An approach for pedagogical hypermedia design

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ABSTRACT

This paper deals with management of multimedia and numeric information in an instructional context. We submit a model in order to represent explicitly the pedagogical information structure. This model is based on a graph of information-units. An information-unit is an autonomous node of the graph, composed with an internal structure, an external structure and a set of associated actions. The model allows managing multimedia interaction, conceptual interaction and pedagogical interaction. We then submit a four-step design method: 1-Pedagogical survey, 2-Modeling, 3-Drafting, 4-Editing. To end with we submit further elements to deal with multimedia interaction in a pedagogical context.

Keywords: Multimedia, Hypertext, Instructional context, Design method, Information structure

1. INTRODUCTION

Multimedia software represent one of the new answers offered in order to fulfill the new needs engendered in the field of education. In the other hand one has to admit that this kind of solution is not so much used in real situation. One of the reasons may be the lack of experiment in an emerging and quickly evolving domain. In order to submit solutions for the design of multimedia learning software, we adopt an approach based on the study of the specificity that the support carries. Whereas textual documents introduce spatial representation (Goody, 1979) "numeric information are computable, and only computable" translated from (Bachimont, 2000). The internal representation of information in a computer is not linear, and this delinearization determines the design of numeric documents. Therefore a new way of representing information has to be adopted.

After having studied basic concepts (information-unit, internal structure, external structure, associated actions) to deal with non-linearity, we describe a design approach based on the integration of four surveys (pedagogy, information modeling, drafting and edition). Finally we propose a set of tools in order to help managing multimedia interaction in a pedagogical context.

2. PEDAGOGICAL HYPERMEDIA MODEL

Because of the non-linearity of the information inscribed in a numeric support, we propose to model an hypermedia as a graph, *i.e.* a set of nodes and links between them. The first implication of such a representation is that the reading depends on the way the nodes are accessed (*i.e.* computed). Indeed, a node is a computation-unit. Since books or videotapes impose the reading process (one page or sequence after the other), numeric supports do not: the reader is expected to build by his own a proper linearity. Therefore, there is no guaranty on what the user has accessed before, and what he will access then, while reading a computation-unit. We submit the following hypothesis in order to deal with this problem: the information representation in hypermedia should be based on **information-units** (IU) corresponding to computation-units.

We define an information-unit as an autonomous node of the graph, which reading is necessary and sufficient in order to understand a concept. This implies that information-units are indivisible and independent from other units.

IU are used in pedagogical hypermedia, which implies that:
- an IU can be composed with a set of media of different kinds (multimedia)
- an IU is linked to other units (hypermedia)
- an IU is associated to a set of pedagogical actions necessary to understand it (pedagogical)

Three questions emerge from this representation:
- How to manage the **multimedia interaction** between the set of media that compose an IU?
- How to manage the **conceptual interaction** between the set of IU that compose an hypermedia?
- How to manage the **pedagogical interaction**, between the actions associated to an IU?

In order answer these questions, we define a model for a pedagogical hypermedia as a set of IU organized with an internal structure, an external structure and a set of associated actions (Figure 1).

The **internal structure** is the explicit logical structure of the set media that compose an IU and the relationships between these media. In the example (see Figure 2) an Exposition-UI (*Exposition* is the type of UI) is defined by a title and some contents. The contents are defined by a main media, a set of redundant media, a set of complementary media and an a set of illustration media.

The **external structure** is the explicit conceptual links between an IU and the other IU that compose the hypermedia. In the example (see Figure 3) an Exposition-UI can be linked to other Exposition-UI (refer to or is followed by), to Exercise-UI (is applied by) or to Question-UI (is evaluated by).

The **associated actions** are the pedagogical actions to perform when accessing an IU. In the example (see Figure 4), a learner can read, annotate, mark and comment an Exposition-UI, and a teacher can emphasize it.

