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## **CEPIAH, a method for Evaluation and Design of Pedagogical Hypermedia**

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### **ABSTRACT**

We are working on a method, called CEPIAH. We propose a web based system used to help teachers to design multimedia documents and to evaluate their prototypes. Our tool integrates two modules such as EMPI (Evaluation of Multimedia Pedagogical and Interactive software), and SP/UL/FC, a method for designing pedagogical hypermedia. The EMPI module is used to evaluate multimedia software used in educational context. We structured a knowledge base composed of a list of evaluation criteria, grouped through six themes: general feeling, technical quality, usability, scenario, multimedia documents, and didactical aspects. We insisted on multimedia particular aspects: we deeply studied the specificity of multimedia documents (investigating various fields such as photography, typography, picture semantics, cinema...). We also evaluated the way multimedia elements are gathered to prepare the reading acts. We finally determined specific criteria for pedagogical aspects, associated to the previous approaches. A global questionnaire joins all these modules. In this paper, we present the two first modules, EMPI and SP/UL/FC, and an application of distant teaching (and distant learning), commenting the first results of this experiment. We conclude by a short presentation of a third module, on which we are still working.

**Keywords:** Learning on the web, Evaluation, E-learning, Instructional design.

## 1. INTRODUCTION

Knowledge transfer takes an increasing place in our society. Different ways of teaching appear, concerning more and more people, beginning earlier and earlier and ending later and later. We do need new tools to answer this new demand. Learning software could be particularly useful in case of distance learning, along-the-life learning, very heterogeneous skills in classes, children helping (etc.).

Our thesis is clearly not to pretend that learning software could replace teachers or schools. However, in specific cases, new supports are particularly advantageous, and can be integrated in the classical teaching process. Nevertheless, close to this new policy, we have to take into account that today's learning software are not so much used. There is no reason why this support should not find its role along with the books, the traditional teaching methods in schools or firms. Thus we think that its relative failure is due to the poor quality of the current products, compared to what they could offer and what the public expects them to offer.

Two main problems can explain this gap. Authors do not know how to write multimedia documents and users do not know how to evaluate their relevancy. People are used to deal with paper and textual documents. Nonetheless the valid principles for those documents are mostly not transposable to numeric and multimedia documents. The experience in the field of multimedia numeric documents is not wide enough, and we do not have equivalent rules to the ones that exist in the classical domain of edition. However our research intends to determine the bases of such rules.

Each technical support records information on a specific way so that it determines the way it will be interpreted. An information is different depending on the support it is written on. Moreover the act of writing information on a support supposes the addition of a supplementary information, directly linked to the nature of the support. Our purpose here is to study the supplements introduced by the use of multimedia numeric supports. We must admit that the author can not be aware of what will exactly understand the reader. However, by understanding the specificity of the numeric support, he could better control the final interpretation and try to bring closer together the information he wants to give and the information effectively read.

We are working on a method, called CEPIAH, for the design and the evaluation of pedagogical hypermedia. We propose a web based system used to help teachers to design multimedia documents and to evaluate their prototypes. Our tool integrates three main modules:

- EMPI (Evaluation of Multimedia Pedagogical and Interactive software), an interactive software built from 1997 to 2001, for evaluating multimedia interactive software, by using dynamic navigation in a set of questions (Hû & Trigano, 2000),
- SP/UL/FC, a method for designing pedagogical hypermedia (Crozat, 2002), on which we have been working from 1999 to 2002,
- A set of predefined models and patterns, by using pedagogical scenarii (not developed yet).

In this paper, we present the two first modules of our CEPIAH method, and we will conclude by a short presentation of the third module.

## **2. EVALUATION OF PEDAGOGICAL SOFTWARE**

We present now a methodological environment we are building in order to assist designers from specifications to final evaluation.

### **2.1 The EMPI Module**

When we use guidelines or questionnaires to evaluate software, some problems can appear: the number of questions increases and thus the duration of an evaluation becomes too long. To try to solve these problems, in educational context, we have conceived a method that dynamically builds an evaluation: precision and depth of analysis, choice and weight of questions, are done during the evaluation. In our method, the evaluator is free to explore questions and to adapt the base to his case. He is guided, helped and confronted to his own subjectivity with an aim of building the most relevant evaluation.

