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Generation of exercises within the PERLEA project

Stéphanie Jean-Daubias, Marie Lefevre, Nathalie Guin
Université de Lyon, France
Université Lyon 1 – LIRIS, CNRS, UMR5205
43 bd du 11 novembre 1918, 69622 Villeurbanne Cedex, France
{Stephanie.Jean-Daubias, Marie.Lefevre, Nathalie.Guin}@liris.univ-lyon1.fr

Abstract: The research we have carried out relates to the personalization of learning thanks to the exploitation of learners profiles through the PERLEA project. We are aiming at designing a module managing the generation of personalized activities. For this purpose, we suggested a typology of pencil and paper exercises that can be given to a learner, as well as the architecture of generators allowing the creation of all of these exercises. We also implemented and tested our proposition in a module helping the teacher to propose exercises suited to his students' knowledge.

Keywords. Interactive Learning Environments (ILE), personalization, generation of exercises, architecture, genericity.

1. Introduction

Personalization of learning is one of the major issues of Technology Enhanced Learning. Personalization relies in particular on using learners profiles to gather information about the learners, thus allowing to describe their knowledge, skills, perceptions and/or behaviors. These data are collected or deduced from one or several pedagogical activities, computerized or not [6].

Our approach consists in helping the teacher proposing to learners personalized pedagogical activities suited to their knowledge and gaps shown in their profiles, and suited to the teacher's needs and to the pedagogical context, expressed in what we name pedagogical strategies. To personalize pedagogical activities offered to the learner based on their profile, we can either use knowledge-based systems to generate the pedagogical activities best-suited to the profile, or provide the teachers with tools allowing them to perform this task themselves. We aim at linking these two options.

In this paper¹ we focus on the exercises generation part of our research. To build the Adapte module, we proposed a typology of exercises that can be given to a learner, together with the architecture of eight generators able to create all of these exercises. We detail these two aspects before moving on to their implementation and validation.

The PERLEA project aims at improving the integration of ILEs in education by building bridges between the use of ILEs and teachers' everyday practices. To do so, we are interested, in a generic way, in learners profiles and their a posteriori use for the

¹ A long version of this paper is available in the research report RR-LIRIS-2009-016.

management of learners and the personalization of learning [6]. Hence we aim at developing an environment that would permit teachers to manipulate existing profiles. This environment consists of two phases: the integration of existing profiles (based on PMDL, the profiles modeling language that we proposed to unify external learners profiles to permit their reuse, either pencil and paper or software ones [7]) and the management of thus unified profiles. The second phase of the environment proposes rich uses of the unified profiles. One of such uses is accomplished by the *Adapte* module, which offers to learners activities adapted to their profiles. These activities may be pencil and paper activity generated by the system (worksheets to be printed) or computerized activities to be done in an external ILE. In the case of pencil and paper activities, *Adapte* generates worksheets matching the profile of each learner, according to teacher's pedagogical goals. To achieve this, it creates tailor-made exercises to be included in the sheets and determines the size of the worksheets themselves. It also provides the teacher with the answers to the exercises contained in the sheets. In the case of computerized activities, *Adapte* sets personalized sessions on external ILEs according to the learners profile. For this, it uses ILE exercises generators or chooses exercises in the ILE database. It also computes the number of exercises, in which order they appear and the duration of the session.