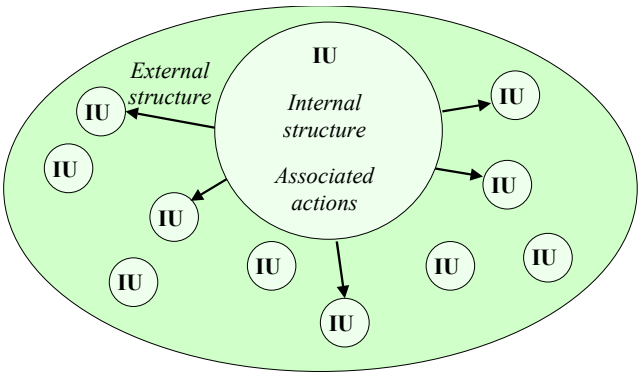

Figure 1 : Pedagogical hypermedia model

```
<!—Internal structure for IU Exposition -->
<!ELEMENT exposition (title, contents)>
<!ATTLIST exposition type (definition | method-
ology | example) >
  <!ELEMENT title (#PCDATA) >
  <!ELEMENT contents (main, redundant*, comple-
ment*, illustration*) >
    <!ELEMENT main (written_text | didacti-
cal_image)>
    <!ELEMENT redundant (written_text | didac-
tical_image | speech | animation)>
    <!ELEMENT complement (didactical_image |
speech | film | interaction)>
    <!ELEMENT illustration (image | music |
sound_effect)>
```

Figure 2: Example of internal structure (DTD XML)

```
<!—External structure for IU Exposition -->
<rdf:PropertyType ID="ReferTo">
       <rdfs:domain resource="#Exposition"/>
       <rdfs:range rdf:Resource="#Exposition"/>
</rdf:PropertyType>
<rdf:PropertyType ID="IsFollowedBy">
       <rdfs:domain resource="#Exposition"/>
       <rdfs:range rdf:Resource="#Exposition"/>
</rdf:PropertyType>
<rdf:PropertyType ID="IsAppliedBy ">
       <rdfs:domain resource="#Exposition"/>
       <rdfs:range rdf:Resource="#Exercice"/>
</rdf:PropertyType>
<rdf:PropertyType ID="IsEvaluatedBy">
       <rdfs:domain resource="#Exposition"/>
       <rdfs:range rdf:Resource="#Question"/>
</rdf:PropertyType>
```

Figure 3: Example of external structure (XML RDF)

```
<!—Associated actions for IU Exposition -->
<ACTION Name="Read" Actor="Learner" Benefici-
ary=" Learner " In="All" Out="None">
<ACTION Name="Annotate"Actor="Learner" Benefi-
ciary=" Learner " In="None" Out="Text">
<ACTION Name="Mark" Actor="Learner" Benefici-
ary=" Learner " In="None" Out="Boolean">
<ACTION Name="Comment" Actor="Learner" Benefi-
ciary="Teacher" In="None" Out="Text">
<ACTION Name="Emphasise" Actor="Teacher" Bene-
ficiary="Learner" In="None" Out="Text">
```

Figure 4: Example of associated actions (XML)

3. A FOUR-LEVELS DESIGN METHOD

Having adopted the previous concepts for the modeling of a pedagogical hypermedia, we identified four distinct functions in the design process:

The **pedagogical survey level** comes first, its purpose is to explicit the pedagogical process in order to identify the role the hypermedia can play within it. We submit a methodological tool in order to help the expert. This tool is based on the description of the process in term of discrete pedagogical acts (Ghitalla, 1999). The organization of these acts constitutes an explicit report that can be used to focus on the aspects to be modeled within the hypermedia.

The **modeling level** translates the pedagogical acts description, in order to model the hypermedia, *i.e.* define the set of IU models. We observed that all the information needed to define the IU models (along with their internal structure, external structure and associated actions) can be extracted from the pedagogical survey.

The **drafting level** instantiates the IU models, *i.e.* produce and organize the multimedia contents following the internal structure and link the IU following the external structure. The first difficulty is to manage the multimedia, conceptual and pedagogical interactions by choosing the appropriated model for the appropriated content. The second difficulty is to draft the contents under the constraint of these models.

The **editing level** realizes the human-machine interface, *i.e.* chooses a physical representation of the UI (information and actions). Both the models and their instances are used in order to make possible the execution of the pedagogical actions onto the contents.

The Figure 5 sums up the design process and the Figure 6 illustrates it on a very simplified example.