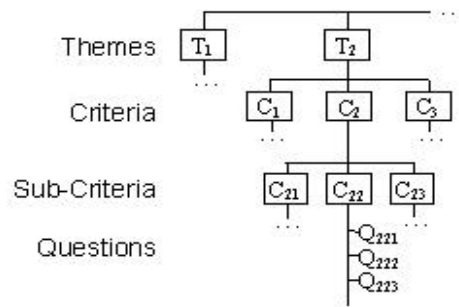
Among all existing methods or techniques used to evaluate software, it is particularly interesting to select questionnaires or lists of recommendations. They are easy to implement, usable without help of a specialist and they can evaluate any kind of observable criteria. And so, they are well adapted for the multi-disciplinary evaluations, done by software users and not by software designers. However, the use of such questionnaires have two major inconveniences: results are depending on the subjectivity feeling of the user, and the evaluation is generally done out of the real conditions of use.

A subjective evaluation (general evaluation), linked to the use of a questionnaire (deep evaluation), is taken into account, capitalized and then compared to the objective evaluation, in order to help the human evaluation. This method has been implemented in a tool, usable during the evaluated software exploration.

There are a lot of domains concerned by the evaluation of pedagogical software. If we want a good accuracy in each theme, the set of questions can quickly become very large. Thus, it is important to have a structured tree of questions to improve the use and the modification of this base.

## Structure

Questions are gathered into a hierarchical structure, containing six main branches, each branch having three levels (Figure 1). In this way, there are six general themes, divided in criteria, each criteria is divided into subcriteria and then into questions. These themes come from several model of pedagogical software or student activity theory (like M. Linard's work (Linard & Zeiliger, 1995) (Linard & al. 1998)).



**Fig. 1.** *Global Structure*

In the EMPI method, we have been using six main themes:

- **General feeling** theme concerns what users think about the software.
- **Technical quality** theme allows the evaluation of the technical realisation.
- **Usability** theme corresponds to the ergonomic quality of the interface.
- **Multimedia documents** theme is associated to the quality of texts, sounds, images.
- **Scenario** theme deals with the writing techniques used in order to design information.
- **Pedagogical tools** theme finally inspects the pedagogical possibility offered by the pedagogical software.

## Questions

In order to help evaluators, each question was written as a simple model:

- The formulation must imply evaluator: We prefer a question like "Did you see something...", rather than "Does the software display...".
- Help is given with each question. This help contains several parts:
  - A reformulation of the question.
  - A longer explanation.
  - Some examples and bibliographical references, if it is possible.

Some questions are subdivided in two phases: A first one to characterise the software's situation, and a second one to evaluate the relevance of this situation. For instance, in order to evaluate the structure of the software, we will first determine what kind of structure is concerned (linear, arborescent, etc.) and then if it is a correct one.

The evaluator, with a synthesis of the instinctive and calculated marks and the correspondent ratings, is given a **final mark** by the evaluating system. But the human evaluator keeps ultimately the capacity of judging the final mark of each criterion.

A **structured and contextual help** is provided for each criterion and question, in order to have the most objective evaluation. This help allows questions reformulation, concepts' definition, theoretic fundamentals explanation and some characteristic examples.

The **weight of questions** on a criterion can be either essential or secondary, to express the fact that some aspects or defaults are more important than others.

We propose in the following parts to develop each theme and criterion.

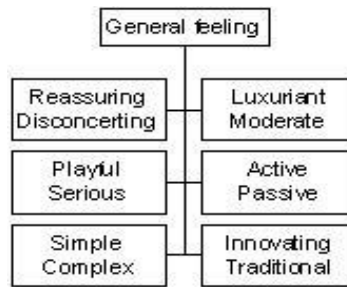
### **General feelings**

Software provides a general feeling to the users. This feeling is issued of graphical choices, music, typographic, scenario structure. The important fact is that these feelings the user felt deeply affect the way he learns. Our experiences revealed that the general feeling is mainly instinctive, easily describable by the users, quite homogeneous inside a large population, and deeply remaining with time.

In order to better understand this phenomenon, we studied various fields, such as visual perception theories (Gibson, 1979), image semantic, musicology, cinematography strategies... With these theories, we managed to submit a list of six pairs of criteria. They make it possible to describe quite satisfyingly what one feels in situation of use of learning software.

We shall specify that this theme is particular in the following senses: the criteria are provided by opposite pairs; they are expected to be neutrals, in order to describe the feelings, not to judge them directly.

The goal is to capitalize, at the beginning of the evaluation, the impressions that the evaluator feels during the use of the software. We propose to him some couples of impressions which will enable him to give a ruling on (Figure 3): Reassuring/Disconcerting; Luxuriant / Moderate; Playful / Serious; Active / Passive; Simple / Complex; Innovating / Traditional.



