SPECIFICATION OF LEARNING TRAILS IN VIRTUAL COURSES

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Abstract *- Life long learning and goal driven learning put new requirements to virtual online courses. The development of virtual courses is not just a technical but moreover a didactic and pedagogic challenge. In order to cope with the requirements met by heterogeneous student groups of online courses, learning trails are classified, which guide students through a course in different ways. A learning trail can be oriented to the didactic structure or the structure of the subject's scientific domain, to learning units of the same type like conclusions or exercises, to selective or modal structures. This enables students to use the same online course in a productive and effective way. L3-XML, an XML-DTD, is presented here to specify an online course enabling different learning trails. The concept is demonstrated at the course "Introduction in object oriented programming".*

Index Terms — *Distance learning, learning trail, XML*

INTRODUCTION

Life long learning and goal driven learning put new requirements to our education system and the structure and contents of the courses offered to students by the institutions. The number of people continuing their studies along with their job and even after a completed professional education increases steadily.

Until some years ago many employees received further education in weeklong courses within their company in Germany. Nowadays, the responsibility lies to a large extent with the employees themselves. Moreover, the number of courses increases that can be directly joined at the working place. As a consequence, costs for further training and especially costs induced by the absence from the working place shall be reduced.

Therefore, a significant need for courses has emerged which are suitable for tele-learning. In the following, such courses are called online courses.

But graduate and undergraduate students use such online courses, too. They can e.g. gain required prerequisites for their studies. Subjects can be studied asynchronously in time. The students are more flexible by having time to earn money or to bring up children.

In the last years many curricula were modularized in Germany with the intention to develop courses that can be held in different programmes and disciplines.

Such use of courses is not only a didactic but also a technical challenge, because the course has to be appropriate for

- further training during the job (life long learning),
- undergraduate and graduate studies and
- different institutions and places.

This leads to high heterogeneity of the participants of an online course, with respect to the learning goals and learning profiles of the students as well.

Because an online course is especially meant for a large number of students that heterogeneity induces new and important requirements to online courses.

Regarding the learning preferences of students is a key to learning success in ordinary classroom teaching. Teaching and learning happen during communication and interaction while the teacher gets to know the learning properties of the students, thus being able to modify the learning subjects and its presentation and enabling the students to learn more effectively.

It is very difficult to implement such a feature in online courses. It requires a permanent observation of the students by the computer and the use of methods of artificial intelligence. We are working on such a solution where intelligent agents are used. But at the moment such an adaptive course cannot be automatically generated out of a normal course. A presentation of the content of a learning unit for effective learning can only be generated from given material and specified learning trails.

The paper is as organized as follows: After outlining environments of online courses, learning trails and their classification are then defined. Learning units are introduced as basic items of courses. For the

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specification of courses, L3-XML is presented and its use is outlined in an example course.

Environment of Online Courses

Common online courses are embedded in an overall concept of a professional study. They are offered by an institution that could be a virtual university like the Virtual University of Applied Sciences [1]. But it can also be used in supporting ordinary classroom teaching. Different teaching and learning forms support learning from text studies, interactive simulations, email conversation, videoconferencing to classroom teaching [2]. In the following, the main subjects are online courses, although they are embedded in the entire course offer including phases of classroom teaching. Moreover, concepts of group work are included.

The online courses can be embedded in a learning space like e.g. Gentle [3] or Blackboard [4]. A learning space provides a uniform access to the tools for e.g. videoconferencing, but does not provide support for coping with different learning profiles.

At the moment, online courses are mainly written in HTML. Newer courses are developed in XML [5], because documents can be better structured in XML. This is especially important for courses.

Learning Trails

Online courses have to cope with differences due to the personal learning behavior of the students. The learning behavior of an individual is e.g. dependent on his or her

- learning goals,
- prerequisites,
- interests and
- preferred modalities (like e.g. visual or auditory).

When preparing an online course for such a heterogeneous audience, we do not want to develop an own course for every different group. Therefore, the content of a course has to be divided into units which can be worked through in different sequences and in different selections.

A path that is followed through these units by a student during learning is called **learning trail** or learning path. Different learning trails are proposed by the system according to the profile of a student.

Classes of Learning Trails

With respect to the learning goals of the students and the learning context different classes of learning trails can be specified presenting typical trails followed by students. The learning trails are oriented to different structures.

A learning trail can be oriented to the:

- Structure of the scientific domain: This is the trail, given by the structure of the scientific domain. Most of the scientific text books are organized in this way.
- Didactic structures for "beginners" or "first learners": This trail is the ideal choice for persons who work through the course for the first time and meet exactly the given prerequisites of the course.
- Repetitive structures: This trail is well suited for repetition and for deeper understanding of the subject (e.g. for preparation for examinations). This class offers indexed trails via e.g. summaries, examples, exercises, statements and glossaries.
- Selective structures: These trails take into account the different preliminary knowledge of the students.
- Modal structures: These trails cope with different preferences with respect to presentation modes of the domain, e.g. pictures, animations, videos, speech or text.

