Συνέδρια της Ελληνικής Επιστημονικής Ένωσης Τεχνολογιών Πληροφορίας & Επικοινωνιών στην Εκπαίδευση

4ο Συνέδριο ΕΤΠΕ «Οι ΤΠΕ στην Εκπαίδευση»

ΕΤΠΕ

ΕΛΛΗΝΙΚΗ ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΝΩΣΗ
ΤΕΧΝΟΛΟΓΙΩΝ ΠΛΗΡΟΦΟΡΙΑΣ
& ΕΠΙΚΟΙΝΩΝΙΩΝ ΣΤΗΝ ΕΚΠΑΙΔΕΥΣΗ

**4ο Συνέδριο ΕΤΠΕ
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Αθήνα

16 - 17 Οκτωβρίου 2004

ISSN: 2529-0916
ISBN: 960-88359-1-7 (τ. Α') &
960-88359-2-5 (τ. Β')

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ABSTRACT

In education, instructors adopt different instructional modes that correspond to their preferred teaching style: some focus on principles and others on applications; some present the material in a logical progression of small incremental steps, others proceed from the big picture to the detail and so on. On the other side, students are characterized by different learning styles: preferences or predispositions to behave in a particular way when engaged in a learning process. In the e-learning area, adaptive educational hypermedia applications are designed in order to offer personalised learning experience based on the personal learning style. It has been proven that the good match between learning style and instructional design drives to effective learning. This paper proposes a systematic approach for designing leaning tasks for educational hypermedia applications that suit the individual learning style. In particular, we show how the design patterns approach can be used as a design model tool.

KEYWORDS: *design patterns, adaptive learning, instructional design, learning styles.*

INTRODUCTION

The rapid evolution of Information and Communication Technologies (ICT) creates numerous new opportunities for the improvement of the quality of education. Researchers and practitioners are concerned about issues like how to present the learning material to the learner in the most appropriate and personalized way, how to maintain the learners' attention, how to support and monitor the communication between the learner and the teacher, and so on. During the last few years it turned out that adaptivity is a desired feature in ICT-based educational environments and especially in educational hypermedia.

Adaptive Educational Hypermedia Applications (AEHA) are gaining the confidence of the research and development community as a means of alleviating a number of user problems related to hypermedia and web-based education. Educational applications delivered over traditional hypermedia systems suffer from certain problems that reduce the anticipated learning outcomes, such as:

- The 'lost in hyperspace' problem, where a user/learner loses his orientation while navigating into a complex hypertext structure.
- The lack of a teacher/mentor who would guide the user/learner during the learning process.
- The absence of concern about the individual characteristics of the users/learners, their previous knowledge on the subject they are studying, their history in navigating through the learning content, their learning style, their preferences, etc.

AEHA aspire to address these shortcomings and provide an individualized and customized learning experience, tailored to the learner needs, facilitating content access and generally making the learning process easier and more profitable for the learner [Brusilovski, 2001]. However, despite the growing interest of the community and the increasing number of available systems, the actual impact of these systems in e-learning remains low. The difficulty and complexity of developing such applications and systems have been identified as possible reasons for this low diffusion of Adaptive Hypermedia in web-based education.

The development of AEHA is a complex task engaging people with different backgrounds: instructional designers, subject matter experts, content developers, multimedia developers, user interface experts, programmers, etc. Experience from traditional Instructional Design, as well as Software Engineering and Hypermedia Engineering, suggests that a model-driven design approach is appropriate for developing applications where such requirements and constraints occur. This approach has a number of benefits:

- It facilitates the communication of the various stakeholders involved in the development process.
- It captures and depicts high-level design decisions and solutions at various levels of abstraction. These decisions and solutions are not only related to implementation issues but also to higher-level matters.
- It establishes a disciplined development process.
- It provides an intuitive, easy to comprehend view of the applications under development, through applying visual modeling techniques. A design model can be derived from existing applications so as to describe their architecture, structure and functionality in a process known as reverse engineering.