**Figure 3. General feelings**

This list comes from an evaluation database that was analyzed by a documents indexing method (Lamrous & Trigano 1999). We also compare this result with theoretical approaches: visual perception theory, for example. These impressions show several characteristics:

- They are *instinctive*: Users provide them without any assistance.
- *Describable*: Users are able to describe them with a few adjectives.
- *Homogeneous*: They are concordant between users.
- *Persistent*: They endure in time and influence further use.

This list allows the evaluator to provide a description of his impressions. He indicates what he feels for each couple of impressions. For example: very diverting, reassuring or very reassuring. There is no “neutral” evaluation to incite the evaluator to give a real opinion.

**Technical quality**

Good software is first of all working software. So we decided to begin by giving the technical criteria that software has to satisfy (Figure 4).



**Figure 4. Technical quality**

When one uses slow, hard to configure or bugged software, the reject is generally obvious. Literature, in software design, abundantly deals with these aspects, we submit here one proposition of criteria organisation. For more details, see (Hû & Trigano 2000).

## Usability

A large set of criteria exists in the field of usability of user interfaces. In our context, our problem was to find a compromise between general criteria (Ravden & al. 1989) and too precise rules (Vanderdonckt, 1999).

To build the following set, we used in depth the INRIA works (Bastien & Scapin 1995), adapting their criteria to our multimedia and educational context (Figure 5). They are more deeply described in (Hû & Trigano 2000) and (Hû & Trigano 1999).

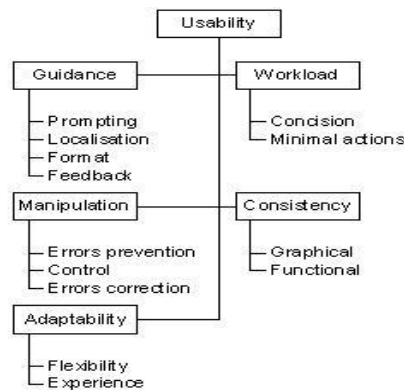


Figure 5. Usability

## Multimedia documents

Texts, images and sounds are the constituents of the learning software (Figure 6). They are the information vectors, and have to be evaluated for the information they carry. But the way they are presented is also an important point, because it will influence the way they are read. To build this part of the questionnaire, we had to explore various domains, such as the pictures' semantics (Type, Frommer, 1985), the textual theories the didactical images works, the photography, the audio-visual (etc.).

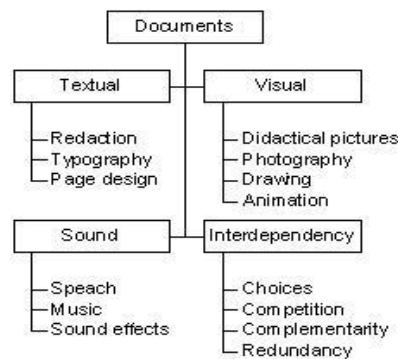


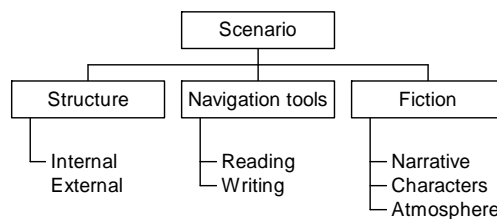
Figure 6. Multimedia documents



Our works also points out that in a multimedia environment each document is always presented along with other documents at the same time. The set of documents presented together generates a web of relations that influences the global signification. These interdependencies between documents are as important as each separate characteristic of the document, in the process of interpretation.

### Scenario

We define the scenario such as the particular process of designing documents in order to prepare the act of reading (Figure 7). The scenario does not deal directly with information, but with the way they are structured. This supposes an original way of writing, dealing with non-linear structure, dynamic data, multimedia documents.

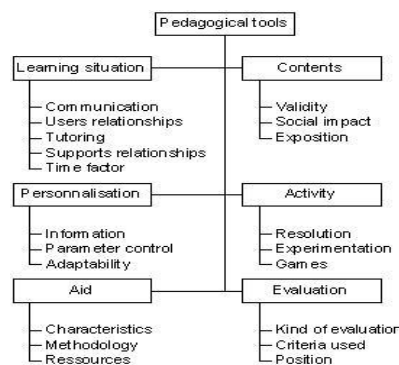


**Figure 7. Scenario**

Our studies are oriented toward the various classification of navigation structures (Sabry-Ismaïl & al. 1997), and the fiction integration in learning software (Sanchez, Lumbreras 1997).