At a specific point in the course the system proposes one main learning trail to the student. This learning trail is marked appropriately in the online course. It is presented by overlaying some standard buttons for turning over to the next page. All other learning trails are still accessible for the students. A restriction of the navigation would be considered as a restriction in learning. Besides, explorative learning has to be enabled in online courses.

Learning Units

First developments of virtual courses have shown that different learning trails could not be easily and smoothly integrated into an already developed course. The different classes of learning trails have rather to be considered and integrated during the conceptual phase and can then be implemented.

In order to avoid the development of an own course for each learning trail, a course has to be divided into a set of parts while being developed. These parts are called **learning units**. A learning unit is a closed unit with respect to its learning goal.

It can be composed of a set of basic blocks and, recursively, of learning subunits, which are again learning units. Basic blocks can be e.g. text blocks,

```
<!ELEMENT course ( (learningUnit | exercise)*,
                   learningTrail*, link*,
                   glossary?)>
<!ATTLIST course title CDATA #REQUIRED>

<!ELEMENT learningUnit
          (learningUnit*, content*)>
<!ATTLIST learningUnit
          subject  CDATA #REQUIRED
          type     (chapter   | section |
                    paragraph | excercise |
                    answer)   "chapter"
          title    CDATA #IMPLIED
          targetGroup
                   CDATA #IMPLIED
          id       ID    #IMPLIED>
```

FIGURE 1: L3-XML FOR A COURSE (EXTRACT)

```
<!ELEMENT content (#PCDATA)>
<!ATTLIST content
   subject     CDATA #REQUIRED
   level       (beginner | normal | expert |
                other) "beginner"
   discipline  CDATA #IMPLIED
   language    CDATA #IMPLIED
   datatype    (xml | html | ascii | binary |
                other) "xml"
   source      (this | file | imageFile | url |
                urlcontent | other) "this"
   mediatype   (text | image | video | sound |
                animation | other) "text"
   contenttype (normal | hint | example |
                runningExample | theory |
                definition  | remark |
                furtherParticular | reference |
                definition | literature |
                educationalObjective | syntax)
                "normal"
   id          ID    #IMPLIED>
```

FIGURE 2: L3-XML FOR CONTENT (EXTRACT)

graphics, pictures, spoken text, music, video, animation, simulation and exercises. They constitute some kind of atomic units for learning trails.

SPECIFICATION WITH L3-XML

In an online course different learning trails have to be supplied to different groups of students, during preparation as well as execution. Therefore, XML (Extensible Markup Language [5]) was chosen as the implementation language. In XML, the presentation can be separated from the content and additional structuring can be specified by defining a specific XML-DTD (Document Type Definition). For XML proposals for the description of meta data for courses do already exist, e.g. the Learning Object Metadata (LOM) [6]. This proposal is also used for the Metadata in our course description.

We developed an XML-DTD that is called L3-XML for the specification of learning units (Long Life Learning XML). An extract is shown in Figure 1 and Figure 2. The definition of a learning unit in Figure 1 reflects the above recursive definition. The degree of granularity is given in the attributes of a learning unit, like e.g. chapter or section. Attributes are also used for describing different modalities.

The developed L3-XML is far more complete. Additional attributes for granularity, learning goals, target groups can be specified. Different classes of links enable support for the students in estimating the usefulness of using further links. Also, different kinds of exercises and glossary items can be given.

The author of a course decides on the granularity of the division of the course into learning units and on the amount of meta data supplied by the description. The finer the granularity of a course the more learning trails exist. The author has to balance effort and benefit.

A course for a very heterogeneous group of students should have a relatively fine granularity and should be described precisely with meta data. But the first version of a course which is used at one institution can initially consist e.g. out of one learning unit for each chapter. A course can thus be refined in further executions.

The authors have to spend much effort on the structuring of the content, the pedagogic concept and the preparation of the learning units for a real online course. They have to provide in advance all information guiding a student on his or her way through the online course in the most suitable way.

Example Course OOP

In the leading project "Virtuelle Fachhochschule" of the German ministry for education and research we develop the course "Introduction in object oriented programming (OOP) with Java" with the above given L3-XML. This course is part of a virtual curriculum of computer science. The student will deepen his or her knowledge in the area of object oriented programming and learns about advanced concepts of implementation in Java, e.g. development of graphical user interfaces, client/server architectures and design patterns.