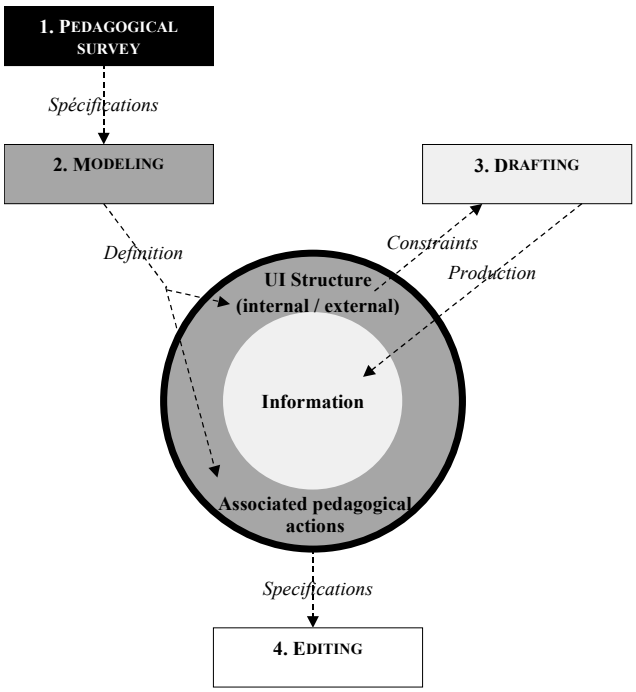

Figure 5 : Design process

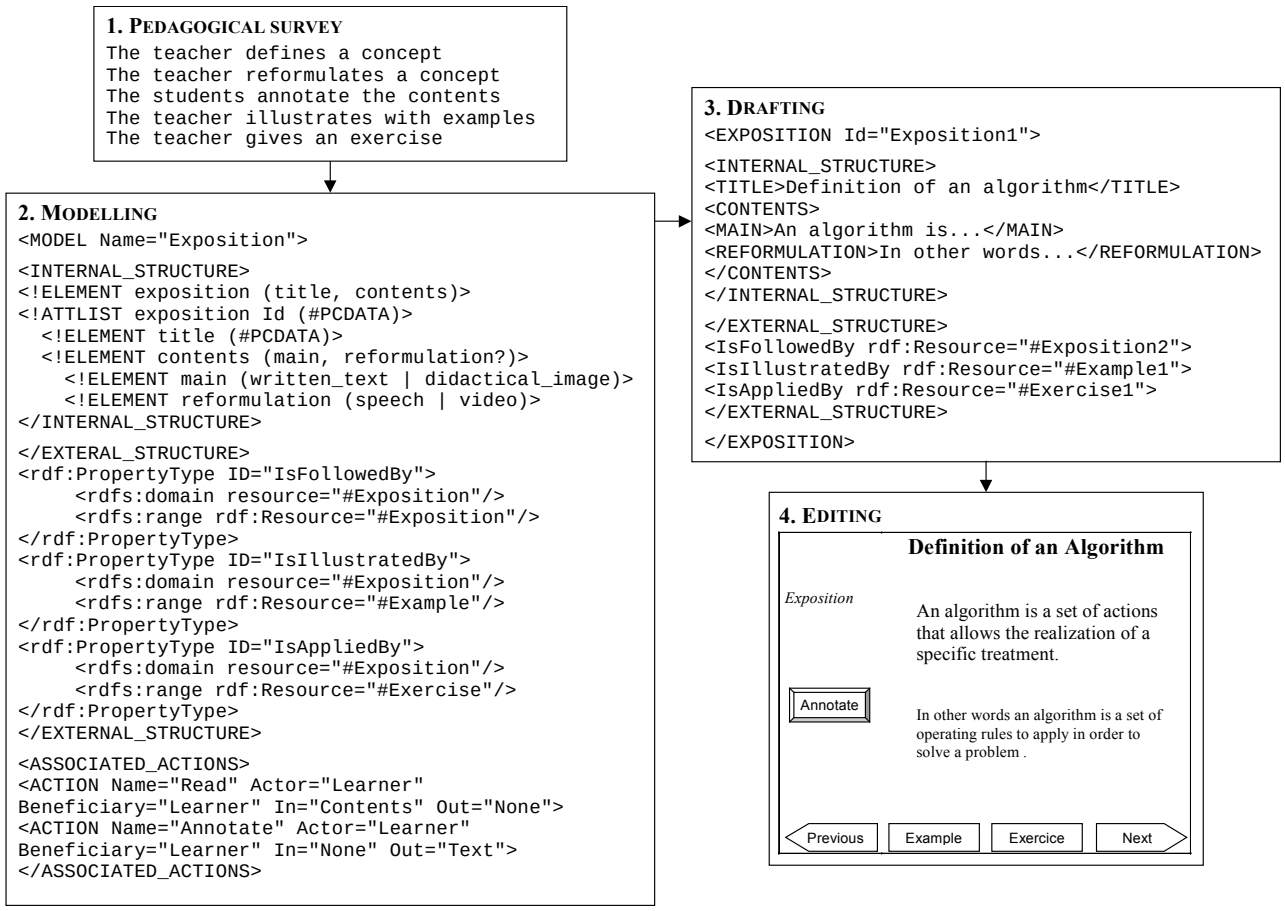

Figure 6 : Simplified example of application of the design process

4. MULTIMEDIA MANAGMENT

Designing pedagogical hypermedia following the methodological approach we submitted implies to be able to deal with pedagogical, conceptual and multimedia interactions. Through the existing experience in the field of education, designers are used to dealing with pedagogical and conceptual interactions. They can reasonably adapt their skills for the particular case of pedagogical hypermedia. However, multimedia interaction is a new parameter to take into account. In order to help designers, we submit a typology of media (Figure 7) along with a set of element to help choosing a type of media depending on the pedagogical goal (Figure 8).