### Didactic

Literature offers plenty of criteria and recommendations for the pedagogical application of computer technology (Park, Hannafin, 1993). We also used more specific studies, such as works on interaction process (Vivet, 1996), or practical experiences. This last theme is expected to describe the specific didactical strategy of the software (Figure 8).



**Figure 8. Pedagogical tools**

Our goal is not to impose such or such strategy, stating it is the better one. This normalising approach can not be applied (whereas it was possible for usability or technical aspects), for two main reasons: We do not have enough experience with learning software to impose a way of doing things and the definition of a didactical strategy is totally context-dependent. That means that our criteria only

provide a main grid to have a systematic approach in determining what is relevant in one particular case.

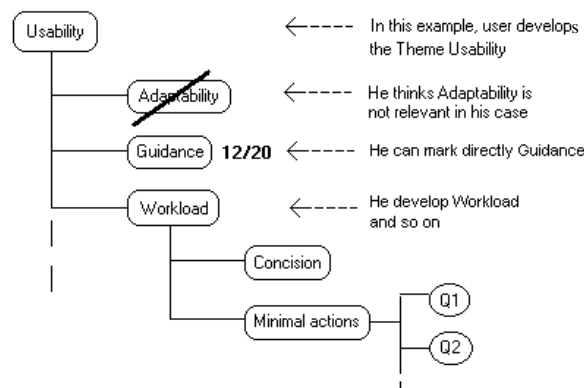
After this presentation of the questionnaire, we now explain how to use it in an evaluation.

## 2.2 The Evaluation Step

### A Dynamic Navigation

An important point of our method is the possibility to use a dynamic navigation into the questionnaire structure during an evaluation. Thus, at each level, and for each question, the evaluator can (Figure 9):

- Delete a criterion or a question and all the associated sublevel, if this criterion, or question, is not relevant for him.
- Go thoroughly into a node or not. If the evaluator is very competent in this domain, he will not have to develop sub-levels, and will only answer to this criteria level. That means that the evaluation can directly evaluate each criterion, instinctively, or go deeper in the criteria structure.
- To modify node's importance of each part of the tree, and modify the weight of criteria, sub-criteria and questions in calculations.



**Fig. 9 An example of navigation in our structure**

Then the navigation into the questionnaire is not fixed. It depends on the evaluator's competencies and needs: The evaluator will be able to adapt the set of question to his own situation. Moreover, the structure of the questionnaire may automatically be modified by the answers given by the evaluator. Then the software dynamically chooses the questions depending on the previous answers.

### Use of Evaluator's Subjectivity

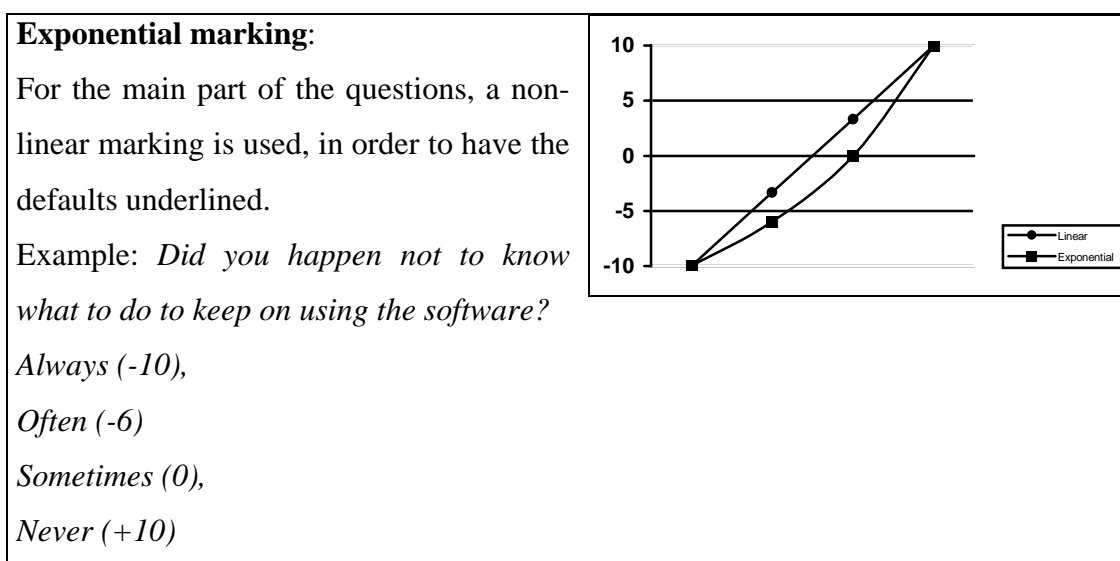
The seduction and the pleasure have an evident impact on the student's motivation and thus on the way of learning. On one hand, the evaluator, during a short period of time, is seen as a final user. Then, he can give his general feelings on the software he has tested. On the other hand, our evaluator knows sufficiently the final users and we think that their opinions are relevant. Moreover, all the

