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Evolutionary learners profiles

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Abstract: If the concept of learners profiles is now well known and treated in various ILE (Interactive Learning Environments), the taking into account of evolution in profiles do not benefit from the same advances. The subject of this paper is to define this notion and to show how it is taken into account in ILE researches. After a definition of the concept of evolutionary learners profiles illustrated with examples, we show how this concept changes the models of our project, notably the evolution of PMDL profiles modeling language to PMDLe, that take into account the evolutivity of profiles. Then we present the consequences and benefits of these changes in the different modules of EPROFILEA environment that implement our models.

Introduction

A learner profile allows gathering information on knowledge, skills or behavior of a learner, information collected from a pedagogical activity, whether computerized or not (Eyssautier-Bavay & al. 2009).

These learners profiles are at the heart of many ILE (Interactive Learning Environments), they are also used, explicitly or not, consciously or not, by all teachers and all learners. Finally, they are also wanted by institutions. However, the different existing profiles are too often under-exploited: they are only used in their context, while their interest may go beyond. Figure 1 shows two examples of learners profiles. SQL-Tutor profile (Mitrovic et al., 2007) provides a report of knowledge studied and acquired by the learner at a given time (see left part of Figure 1). The second example is an extract from a pencil and paper learner profile, used by teachers of 3 to 6 years old pupils of a French infant-school (cf. right part of Figure 1). This profile shows to teachers, family and eventually the pupil him-self the level of mastery of different skills targets by the learner.

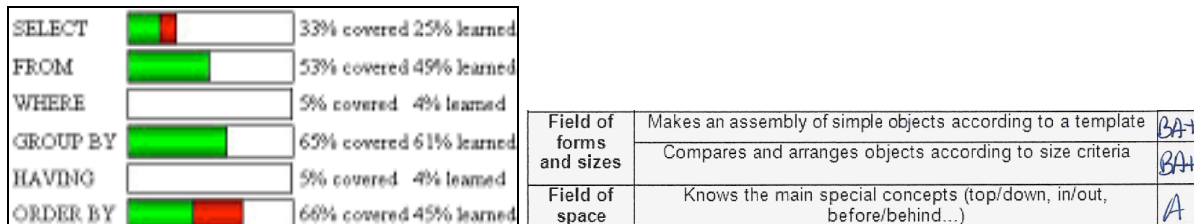


Figure 1 : Profiles examples, one from SQL-Tutor and one from Antoine Remond infant-school.

In the work presented here, we focus on the reuse of existing heterogeneous learner profiles by actors other than their authors, in particular to promote the use of profiles beyond the context of their creation.

The reuse of profiles requires a harmonization of the profiles. It can be made by several approaches. A priori approaches, based on standardization (PAPI, 2007), (IMS LIP, 2011), on ontologies (Heckmann, 2005) or on the portfolio (Grant & Hubner, 1998) require that the learner profiles are initially written in a specified formalism. The fact whether they are a priori approaches is a limit to a large exploitation of tools based on these works. Indeed, only profiles that respect the specifications could be treated, while the existing profiles are very heterogeneous and most of them do not respect such specifications.

As for a posteriori approaches, they involve rewriting profiles in their own formalism in order to treat them, such as DynMap + (Rueda et al., 2006) or VisMod (Zapata-Rivera and Greer, 2004). The main limit of

systems that adopt this approach is their lack of genericity: they only know how to rewrite the profiles from identified sources. (Ramandalahy et al., 2009) adopt a more flexible approach.

In our work, we adopt a generic approach: we provide an environment able to rewrite all kinds of existing profiles which we know neither the structure nor the data, without imposing any a priori formalism. This approach relies on a generic environment without any content that users will complete with the information they need: it is the users who add their own semantic to the system, in contrast to a priori approaches in which semantic is given and imposed.

In this paper, we focus specifically on the taken into account of evolution in the learners profiles. Getting information about the evolution of profiles allows keeping trace of previous states of knowledge for future exploitations: either for diagnosis in ILE or learners following by different actors (teachers and institutions, but also families and learners in a metacognitive context). Thus, an ILE can use the evolution of mastery of a given knowledge to adapt the level of proposed exercises, a teacher will not only be interested in the learner mastery level, but also in this level evolution since the last evaluation. For this, the profiles should include the concept of evolutivity.