2. Generation of pencil and paper activities

2.1. Typology of exercises

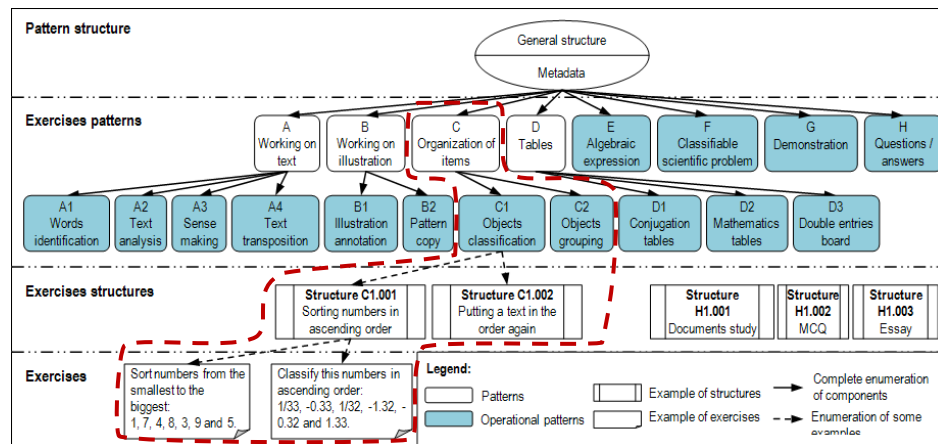


Figure 1: Typology of pencil and paper exercises

By studying curricula published in the official texts of the French Ministry of Education, and subsequently working with teachers in elementary schools, as partners in the PERLEA project, we have identified fifteen types of exercises that can be proposed to a learner, taking into account all subjects and levels. The identified typology of exercises is presented in Figure 1. Our typology contains eight exercises patterns (see A to H in Figure 1), some of which can be split into several operational patterns. An *exercises pattern* (e.g. C - Organization of items, in Figure 1) defines a category of exercises generated with the same exercises generator. An *operational*

pattern (e.g. C1 - Classifying objects) specifies a subset of exercises generated through the pattern generator (here C), but with particular generation constraints. Our typology contains fifteen operational patterns defining fifteen types of exercises. The generic structure of these patterns and the set of metadata common to all patterns are defined in a patterns structure. From there, creating an *exercises structure* consists in associating an operational pattern with generation constraints. Creating an *exercise* consists in assigning to the parameters of the exercises structure values that satisfy these constraints. Thus created exercises are composed of elements of wording and elements of answer proposed to the learner, as well as the solution to the teacher.

2.2. Generation of exercises

2.2.1. What type of generator for Adapte?

Existing exercises generators can be classified into three categories. Fully *automatic generators* generate exercises without any intervention of the user [1] [2]. They permit to quickly create a large number of exercises, but are not customizable by teachers who can neither adapt them to their work habits, nor to their students' specificities. On the opposite, *manual generators* (authoring tools) guide the user in the exercises design [3]. They give the teacher complete freedom. But, he must fully define the exercises and their solutions, which is a tedious task that restrains the use of such systems. Half-way between these two types, *semi-automatic generators* can construct the terms of exercises themselves, but allow the user to intervene in the creation process by specifying a set of constraints on the exercises [4] [8]. Semi-automatic generators have the same strengths as automatic generators (quickly generating a large number of exercises) and provide a solution to their lack of flexibility: teachers can tune the parameters of generated exercises.

The most suitable approach is for us to incorporate semi-automatic generators. We use this approach, which relies on the teacher to provide the knowledge bases for the semi-automatic generators, in cases where state of the art semi-automatic generators seem unrealistic in our generic context. We then studied the possibility for each Adapte exercises pattern to use existing generators. If we except the F-type exercises of Figure 1, with the generators which were available to us, the teacher has either to key in the exercises completely or he cannot influence at all the creation process. Using such types of generators would have prevented us to propose a random option to teachers in the generation of their exercises. For categorized scientific problems (F-type in Figure 1), we integrated into Adapte, GenAMBRE, the generator of AMBRE-Teacher [4] [8], implemented to create arithmetic word problems in the AMBRE-add ILE. By providing the necessary knowledge bases, this generator could be used in a generic way and thus provide exercises on problems of combinatorial analysis, thermodynamics, etc.