evaluators are not specialists in ergonomics, in educational sciences or in multimedia design, and it is impossible to develop a questionnaire with all the characteristics of every software application in all educational contexts. By enabling an evaluator to give his judgment, we add new chances to detect a default felled by the evaluator, even if they can not identify the exact reasons of this default.

For all the themes, criteria or sub-criteria, the evaluator can give a mark “instinctive” on the scale “- - ; - ; + ; + +”. Because the evaluators do not have the required competencies in all evaluated fields, help must be provided. This help is divided in three parts: A reformulation, an illustration and a deepening. We obtain a memory of the perception of reality by the user. This result can be compared with the objective evaluation of this same reality by the questions themselves.

### Calculation

While the questionnaire filled, the method gives a rapport enabling the evaluator to see a global view of his evaluation. A notation has been done at any point of the tree: Themes, Criteria, and Sub-criteria. For a question, the answer corresponding directly does the mark. In order to detect major defaults, some marking could be not linear (Figure 10).



**Fig. 10 Example of exponential marking**

### Final Mark

As we already said, our objective is to help an evaluator to use a questions base and not to judge for him. Thus, and contrary to other approaches (such as (MEDA, 1990) for example), the final mark will be proposed by the method: The evaluator can modify it if he wishes. To help him in this step, some marks and indications are proposed to him for each theme, criterion and sub-criterion:

- *A calculated mark:* It results from the questions themselves.

- *An instinctive mark*: It corresponds to the instinctive mark given to this level by the evaluator. A more global instinctive mark is also given; it is an average between the instinctive mark of this level and lower levels ones.
- *A correlation index*: It measures the similarity between instinctive mark and calculated mark.
- *A coherence index*: It measures the coherence of instinctive marks between a level and its lower levels.

$$I_{\text{coherence}} = \text{Moy} \left( \frac{|NI - NI_i|}{10 + \max(NI, NI_i)} \right); \quad I_{\text{correlation}} = \frac{\text{Min}(NI, NC)}{\text{Max}(NI, NC)}$$

$NI$ : instinctive note of the level;  $NI_i$ : instinctive note of the  $i$  level;  $NC$ : calculated note of the level.

- *A final mark*: it is computed with the calculated mark, the global instinctive mark and the coherence index. Weaker the coherence index is, closer the final mark is to the calculated mark.

With all these marks and indexes, the evaluator will be able to fix for each theme, criterion and sub-criterion, the final mark that he considers as being the right one.

### **Validation of the method**

Several versions of the questionnaire have been interactively realized, and several validations have been done. All these experiments are validations done during an iterative conception of our questionnaire. They have not been realized in real situation of use. Our goals were to validate calculation techniques of our method, to test stability of our evaluations (several evaluation of a same product, with various evaluators must produce same results) and to verify the usability of our dynamic questionnaire before to submit our method to real evaluators, teachers for example. Several important results appeared during these tests:

- The exponential notation and ponderations of some parts of the tree increase a lot the evaluation stability (Differences on minor points are erased). This also allows the detection of major defaults of the evaluated software.
- The use of numeric marks as a unique form of results does not reflect all aspects of the evaluation. For example, it is difficult to see the difference between a bad characteristic and the lack of this point in the software.
- The comparison between subjective feelings and objective questions improves the evaluation quality.

- Finally, the use of a dynamic tree offers more flexibility in our method. It enables evaluations according to different levels of details, lower time to fill in a questionnaire, and the opportunity to focus evaluation on a precise points.

In a second step of validation, we wanted to check if our method is well adapted to our public: Teachers. We have worked with teachers from several standards (school, high-school, university...) and from several domains (foreign language, computer science, mathematics, technical studies...).