Let's take an example of evolutive profile, translated from a pencil and paper profile used by teachers from a French infant-school. This profile is used to follow the pupils competencies during three years (small section -SS-, middle section -MS- and high section -HS-). Each year includes two evaluation periods. The profile extract presented in Figure 2 concerns the section "Discover the World", composed of three topics themselves composed of different components to evaluate. The rating scale used by this school is textual and graduated: an element evaluated over a period may be associated with "not acquired" (NA), "being acquired" (BA), or "acquired" (A). The level "being acquired" is divided in BA- and BA+ and for a greater accuracy in the evaluation. In our example, "Knows the main spatial concepts" is a skill acquired for each evaluated period. An element of the profile may not be evaluable over a period, then it is associated with a black box. In the example of Figure 2 "Compares collections and arranges them according to quantitative criterion" is not evaluable in small section. It also happens that learners are not evaluated for an element over certain periods, in this case the element is associated with an empty box for the corresponding period. This is the case for example on the profile of Figure 2 for the first periods of small and medium sections for the element "Makes a collection containing the same number of objects as a referent collection".

		SS	MS	HS
Discover the world				
Approach of quantities	Knows the numeric song (10 for SS, 15 for MS and 30 for HS)	BA+ A	BA- BA+	NA
	Counts small quantities (3 for SS, 6 for MS and 10 for HS)	BA- A	BA+ A	BA+
	Makes a collection containing the same number of objects as a referent collection		NA	BA-
	Compares collections and arranges them according to quantitative criterion			BA+
Field of forms and sizes	Makes an assembly of simple objects according to a template	BA- A	BA+ A	A
	Compares and arranges objects according to size criteria	BA+ A	BA+ BA-	BA-
Field of space	Knows the main special concepts (top/down, in/out, before/behind...)	A	A	A

Figure 2 : Extract from pencil and paper evolutive profile from Antoine Rémond infant-school.

In existing works providing tools for profile management, evolution in learner profiles is currently not taken into account or not in a satisfactory manner. It is thus currently not possible to manage in a rich manner evolutive profiles such as the one presented in our example (cf. Figure 2).

Regarding a priori approaches, some standards take into account the time (like PAPI and IMS LIP which allow storing information on learner performance for different periods). The portfolio also keeps trace of several periods of learning, indicating the evaluation date. Let's remember however, that these approaches have a significant limitation: they only apply to profiles that respect their own formalism.

Regarding a posteriori approaches, among the works we have cited, only DynMap+ takes into account evolution in profiles. But let's remember its lack of genericity: it covers only the learners profiles as Bayesian networks.

In the rest of this paper, we show how we take into account the evolution in learners profiles in our approach. After this introduction, we first present the context of this research, PERLEA project, and then the models proposed in this context, including the PMDL profiles modeling language and its extensions, and their implementation in EPROFILEA environment. We present in the paper heart how we have changed these models

and tools to take into account evolution in profiles. We conclude by referring to the exploitations that may be made of these profiles now evolutive. We illustrate these different parts with examples.

Context

PERLEA project focuses on learning personalization through exploitation of learner profiles. It aims to provide models and tools for re-use of heterogeneous learners profiles without distinction of level or discipline, existing or future, pencil and paper or software, in different contexts and by actors other than their author.

PERLEA project has resulted in the specification of **REPro model** (Reuse of External Profiles), a profiles management process model which runs from the creation of learners profiles to their uses (cf. bottom of Figure 4 for an overview and (Eyssautier-Bavay et al., 2009) for a more detailed presentation). This model, beyond a preliminary profiles constitution stage, highlights the need to harmonize structure and data of profiles to provide a unified representation, before possibly transform, then use these profiles. For harmonization, REPro is based on a formalism describing profiles to make external profiles reusable.

PMDL language (Profiles Modeling Language), that is used as pivot language between external profiles that respect various formalisms and reusable profiles rewritten in a common formalism, is a profiles modeling language that describes the structure of a profile in order to express different heterogeneous profiles in a same formalism (Eyssautier-Bavay & Jean-Daubias, 2009). For this, PMDL distinguishes in a learner profile its structure part, which may be common to several profiles, from its data part, containing information specific to each learner. Thus, PMDL is a theoretical model that defines basic elements that a teacher can instantiate and combine to form the profiles model that he would like to manipulate, model which we call profile structure. This profiles structure, common to several learners, will be instantiated to contain the data corresponding to each learner profile.