2.2.2. Architecture of semi-automatic generators

To each exercises pattern presented in Figure 1 corresponds a generator that creates exercises for the learner and answers for the teacher. An answer will be either defined by the generator if possible, or keyed in by the teacher. If some constraints are not specified by the teacher, they will be specified by the system. Moreover, at the time when an exercise is generated, the exercises structure may contain constraints of re-generation preventing the same exercise to be generated again for the same exercises structure. All generators proposed for Adapte comply with a generic architecture (see

Figure 2). The knowledge of the generators is provided partly by the designer of the system, and partly by the teachers who thus complete gradually the knowledge bases.

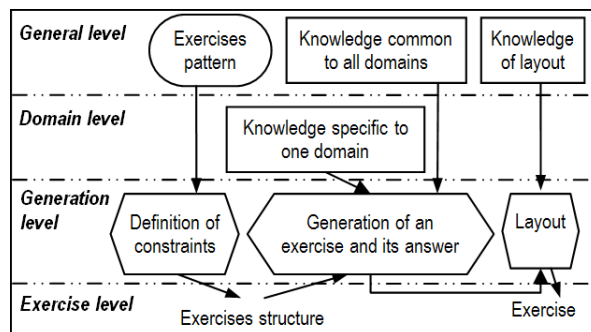


Figure 2: Generic architecture of exercises generators

Thanks to this generic architecture of exercises generators, we can specify four levels. The *general level* contains the knowledge common to all domains for which we want to generate an exercise, e.g. the knowledge required to write a statement in natural language. The *domain level* contains the knowledge specific to the domain, e.g. the knowledge of calculation. The *generation level* contains the specific processes to create an exercise: definition of constraints on an exercises pattern saved in an exercises structure; instantiation of this structure to generate an exercise and its answer; layout enabling to provide exercises with a uniform presentation. Finally, the *exercise level* contains all the documents for the created exercise, including the exercises structure and its instantiation (wording of the exercise and its answer). We specialized the generic architecture alike to define the exercises generators associated with the exercises patterns except for the "Demonstration" pattern (G in Figure 1).

These architectures are implemented in the Adapte module. When a teacher wants to create an exercise, he has first to choose the corresponding type of exercises. From this operational pattern, the system presents the teacher with an interface enabling him to define the constraints of exercise generation depending on his pedagogical goal. For example, for the conjugation operational pattern, the teacher chooses a language and can specify the tense, persons, types of verbs (regular or irregular for English language) and/or verbs, and the number of verbs to be proposed to the learners. All these constraints are saved in an exercises structure, described with metadata to facilitate its reuse. The system generates the exercises contained in the personalized worksheets from this exercises structure. Thus it generates different exercises from the same exercises structure.

3. Conclusion

We established an approach of personalization of learning helping teachers to propose pedagogical activities suited to learners' knowledge and to teachers' needs. In this framework, we focused here on the generation of pencil and paper exercises.

First, we presented our typology of exercises that can be given to a learner from primary to high school. This typology includes fifteen types of exercises. We defined it with the primary school teachers associated to the project and test its scope with

secondary teachers. We observed each of the exercises they use for their French, English, mathematics, biology, history and geography classes. All the exercises used were in our typology. Now, we have to work with experts in educational science to completely validate our typology, both in its genericity and its completeness.

We then proposed a generic architecture of exercises generators and set the architectures of the eight exercises generators that we considered necessary to create the exercises of our typology. These generic architectures can be used to develop exercises generators whatever context they are meant to be used in. If these architectures facilitate the setting up of generators in new domains of application, there is left to do a considerable work of instantiation of knowledge bases for a new domain. We were able to test the genericity of these generators by implementing some of them in varied domains (for example we have implemented the tables generator to propose conjugation exercises but also multiplication or addition ones).

We also developed *Adapte* in partnership with teachers according to differentiated design [5] and submitted it to few teachers. Every feedback validates the software: it is usable and permits teachers to define the constraints allowing to generate exercises matching their needs (expressed in their constraints) and their learners' knowledge (due to *Adapte* functionalities not presented in this paper [9]). We must now make further evaluations involving all concerned modules of the PERLEA project environment [6], and ranging from the description of a learners profiles structure by the teacher [7] to the effective use of personalized activities by learners [9].

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