Then they used EMPI module for their evaluations and noted down all their comments. Such experiment had two goals: First, we wanted to check with the potential users, if our method is pertinent and easy to use. Secondly, it was important to test the limits of EMPI on a large set of pedagogical software in several pedagogical situations. We already obtained various results. The evaluation of software tools (text processing, data management...) did not produce really pertinent results. While, the method is well adapted to evaluate cultural software, besides, these programs are really used in classrooms, notably in primary schools.

Other experiments have been done in order to check if our results correspond to the ones coming from real uses, during pedagogical process. In a first time, we had interviewed several teachers using a same software ("Perfect your English 3eme", edited by the CNDP: The French National Center for Pedagogical Documentation). The results showed a good detection of ergonomic defaults actually detected by students.

Our goal was to make a set of questions more dynamic, in order to improve it and make it useful and easily usable. The use of an adaptive questionnaire, which dynamically takes into account the human needs, seems to be a good point.

### **3. DESIGNING PEDAGOGICAL HYPERMEDIA**

A second module of our CEPIAH Method is based on the SP/UL/FC methodology (Crozat, 2002) for the design of multimedia software for education (distant teaching and distant learning), by **using the Internet**. Authors and users of multimedia educational software are in front of the lack of experience in this recent field. We propose to distinguish between three main approaches, the first one centred on documentary discipline, the second one on multimedia one and the third one on pedagogy. This distinction will lead us to suggest integrating this three way of thinking into one single methodology.

#### **3.1 Three ways of thinking**

The documentary approach is based on the organisation of information in the documents. Generally these approaches are based on the separation between the logical structure and the physical one. That means that authors define logical structures and draft following it, and that editors use this structure in order to present information to the readers. The logical structure can stand at two levels: to

determine what can exist inside an information node and to determine what kind of relationships can exist inside a set of nodes. This specificity provides many advantages in our context: Separation between authoring and editing jobs, reuse of documents, helping in structuring redaction, better possibilities of manipulation of the information, low cost edition for several different supports and way of presenting information.

The bases of multimedia approach is to search the reason why using numeric documents instead of normal ones. For each problem, this approach tries to find the supplements the support could bring. It particularly tries to benefit from the dynamic aspects (i.e. simulation, adaptation to the user, solicitation of user's action, etc.) and from the multimedia potentials (i.e. introducing visual or sound representation when it can bring a different and complementary vision on what classical textual documents already offer).

Authoring tools provide larger and larger possibilities to realise these objectives, whereas they do not provide methodologies. The research in this domain is oriented toward three main directions: Guidelines to avoid errors in making multimedia software, project methodology to deal with the complexity of the development, and specific authoring tools to control the realisation in particular framework.

Guidelines have been largely developed in the usability domain, for instance the large set of rules proposed by Jean Vanderdonckt (Vanderdonckt, 1999) or the INRIA works (Scapin & Bastien, 1997). Several works also propose management methodologies for multimedia production, introducing concepts of multimedia story-board, for instance.

The last approach is oriented toward the use of computers in order to solve a local and identified didactic problem. This approach is generally based on pedagogical design innovations to improve traditional teaching, especially around the particularly hard to teach aspects of a curriculum. Several efforts are made to have the traditional pedagogy go forward, thinking problems of knowledge generation, sharing, appropriation and application. In this context of invention of original way of teaching, computers are used as a mean to transform, more than a goal to purchase. Multitudes of examples are available in literature, for instance.

### **3.2 Integrating the three approaches**

Digital documents bring new potentials of information representation, based on dynamic calculation. This position we adopt implies that:

- We need logically structured and annotated documents in order to control their manipulation inside a complex hyperdocument.

- We need multimedia methodologies in order to benefit from the support potentials (multimedia and dynamic interaction) and deal with readability of multimedia documents.
- We need pedagogical design principles and experiments in order to provide useful tools that profit from the support to improve the training process.

Because of the non-linearity of the information representation 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, before 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** corresponding to computation-units. We define an information-unit as a node of the graph, which reading is necessary and sufficient in order to understand a concept. This implies that the information-unit is indivisible (no hyperlinks inside it for instance) and that no hypothesis should be done, while drafting, on the links between the units.

Two questions emerge from this representation: How to manage the interaction between a set of media that compose an information unit? How to manage the interaction between a set of information-units that compose an hypermedia? The internal structure of an information-unit represents the explicit logical structure of the different kind of multimedia elements that compose it, and the relationships between these multimedia elements. The external structure of an information-unit represents its explicit conceptual links with the other information-units that compose the hypermedia.

Our purpose is clearly to integrate documentary, multimedia and pedagogical approach in one single methodology.