PMDL language is described formally in a BNF notation, coupled with a more accessible graphical representation (cf. Figure 4), the one used in this paper. PMDL allows describing the profiles structure at the harmonization step. This language, independent of any platform and therefore reusable, can express to the same, that is to say without loss or corruption of information, most existing profiles according to the same formalism, whether these profiles come from software or pencil and paper practices. A profile described with PMDL is composed of information about the learner, with a structure part and a data part. The profile structure, independent from data that it contains, includes a set of elements (for instance "mathematics" or "grammar"). There are four types of content for an element: *components_list*, *distribution_list*, *graph* and text (see Figure 3). These four types of content allow the creation of profiles which structure can vary in order to answer to teachers' needs. However, PMDL does not represent evolutive learners profiles.

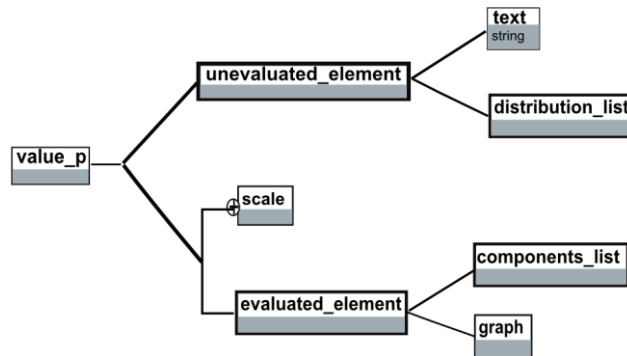


Figure 3 : content of a profile in PDML.

We defined PMDL application context and the language expressivity in this context. PMDL application context accurates information that the language takes into account or not. We then evaluated PMDL expressivity within this application context while expressing different profiles with PMDL, in order to test the limits of its expressivity. The main limits of the language revealed by the evaluation are its inability to take into account evolution in profiles, time spent on activities, the link with the activities at the origin of evaluations and the profile's elements organization. On the contrary, some limits, such as not taking into account traces are related to the nature of the learner profiles and do not need to be removed.

PERLEA project also resulted in the development of an ILE, **EPROFILEA environment** that implement models defined in PERLEA. EPROFILEA concerns the different actors of learning, even if it is primarily intended for teachers. It has three parts themselves composed of several modules (cf. Figure 4).

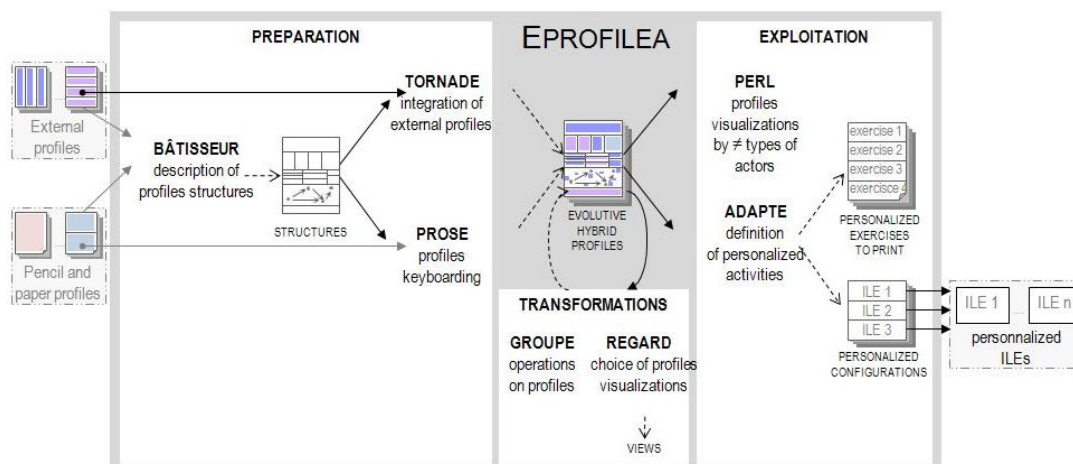


Figure 4 : Architecture of EPROFILEA.