Figure 3 shows a screen shot of a page of the course (in German). The page is prepared for a beginner. Two particular learning trails are also offered. Further learning trails are visualized in a site map which is accessible by a button in the lower left corner. Besides, the students have direct access to the pages via the table of

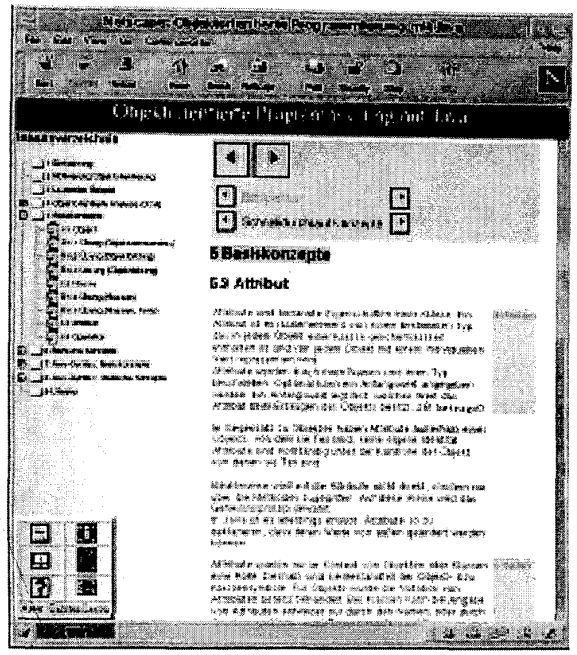

FIGURE 3: SCREEN SHOT OF THE COURSE OOP

contents or the glossary. Other learning trails, e.g. trail via the exercises, are reachable via the appropriate icons.

For a quick repetition of the course a learning trail over the summaries is generated.

Generation of Presentations

The different presentations of the course with eventually different learning trails can be generated out of the XML description in advance for storing on the WWW server. This is a kind of pre-compilation. The presentation in Figure 3 was generated in such a way.

The generated presentation is a set of HTML pages. Most browsers support HTML very well but do not support XML. The learning trails are implemented as appropriate chains of hyperlinks between the pages.

The generation process can be parameterised to allow e.g. different navigation bars at different page positions (e.g. left or right) and to support different learning trails. The generator is implemented in Java using the Document Object Model of XML.

The presentation of a course can also be generated "just in time". This means a presentation is generated when someone wants to access the page. This enables an adaptive user interface, which can be realized by an agent system. This is part of our further work [7]. The pre-compilation is used at the moment.

In [8] a similar representation of learning units is proposed. For this purpose the *Learning Material Markup Language (LMML)* is developed. LMML is based on XML and serves as an abstract and domain-specific model for learning units. Conceptual relationships and trails (guided tours) are expressed by links. The use of these links and meta data allows the adaptation of learning trails. The main fields of application are the reuse, adaptation and recomposition of existing learning material for supporting classroom teaching.

A somewhat other approach is chosen in the KBS hyperboook [9]: The generation of learning trails is mainly determined by topics, which are represented by a set of hyperbook pages, and so-called *knowledge items*, which denote either elementary knowledge concepts of the application domain, for example "if" or "while" concepts, or compound concepts like "knowledge about control" statements. The knowledge items are assigned to *semantic information units* on which learning trails are based.

In our approach the interdependence between learning units is determined by a special kind of links, which are part of the XML document. This is a simpler model for the authors and induces less additional effort in the specification of a course. Moreover, our approach supports continuous refinement of courses.

SELECTIVE TRAILS

In the example course, we can demonstrate selective trails in the introduction of object oriented programming. According to the prerequisites of a student a different approach to object oriented programming is useful.

If the student already knows abstract data types, concepts like object and class are then explained in an opposition to abstract data types.

If there is no knowledge of abstract data types, a detailed and evident introduction to the concepts object, class etc. is given. Abstract data types are not introduced, because their knowledge is not necessary.

Normally, younger participants do not know abstract data types, whereas participants with good and long-termed programming skills master the concept and get a good access to object oriented programming.

According to our experience the learning success in this example depends on the right way to a large extent. If the right way is used, the concepts are comprehended after a short time and are accepted as useful and effective for programming. Otherwise, in an extreme position, object oriented programming can be thought of being useless.

When providing selective trails, the authors of a course have to give many different descriptions of a subject. According to our experience this is only useful and beneficial at some parts of a course. A typical point is the start of the course and again at some point of further engagement and where examples are presented.

Conclusion

To cope with the requirements of heterogeneous groups of students of online courses, learning trails are classified, which guide students through a course in different ways. A learning trail can be oriented to the didactic structure or the structure of the subject's scientific domain, to learning units of the same type like conclusions or exercises, to selective or modal structures.

The different learning trails enable students

- with different preliminary knowledge,
- that are in different learning phases,
- who follow different subsets of learning goals, or
- who have a different modal access to the domain,

to use the same online course in a productive and effective way.

An XML-DTD, L3-XML, is presented for specifying a course. Different presentations of a course can be generated from the L3-XML description, which are different with respect to the learning trails and the layout.

This concept is very well suited for the description and provision of courses, which are dedicated to a heterogeneous group of students.

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