**Pedagogical intentions stating:** This first step aims to assist the teacher in charge of the curriculum to state on the pedagogical context he has, and the pedagogic objectives he wants to achieve. We want to use works on pedagogic act definition in order to propose a formal language to the teacher in order that he describes his pedagogical process. Having described his particular process he could then decide if and how the introduction of numeric documents could be useful.

**Authoring phase:** Having determined the frame of use of the numeric documents, the teacher shall write this document. He then has to be helped in writing the script of the document,

including the structure of the hyperdocument, and what kind of tools have to be available for the learner to manipulate this structure (reading and rewriting tools). Together with this works, the author has to determine the categories of node he would have (exposition, exercises, simulations, etc.) and the logical structure these nodes should have. This includes a grammar for the way of using of each media, depending of his specificity and the goal aimed.

**Multimedia charter for edition:** Once the documents' structure defined, the way these documents will be edited can be set. Our environment shall give recommendations and rules either to implement automatic edition or to guide manual one. The guidelines are mainly based on usability of the interface and presentation of the media.

In the following section we present the experiment of a pedagogical Web site built with our SP/UL/FC method as well as an evaluation carried out with EMPI method.

#### **4. OUR DISTANCE LEARNING EXPERIMENT**

Technicians working in firms can follow along-the-life training in our university (UTC), in order to obtain an engineer diploma. To follow the engineer training, they first have to acquire basic skills they might have missed or forgotten through their initial training. These basics are teaches during one year, while the students keep on working in their firms. Some of them can not be present in Compiègne for the courses and have to follow distance training.

An application has been realised in the field of **teaching basics of algorithmic and computer programming**, in Pascal language, **on the web**. We have implemented a multimedia CD-Rom, linked to a web site, integrating pedagogical simulations, lecturers, exercises (drills) and their solutions, and practical works. All these modules are integrated in an interactive and multimedia environment.

Several ways of teaching this material have been tested, mainly based on books and videotapes. The main problem of these previous approaches was the lack of interactivity and adaptability of the supports to the specificity of each student.

We decided to submit an original device, mainly based on a Web site and a CD-ROM. We thought that the particular characteristics of numeric supports could help in introducing ways of teaching that could bring in more interactivity and help in taking into account each student personal needs. Introducing closer tutoring can also treat this personalisation problem, what we jointly decided to do.

##### **Device description**

The device the students have is composed by the following parts:



- A Web-site enables the course consultation, to make exercises and auto-evaluations after each chapter. A controlled access to the correction of exercises makes it possible to follow the students evolution in their training. They are expected to send their auto-evaluation results before being able to access the correction.
- A CD-ROM permits the off-line consultation of the courses' contents<sup>1</sup>.
- A paper version presents a linear version of the lessons.
- Each month the students have one hour to meet the teacher and check if they well understood the concepts.
- The students can also ask questions more regularly by e-mail to a tutor.
- They also use a Pascal compiler to apply the algorithms they learn.

### **Evaluation**

The first remark of the evaluation we can make is that our approach seems reasonably efficient, as the students learning this way obtained similar results to the exams than the students following classical courses. In order to deeply evaluate our experiment we sent a questionnaire to the students. We used this questionnaire along with the remarks we already capitalized since the beginning of the training. This set of elements allows us pointing out the strengths and the lacks of our device. In the following paragraphs we submit a thematic development of the principles we identified as essential in our approach. Some of these aspects are not still completely treated, however they have been identified as important interpreting the present lacks of our device.

### **Multi-support environment**

A traditional pedagogical device is composed by a large set of supports, such as paper documents, oral presentations, slights, blackboard, ... As described previously, our experiment is based on several supports (numeric ones, but also paper documents, human interventions, ...) and we notice that each of these supports is used by the students. Moreover we can determine specific roles the supports have in the learning process, due to their particular properties in term of: information representation and presentation (textual, visual, sound); reading scenario (linear or not); readability and usability (screen, paper) technical constraints (cost, availability)

The Web site is used to access dynamic information, i.e. information that is expected to change in time. For instance the exercises' corrections (accessible when auto-evaluation have been sent) or the exams memory (that is refreshed each semester). The cost of on-line consultation prevents students from using the Web for static information they already have on other supports.

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<sup>1</sup> The students are lent a computer and an Internet connection in order to use these electronic tools.