The first part of EPROFILEA environment, the part of profiles preparation, consists to establish the profiles structure we manipulate, before we integrate data from external profiles in order to build learners profiles in accordance with the teacher's wishes and respecting the formalism of EPROFILEA. PMDL language is operationalized in Bâtitseur module that allows you to define the structure part of learners profiles in a unified formalism. Profiles structures from Bâtitseur will be completed in the data integration modules: Prose and Tornade. Prose module helps the teacher to enter data from each student pencil and paper profiles according to the profile structure defined in Bâtitseur. To integrate external software profiles (from educational software outside from EPROFILEA), Tornade module allows experts to create conversions profiles systems, which teachers can use to integrate data from the corresponding profiles to profiles respecting EPROFILEA formalism. Profiles thus formed may be hybrid: they may come from different sources whether they are pencil and paper or software. A profile part can come for instance from the use of an ILE of algebra, another from an ILE of grammar and the rest of the profile can come from evaluations made by hand by a teacher.

The second part of EPROFILEA is dedicated to profiles transformation. These transformations can be related to their structure or their data (Groupe module allows among others the constitution of a group profile from the group's learners profiles) or prepare profiles visualization (Regards module enables teachers to define different profiles views and to specify which views are accessible by which actor, teachers, learners, families...).

The third part of the environment, the part of profiles exploitation, offers from one hand activities on the profiles, with Perl module, and on the other hand personalized pedagogical activities defined based on the learners profiles content with Adapte module. Perl module will enable interactive profiles visualization by the different actors according to the views defined by the teacher in Regards. It also offers learners, in addition to profiles viewing, activities on profiles (rewording, negotiating profile elements...) allowing the learner to enter into a reflexive approach relative to his learning, and thus to better assimilate and exploit the information provided to him. As for Adapte module, it aims to give teachers the possibilities to personalize pedagogical activities proposed to their students according to their needs based on their pedagogical choices (Lefevre et al., 2009).

Evolution in PERLEA models

Until now, even if it was one of the initial objectives of PERLEA project, models and tools of the project do not take into account evolution in profiles. In this section, after defining the concept of evolution in learner profiles, we show how we made change models and tools of PERLEA project so they support evolution in profiles management.

The concept of evolutive learners profiles

In PERLEA project context, a hybrid and evolutive learner profile refers to a file collecting various information about the learner. This information may relate to his knowledge, skills, conceptions, behavior, or metacognitive information. Such a profile can include information from different sources that can be heterogeneous: we call it hybrid profile. Information that it contains can also cover different periods for a single element evaluated: we call it evolutive profile. Thus, evolutive profiles notion refers to the evolution of learner data in his profile.

Let's take again the example of the pencil and paper profile of an infant school pupil of Figure 2. This profile is evolutive: it keeps the results of all evaluations made during the six evaluation periods in infant school, in order to follow the learner's skills evolution. Thus, we see that the learner's knowledge rose in small section year for the element "counting small quantities" for the topic "approach of quantities". Indeed, this competency was "being acquired" for the first evaluation period and "acquired" during the second period. On the contrary, the learner has declined in middle section for the element "Makes an assembly of simple objects using a template" for the topic "Domain of forms and sizes", as it was "being acquired +" during the first period and "being acquired -" during the second period. Unlike this example, especially in ILE, most profiles are not evolutive, like the profile of SQL-Tutor (cf. Figure 1). For these profiles, it is not possible to identify fields in which the learner has achieved consistent results and those in which it has risen or declined.

Extension of PMDL language in PMDL_e

Taking into account the concept of evolution in learners profile has caused the modification and extension of PMDL profiles modeling language to PMDL_e, for PMDL *evolution*.

In its graphic representation that completes the definition in BNF, each element of PMDL is represented in a framework with a white part and a gray part. The white part contains the element name. If the element is terminal, that is to say if it is not composed of any other element, the gray area contains the element type, this field is empty otherwise. The diagrams of this graphical representation are tree structures that must be read from left to right. Elements on the left side of other elements and connected to them by a line contain them. Thus, the symbol < represents a logical OR relationship, [represents a logical AND relationship, * means the element can be present from 0 to n times, + means the element can be present 1 to n times, ? means the element can be present 0 or 1, that is to say, it is optional. The absence of symbol before an item means it is present exactly once.

