for the student is "not mastered" then he will have a A-type exercise, (resp. one B-type and one C-type for "partially mastered", and no exercise at all for "mastered"). Joey also wants to make work his students on addition tables. He wants that students which do not master this skill work on a D-type paper exercise, (resp. E-type for "partially mastered", and F-type for "mastered"). The value of this skill ❷ is defined by an integer grade from 0 to 10. If the value for the student is strictly lesser than 5 then he will get a D-type exercise, (resp. E-type if the value is comprised between 5 and 8 excluded, and F-type in other cases). Finally, Joey wants to have his students work on multiplication, using the available software in the computer room where he works. He wants students not mastering the multiplication to do a G-type activity on the software and others do a H-type and I-type activities on the software. Here also the value of the skill ❸ is defined by an integer value from 0 to 10. Thus if the value for the student is strictly less than 5, he will get a G-type activity on the multiplication software, otherwise he will get one H-type and one I-type. For the next support session, Joey wants his students to work mostly on the conjugation, then on the multiplication tables. In addition, he wants each student to get between three and four activities done. This personalization strategy can be formalized with the PERSUA2 model (see Fig. 3).

To exploit this personalization model, first, we compare the values contained in the profiles with the conditions of assignment rules defined by the teacher to obtain, for each student, the list of rules activated by his profile, and the list of constraints on activities involved for each rule. Let us illustrate this exploitation with the profile of Jules (see Fig. 2). To interpret the assignment rules AR_1 and AR_2, we obtain the value of the element "French - Conjugation" ❶ by averaging the values of its sub-elements. Jules got a "Partially master" for this item. Thus only the rule AR_2 is selected. To interpret the assignment rules AR_3, AR_4 and AR_5, we exploit the element "Mathematics - Addition - Know your tables" ❷. Jules got a 10 for this item. Thus only the rule AR_5 is selected. To interpret the rule AR_6, the element "Mathematics - Multiplication" ❸ is used. Jules got a 8 for this item We therefore select the rule AR_6 with the second list of constraints on activities.

Pedagogical strategy				
ID	**IF**	**THEN**	**ELSE**	**Priority**
AR_1	Conjugation = [Not master]	A-type paper act.		High
AR_2	Conjugation = [Partially master]	B & C-type paper act.		High
AR_3	Addition – Know your tables = [0, 5[	D-type paper act.		Low
AR_4	Addition – Know your tables = [5, 8[	E-type paper act.		Low
AR_5	Addition – Know your tables = [8, 10]	F-type paper act.		Low
AR_6	Multiplication = [0, 5[	G-type software act.	H & I-type software act.	Normal
Context of utilization				
List of learners		Ethan, James, Jules, Liam, Lisa, Stanley		
Number of activities		Min = 3; Max = 4		

Fig. 3. *Schema of the personalization model of Joey*

From these two lists (assignment rules and activated constraints on activities), it is possible to take into account the context of utilization for defining the final list of activities to generate for each learner. Let's consider the example of Jules. The result of applying the assignment rules on his profile provides five activities to be generated (types B, C, F, H, I). However, the utilization context specifies that the maximum is four. To remove one activity, we use the priority level of the assignment rule: the activity to be deleted is that associated with the assignment rule of lower priority level, *i.e.* the rule RA5 (activity F). Conversely, for Lisa, the assignment rules give only two activities. We must therefore add an activity to the list of activities to be generated to meet the constraints specified in the context of utilization. This additional activity will be that associated with the assignment rule of highest priority, *i.e.* the rule RA_6 and a second type G activity. Now that the list of activities to be generated has been established for each student, the principles of the GEPPETO approach [11,12] are used to generate these activities (exercises to print and sessions on the multiplication software). At the end of the process, we obtain for Jules, a printable worksheet with two exercises of type B and C, and a configuration file for the multiplication software to do two activities of type H and I; for Lisa, a printable worksheet containing an exercise of type E, and a configuration file for the software to make two activities of type G (these two activities have not the same statement, but have characteristics in common).

5 Discussion

According to our analysis of current researches, no attempt to unify approaches of personalization of learning has been proposed yet. Depending on the problems they intend to address, proposals deal only with a subset of the aspects of personalization of learning. Some approaches use rules to adapt teaching to the learner. For example, several authoring tools [7] enable teachers to create educational software to set up models of pedagogical strategies. However, in these systems, a pedagogical strategy is associated (even included) in a given pedagogical software. Moreover, a teacher cannot define a strategy leading to the creation of a work sequence on multiple media. The PERSUA2 model is, as far as we know, the first model enabling a teacher,

whatever the area he teaches, to create individual activities sessions specific to each learner. These sessions can involve various media, paper and / or software. The PERSUA2 model was defined after interviews with teachers aiming at identifying their practices for personalization. If not exhaustive, it has the advantage of being open. Indeed it has been created to be extensible and can evolve to include new practices and educational needs. This model has been implemented in the ADAPTE software [13] that provides sequences of work suited for the profile of each student and to the pedagogical goals of the teacher. This software demonstrates the technical feasibility of our proposals and has allowed us to evaluate our model thought experiments involving teachers. These experiments, available in [4], showed the utility of our model and relevance of personalization provided by our software. They also showed the complexity of the task required from teachers during the formalization of their personalization rules. For this critical aspect of the personalization process, it is therefore essential to assist the teacher with adapted tools. We therefore seek to improve our system by offering assistance at two levels: a classic help to guide the user through technical issues related to software and an "intelligent" assistance guiding the user in his choices of personalization.

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