The CD-ROM documents are used for the advantages provided by a non-linear consultation. It makes it possible to have a personal approach in the reading choosing between various scenarios the teacher offers. It also allows more efficient consultation when doing exercises or programming algorithms, thanks to the links between concepts. Nevertheless the readability problem, linked to screen display, hinders hard concentration on texts.

Paper documents remain imperative, for the students generally begin with them. They prefer these documents to deal with new concepts, in order to concentrate their attention on them. Despite the paper support remains the first entry, when the concept is globally understood, the students can profit better the advantages of other supports, and search for more personal deepening.

### **Tutoring**

An aspect that deeply emerges from our experiment is about teacher intervention in the learning process. Two main means exist to help the teacher in the follow-up of the students works: The auto-evaluation (after each chapter the students are expected to send a form with the time they spent doing the exercises) and the meeting once a month between the students and the teacher. We observe that the students hardly work when the meeting comes closer, and the students confirm that the auto-evaluation principle help them in being regular and scheduling their work.

Moreover the students ask more means to be followed-up in their learning process: For instance corrections and remarks about their works, indicators about exercises (difficulty, expected time to do them, etc.), more elaborated auto-evaluation (Multiple Choice Questions with automatic correction and work suggestion).

We also test another kind of tutoring, based on email communication. Each student can send questions on points they do not understand, on aspects they want to be developed, on advice they request about their methodology (etc.). The fact that the students have to draft their question is very interesting for they are lead to correctly formulate their problem. They realize the interest of such an approach, because writing their questions they often find themselves the solution.

The initial-training students of UTC already use the Web site to complete their lessons, especially to prepare exams. Then, we tried a deeper experience, isolating 20 students from the 150 that constitute the pool of students learning bases of algorithmic. These 20 students did not follow the classical courses with the others but spent 4 hours a week with a teacher in a special classroom with computers. They used a specific device based on the Web site, the CD-ROM, and also the blackboard, the teacher oral intervention (etc.). Our goal was to test new ways of teaching, allying

traditional and new aspects, in order to determine what in the learning process can be improved. These students obtained good results at the final exams.

## 5. CONCLUSION AND PERSPECTIVES

Our CEPIAH project has as final goal: a tool for the instructional web sites designer. We want to valorise at maximum the support characteristics in correlation with the particular pedagogical contexts and Human-Computer Ergonomic Multimedia Interface.

To help the designer in his instructional Web site creation, we developed an interactive guideline accessible on the Web. Three modules compose the guide: Evaluation Help, Design Help and Predefined Models. We yet described the first module that provides help for evaluation, by using the EMPI Method (see section 2).

The pedagogical web site help design modules is the second module (see section 3). It is structured into a group of atomic information, that we will call information unit. According to (Crozat, 2002) an information unit correspond to all the mobile contents aggregations from a pedagogical frame. The body structure corresponds to the contents. They are gathered around six main themes.

**Project Management:** regards the design and development steps of a multimedia pedagogical product (for instance the online course design).

**Technical Quality:** concerns the technical accomplishment of an educational Web site: the software compatibility, the speed, the installation, the accuracy, etc.

**Web Usability:** corresponds to the ergonomically design of the IHM Web sites.

**Man Machine Graphical Interface:** refers to pedagogical design elements, and also to multimedia elements such as image and sound, that may be well adapted for an educational Web site.

**Pedagogical Writing:** concerns the presentation quality of the information priority and the pedagogical scenario: content subdivision, fiction, metaphor etc.

**Pedagogical Environment:** Concerns the pedagogical activities proposed to the learners and also the tools already introduced, among others, for the learners evaluation and their supervising during the study process.

In this structure, every unit's body is made by elements representing several text blocs. A text body is an information unit of three elements: the definitions, examples and references. The definitions describe the criteria to be taken into consideration by the course author during the design process. Related to a given criteria the examples can show the actions to be avoid by the author (negative examples) and/or what he is advised to follows for his course design (positive examples). The references provide information on the available sources for the educational web sites help module design and more bibliographical references.

This second module is directly linked to the first module for Evaluation Help (EMPI). The idea consists in the possibility of the pedagogical web sites authors to evaluate their prototype during designing process. This evaluation enables them to find their design defaults in order to improve the bad points.

We are working on a third module that gathers two sections: image library and models. This library is useful in order to customise sites models. The second section proposes predefined site models that authors can download and customize, as they desire. The customizing concerns the course structure, seminar, laboratory and also the contents subdivision and the site navigation. Our next research will be done on pedagogical patterns (Merrill, 1999) in order to improve these predefined models.

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