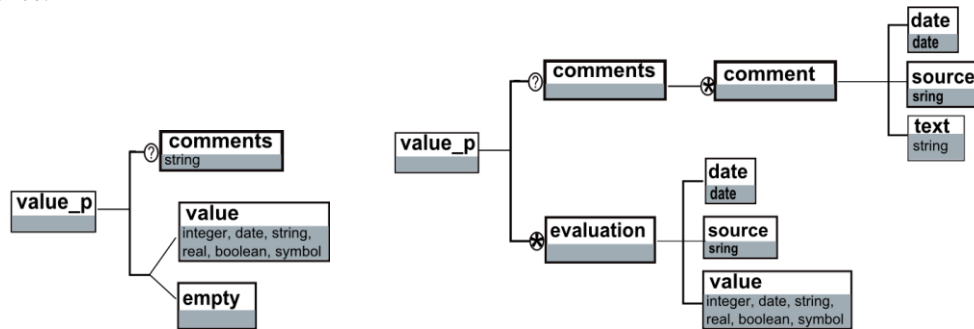


Figure 5 : Graphical representation of `value_p` in PMDL (on the left), and in PMDL_e (on the right).

To respect the concept of evolution in learners profile and thus allow a profile to contain information on different periods for a single evaluated element, it is necessary to keep in the learner profile data part each value and comment, by associating them with a date and possibly a source of evaluation. That is why some elements of PMDL have been modified, whether they concern the structure part or the data part (Ginon and Jean-Daubias, 2010). Thus, the content of `value_p` of PMDL, has been modified in PMDL_e (cf. Figure 5). It now contains zero, one or more *evaluation*. The *evaluation* contained in `value_p` elements is associated with a *date*, a *value* and possibly a *source*. This allows associating a new *value* with `value_p`, without deleting the previous ones. The optional *comment* element is replaced in PMDL_e by the optional *comments* element. In

PMDL a *value_p* contains a single *comment* as string: thus, each new *comment* associated with a *value_p* replaces the previous one, which is totally deleted. On the contrary, *comments* of PMDLe contains zero or more *comment*. Each *comment* of PMDLe is associated to a *date*, a *text* that aims to contain the comment and possibly a *source*, which allows associating a new *comment* with *value_p* without deleting the previous *comment*. A concrete example illustrating the interests of the change is in next section.

By defining PMDLe, we also completed PMDL beyond that required the taken into account of evolution by allowing for example to associate with a profile as much information about the learner the user wants, structured as he wishes, and not just a name and a surname, as it was the case in PMDL, or by adding the source of the evaluation concept that was missing until now. Thus, PMDLe can now represent not only the personal learners data (whether they are behavioral, cognitive or metacognitive), but also allows taking into account temporality, time spent on activities and links towards the productions associated with the evaluations.

We evaluated PMDLe expressivity in its application context, while studying changes in comparison to PMDL expressivity. The results are logically close to those of the evaluation of PMDL expressivity. Indeed, all profiles supported by PMDL are also naturally supported by PMDLe. Most profiles outside PMDL application context can be supported by PMDLe. Concerning the profiles based on a Bayesian network, resulting profiles can be represented without problem, but the Bayesian network itself can only partially be represented by PMDLe. A profiles modeling language does not aim at modeling the profiles formation stage, but profiles themselves. So, the representation part of the resulting profiles is sufficient for the validation of PMDLe. Thus, in its application context, PMDLe allows representing all profiles that we studied.

PMDL language is completed by operators that define the possible profiles transformations. These operators can answer to the needs of profiles modification, after their creation, whether these needs relate to their structure or their data.

These operators on PMDL profiles have been defined in a semi-formal manner. They allow for example to read the comments in the text elements, add or delete an element to a profile, create a group profile from the profiles of several learners with the same structure: the resulting profile will have the same structure that learners profiles from which it was created, but the values it will contain will be calculated from the values contained in the individual profiles.

Operators on profiles respecting PMDL formalism are still suited to evolutive profiles respecting PMDLe formalism. But thanks to new opportunities provided by PMDLe, new operators can be defined. For instance, synthesis operators by average or sum (cf. ① and ② Figure 6) allow reducing an element by replacing all evaluations which the date is within a certain interval with an evaluation that has for value the average or the sum of the replaced evaluations. These operators take as input the profile, the element and a set of two dates making up an interval. One or all of these two dates may be null: it would compress all evaluations before or after a given date. The operator returns a profile with the same structure as the initial profile, but in which the specified element has been compressed. This can be used to keep trace of the progress of a pupil over months, without keeping each intermediate result in his profile.