In order to help managing the multimedia interaction, each media function has to be explicitly identified and chosen. We submit four functions to characterize the set of media composing a IU:

- The main function for one unique media representing the core of the information
- The redundancy function for the media reformulating the main one
- The complement function for the media adding secondary information to the main one
- The emphasizing function for the media accompanying the main one without giving real information

The Figure 9 gives examples of application of function for each media.

Media	*Senses*	*Dimension*	*Temporality*	*Nature*
Written text	Sight	Spatial	Static	Elementary
Speech	Hearing	Temporal	Kinetic	Elementary
Sound effects	Hearing	Temporal	Kinetic	Elementary
Music	Hearing	Temporal	Kinetic	Elementary
Picture	Sight	Spatial	Static	Elementary
Didactical picture	Sight	Spatial	Static	Composed
Animation	Sight	Spatial + Temporal	Kinetic	Elementary
Audiovisual	Hearing + Sight	Spatial + Temporal	Kinetic	Composed
Interaction	Hearing + Sight + Action	Spatial + Temporal	Dynamic	Composed

Figure 7 : Typology of media

Media	*Characteristics*	*Pedagogical examples of use*
Written text	Thinking – Concentration – Rereading – Persistence	Complexe information, demonstrations, definitions
Speech	Persuasion – Subjectivity – Evanescence	Short and important information, sensitization, insistence, redundancy, explanations
Sound effects	Designation	Meta-information, attract attention
Music	Emotion – Memorization	Effect on concentration, atmosphere
Picture	Universality – Multiple meanings – Non-trustable – Contextual	Illustration, estheticism, visual memorization
Didactical picture	Spatial – Synthetic – Organized – Normalized	Complex information, information hardly formulated by language
Animation	Dynamic	Temporal processes, attract visual attention
Audiovisual	Dynamic – Captivating	Seduction, persuasion
Interaction	Implication – Pleasure	Concrete, experimental or real information, entertainment

Figure 8 : Parameters for media choice

Function / *Media*	*Main*	*Redundancy*	*Complement*	emphasizing
Written text	Classical case of written exposition (book)	Reformulation of a main text, example, description	Demonstration, detailed explication	X
Speech	Classical case of oral exposition (lecture)	Reading of a main written text	Additional definitions of some words of the main text	Slogan to insist on an pedagogical aspect
Sound effects	X	X	Typical sound (a motor sound in a mechanical context for instance)	Focalization of the attention
Music	X	X	Extract in a music teaching context	Musical ambient
Picture	X	X	The photo of an important character (author, scientist, …)	Background picture
Didactical picture	Technical diagram, charts, …	Graphical formulation of a main text	Map (when studying history for instance)	X
Animation	X	Dynamic representation of a didactical picture	Example of process quoted in a main text	Metaphorical association between an animation and a concept
Audiovisual	Description of a process	Description of a process described by a main text	Commentary personified by a virtual character	Short entertaining video-clip
Interaction	Virtual world used to immerse the student	Illustrative simulation	Virtual experience to concretize a concept	Game

Figure 9 : Examples for each association function-media

5. CONCLUSION AND PERSPECTIVES

In this paper, we have showed that an approach based on an explicit structuring help in taking into account the interaction inside a set of multimedia information. This approach is especially relevant in the field of education, since the way the information is presented determines the way it is learned.

We applied our method to design a pedagogical hypermedia, used to teach computer sciences (the basics of algorithmic). This hypermedia has been experimenting for one year in our university, in a real learning situation. It is yet too early to extract real conclusions, but it seems fully positive in term of acceptation by the students.

The next step is to realize a software environment that assist in the application of the method. This environment will help the designers through each step, offering a set of tools to achieve the pedagogical survey, the modeling, the drafting and the editing.

We are also studying some secondary benefits that our approach can bring such as the reuse and sharing of the contents, the multi-support edition or the constitution of an ontology of the pedagogical documents.

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