	Operator	Description	Type of element concerned
①	CompM	Element synthesis by average, according to an interval	components_list, graph
②	CompS	Element synthesis by sum, according to an interval	distribution_list
③	FiltreE	Element filtering, according to an interval	all
④	FiltreP	Profile filtering, according to an interval	all
⑤	ConcatE	Comments concatenation in an element, according to an interval	all
⑥	ConcatP	Comments concatenation in a profile, according to an interval	all
⑦	InterEvalE	Evaluations intersection between 2 profiles, according to an interval	all
⑧	InterEvalP	Evaluations intersection between 2 profiles	all

Figure 6 : New evolutive profiles operators.

Let's take again the example of the evolutive profile of an infant-school pupil, given in Figure 2. Some evaluated elements have the same title for the three sections of infant school, while they do not correspond exactly to the same exercises. For instance, for element "knows the numeric song", the numeric song has 5 numbers in small section, 10 in middle section and 30 in high section. To know the learner evolution for this

element, it is important to consider only the evaluations related to the same year of infant school. Indeed, we observe that for the second period of evaluation in small section, the learner had "acquired" this skill when it was only "being acquired" for the first evaluation period in middle section. However, this is not a regression; the numeric song is longer and thus more complex when the learner moves into a higher section. In these conditions it is necessary to use a filtering operator in order to keep only the evaluations of a same year before seeking to determine the learner for a given element.

cPMDL constraints on profiles model defines the various constraints that may be associated with a learner profile defined by PMDL formalism (Lefevre & al., 2009). Three types of constraints are defined by cPMDL: constraints on profiles on a value, on an element and on a number of occurrences. In order to exploit new possibilities offered by PMDL, we defined three new types of constraints added to cPMDL to expand it in cPMDLe for cPMDL *evolution*: constraints on profiles on value evolution, on a value, an element or a number of occurrences. These types of constraints correspond to the existing types in cPMDL, which are still valid with evolutive profiles, but focus specifically on the evolutive nature of profiles.

These new constraints allow studying the learners results evolution for an element of a given profile and a given period to determine if the learner has risen, regressed or if he has obtained stable results. cPMDLe makes it possible to study the regularity of the learner's evolution.

Evolutivity in EPROFILEA environment

The implementation of the concept of evolutive profiles in PERLEA project, apart from changing the affected models, has caused the modification of various modules of Eprofilea environment (cf. Figure 4). Indeed, changes in the profiles modeling language have had effect in its operationalization in EPROFILEA, for the profiles structures definition, their completion, their possible transformations and their exploitations.

So we needed to modify the **module of profiles structures description**. Bâtisseur module allows the teacher to describe the structure part of a learner profile through an interface; the result (the profiles structure) is stored in a file respecting PMDL operationalization (cf. Figure 7).

```
<brick id="7" type="0" name="Discover the world">
<comments/>
<tree_of_components>
<component name="Approach of quantities">
<subcomponent name="Knows the numeric song"><value/></subcomponent>
  <subcomponent name="Makes a collection "><value /></subcomponent>
  ...
</component>
</ tree_of_components >
</brick>
```

Figure 7 : Extract from an evolutive structure of profiles outcome of Bâtisseur.

```
<brick id="7" type="0" name="Discover the world" indice="6" comment="Good work" ①>
<tree_of_components>
<component name="Approach of quantities">
<subcomponent name="Knows the numeric song"><value>NA ②</ value></subcomponent>
<subcomponent name="Makes a collection"><value>BA-</value></subcomponent>
...
</composante nom>
</tree_of_components>
</brick>
```

Figure 8 : Extract from a file of non evolutive profile in EPROFILEA.

Bâtisseur allows the creation or modification of profiles structure, which may be common to several learners profiles, usually at least one class. In EPROFILEA environment, profiles structures and learners profiles are stored in XML files, the doctype of these two files types has been modified to fit the definition of evolutive learners profiles described with PMDL. Bâtisseur has been modified so that profiles structures files that it creates are in conformity with the new doctype (cf. Figure 7).


```

<brick id="7" type="0" name="Discover the world" indice="6">
  <comments ③>
    <comment date="2009/06/11" source=" semester2SS">Good work for the whole year ④</comment>
    <comment date="2010/06/18" source=" semester2MS">Good work</comment>
  </comments>
  <tree_of_components>
    <component name="Approach of quantities">
      <subcomponent name="Knows the numeric song">
        <value>
          <evaluation date="2009/01/21" source="semester1SS">BA+ ⑥</evaluation>
          <evaluation date="2009/06/07" source="semester2SS">A ⑦</evaluation>
          <evaluation date="2010/01/23" source="semester1MS">BA- ⑧</evaluation>
          <evaluation date="2010/06/05" source="semester2MS">BA+ ⑨</evaluation>
          <evaluation date="2011/01/15" source="semester1HS">NA ⑩</evaluation>
        </value>
      </subcomponent>
      <subcomponent name="Makes a collection">
        <value>
          <evaluation date="2009/06/07" source="semester2SS">NA</evaluation>
          <evaluation date="2010/06/05" source="semester2MS">NA</evaluation>
          <evaluation date="2011/01/15" source="semester1HS">BA-</evaluation>
        </value>
      </subcomponent>
    </component>
  </tree_of_components>
</brick>

```

Figure 9 : Extract from a file of an evolutive profile in EPROFILEA.

Figure 8 and Figure 9 show an extract of the same learner profile which structure is given Figure 7: the part corresponding to the component "approach of quantities ", of the brick "Discover the world". In Figure 8 this extract is written in PMDL and gives only the last value for each element of the profile, in Figure 9 it is written in PMDL_e and therefore allows to see the students' evolution.

Comparing these two extracts, we notice that the first profile can only contain information related to a single evaluation for the sub-component "knows the numeric song" of the component "approach of quantities" NA (cf. ② Figure 8). In case of further evaluation, this information will be lost and replaced by a new one. In contrast, in the second profile which is evolutive, information related to each evaluation is kept, modifiable and reusable (cf. ⑥ to ⑩ in Figure 9). For instance, Figure 14 shows in ⑥ that the learner had level BA+ for the sub-component "knows the numeric song" in the evaluation from 2009/01/21, then in ⑦ he has the level A for the evaluation from 2009/06/07. This information would not have been kept by the non-evolutive profile. In addition, the non evolutive profile kept neither the date nor the source of evaluations, in contrast to evolutive profile. As well, we see that the second profile keeps each comment, unlike the first. Thus, in our example, the learner had on 2009/06/11 as commentary related to the brick "Discover the World", "Good work the whole year" ④ while on 2010/06/18, the comment was "Good work". Again, the evolution is meaningful and interesting for the different actors of learning. The main change is thus the fact that Bâtisseur operationalizes now PMDL_e, and not PMDL, allowing it to integrate the notion of evolutive learners profiles. These modifications have repercussions on all EPROFILEA because the other modules of the environment handle learners profiles with a structure defined with Bâtisseur.

We also needed to modify the **module of profiles keyboarding**. Prose module allows the teacher to complete learner profiles corresponding to a structure of profiles from Bâtisseur, and create at first the profiles if they do not already exist, this transparently to the user. This module allows completing the data part of a profile in PMDL_e, part specific to each learner. In Eprofilea, a learner profile is store in a XML file that follows the same doctype as the profiles structure files. Learners profiles changed to satisfy the concept of evolutive profiles, so Prose has been modified accordingly. Thus Prose now allows capture in profiles for different periods. To take into account the new possibilities enabled by evolutive profiles, the interface has also changed

to allow the teacher to choose between adding a new evaluation for selected profiles and modify its previous evaluations. These changes make Prose fully able to handle hybrid evolutive profiles.

We needed to modify the **module of external data integration** too. Tornade module makes it possible to complete the data part of a profile, described in Bâtitseur based on an operationalization of PMDLe, using data from external software, and if necessary, to create previously the profiles transparently to the user. Tornade has been modified in order to take into account the concept of evolutive learners profiles. For this, we first modified the parser structure created by Tornade. The parser is a conversion system for data integration from an external ILE profile, in a profiles structure respecting EPROFILEA formalism, based on PMDLe. The parser structure is similar to the profiles structure which it relates, with the difference that evaluations and comments nodes do not contain text or integers representing values for a pupil, but information allowing to identify how to properly complete these nodes from the external software data for the considered learner. The parser structure is now based on those of evolutive profiles. Thus Tornade, as Prose, can now manage learners profiles not only hybrid, that is to say containing information from different sources, but also evolutive, that is to say keeping trace of different values of successive states for profiles.

Finally, we needed to modify the **module of personalization of pedagogic activities**. Adapte module allows the creation of worksheets and pencil and paper sequences of personalized activities in different ILE according to each learner profile, to teaching strategy and its context of use defined by the teacher. For this, the generation stage of worksheets to print or personalized activities sequence needs the definition of rules for allocation of pedagogical activities to learners. These rules are based on profiles constraints defined using the profiles constraints model cPMDL (Lefevre & al., 2009).

As PMDL has been extended in PMDLe, we have modified in Adapte the profiles consultation functions that find in the learner profile the value associated with an element, to determine the value associated with the latest evaluation on this element, thus making Adapte compatible with evolutive profiles.

Moreover, the notion of evolutive learners profile allows increasing the possibilities of Adapte by extending cPMDL to cPMDLe. The teacher can also personalize learners' learning, based not only on their knowledge but also on this knowledge evolution. cPMDL extension allows affecting for example review exercises to learners whose results have fallen, or upper level exercises for students whose results are always excellent. If a more systematic study is needed to identify all the constraints considering evolutivity, we have already created several constraints that we have implemented in Adapte. Thanks to one of these new constraints, the teacher can notably select the profiles of learners who progressed in an element, and has been regular during a given period, that is to say their result has increased with each new evaluation in this period. The teacher can also select the profiles of learners whose results were globally stable, that is to say the gap between the best and worst evaluation in this period belongs to a small interval specified by the teacher.

Let's go back to our example of the evolutive profile of a pupil given in Figure 2. We have seen that in middle section, the learner has regressed for the element "compares and arranges objects according to size criteria" in the "Field of forms and sizes". The teacher may decide to start the session with a small section exercise for students in this case, to put them in trust for the rest of the session. For this, the teacher must create an evolution constraint for the element "compares and arranges objects according to size criteria" and the period of middle section, to assign to this students a review exercise in the beginning of the session.

Conclusion and perspectives

In this paper, we discussed the concept of evolutive learners profiles, and its taken into account in both models and tools of PERLEA project, maintaining the generic approach claimed in the project. After defining the concept of evolutive learners profile, we firstly show how we modified the profiles modeling language PMDL to PMDLe, which supports the evolutive nature of profiles. This has resulted in the modification of the different representations of the language: BNF notation and graphic representation, which we added a XML representation, more convenient for the operationalization of the language. Thus, PMDLe allows keeping in the learner profile, if the teacher wishes, each evaluation result and each comment by associating them with information such as date and source of evaluation. Integrating the concept of evolutivity allows keeping information on learner progress.

Moreover, to highlight the various possible uses of the formalism described by PMDLe, we defined eight new profiles operators respecting this formalism, suitable for all profiles described in PMDLe. In

addition, we extended the profiles constraints model cPMDL in cPMDLe for cPMDL *evolution*. We have defined five new types of constraints allowing the user to constrain the evolutivity of learner profiles. We then implemented some of these evolution constraints in Adapte module of EPROFILEA environment.

We also showed how we have implemented PMDLe in EPROFILEA. This operationalization has resulted in the modification of all existing modules of the environment. The whole EPROFILEA environment thus allows to manage not only hybrid, but now also evolutive learners profiles. Profiles structures and profiles used in EPROFILEA must now respect PMDLe formalism. Nevertheless, to ensure compatibility with non evolutive profiles, it is possible to use Tornado to insert the information they contain in an evolutive profiles structure.

The taken into account of the concept of evolutivity for learner profiles management opens new perspectives. First, the evolutivity of a learner profile should be taken into account when viewing this profile. Indeed, an evolutive learner profile will allow not only viewing the profile, but also the learner's progress. It will also allow, beyond different planned activities on profiles, to create activities around the concept of evolutive learner profile, such as goals definition for the learner. Thus, a teacher may, for example, define a goal with a learner, and then view with him the results he has achieved, and thereafter determine whether the goal has been met or not and even surpassed. Then, taking in account the evolutivity of profiles in EPROFILEA extends the possibilities of personalization of pedagogical activities permitted by Adapte.

This work shows first the feasibility of taken into account the evolutivity of learners profiles in a generic approach, and also makes possible particularly rich exploitations of these evolutive profiles, increasing the already significant possibilities proposed by EPROFILEA environment.

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