Our research attempts to ease the design adaptive hypermedia educational application using as input existing learning style theories and well documented instructional design models. The ultimate aim is to help in creating exemplar designs of AEHA where there is a "good matching" between learning styles and AEHA design solutions. This "good matching" is a strong requirement in this research proposal. A number of studies in traditional class-based education [Pask 1976; Claxton & Murrell 1987, Lee 1992] show that students whose learning styles match with the instructional approach "tend to retain information longer, apply it more effectively, and have more effective post course attitudes towards the subject than do their counterparts who experience learning/teaching mismatch" [Felder & Silverman 1988]. So, in the educational hypermedia space, application should provide personalized views over the learning tasks and content.

This research work also tries to take a step forward. We try to model and document the design decisions of AEHA as design heuristics for educational hypermedia designers, who can use them to build educational hypermedia that match a specific learning style.

We model these heuristics in terms of design patterns. According to the classical definition of architect Alexander, the pioneer of design patterns (who applied them to architecture and urbanistics), "… a design pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" [Alexander et al. 1977]. In its simplest form, a design pattern is a recurrent problem associated to a design solution within a specific context. It provides a structure for integrating the analysis and solution of a problem, in a way that is sensitive to context and is informed by theory and evidence.

The rest of the paper is structured as it follows. Section 2 discusses the model we have adopted for representing learning styles, as well as the design dimensions along which we can describe hypermedia application properties. In section 3 we present some examples of design patterns for educational hypermedia and in section 4 we draw the conclusions.

LEARNING STYLE AND INSTRUCTIONAL DESIGN

Learning style is the particular and different way of perceiving and organizing information [Honey and Mumford, 1986; Woolfolk 2000]. A learning style can be strengthened by proportional strategies and techniques of learning and teaching. Some researchers suggest that learning style refers to an individual way of gaining, absorbing, acquisition processing, storing, and retaining information" [Dunn et al., 1989; De Bello 1990].

The present study proposes a learning design based on Kolb's theoretical model [Kolb, 1984]. In a previous study [Garzotto et al. 2004], we employed the Felder/Silverman learning style model [Felder & Silverman 1988], one of the most used in engineering education – the field we are more familiar with. Still, our approach is largely independent from the chosen model, and the way that we will use them for designing the educational hypermedia material can be applied to any taxonomy of learning style models.

Kolb's model presents an Experiential Learning Cycle shown in Figure 1, and suggests that learning requires abilities that are polar opposites. Kolb's suggestions support the theoretical places of cognitive psychologists such as Piaget, Bruner, Harvey, Hunt and others, who point out that the construction of knowledge occurs by the concrete or abstract continuum of human cognitive development. Kolb created a model out of four elements:

- Concrete experience
- Observation and Reflection
- Abstract Conceptualisation (abstract concepts)
- Testing concepts in new situations

Kolb suggests an instrument, the Learning Styles Inventory (LSI), according to which, four learning styles are determined [http://www.nwlink.com/~donclark/hrd/styles.html]:

- **Divergers** – (feeling-sensing) concrete experience and reflective observation. They have the possibility of seeing the particular experience from various prospects. Divergers tend to be empathetic. They generally find theoretical approaches to be unhelpful and prefer

to treat each situation as a unique case. They learn best from specific examples. These learners tend to relate to peers, they are people persons. Theoretical readings are not always helpful while group work and peer feedback often leads to success. Planned activities should apply learned skills. The instructor acts as coach/helper for this self-directed autonomous learner.

- **Assimilators** – (watching) reflective observation and abstract conceptualization. They create and shape theories. They have inductive reasoning and prefer the abstract concepts than the persons. They combine preferences for action and thinking. A high score in reflective observation indicates a tentative, impartial and reflective approach to learning. These individuals rely heavily on careful observation in making judgments. They prefer learning situations such as lectures. These individuals tend to be introverts. Lectures are helpful to this learner (they are visual and auditory). These learners want the instructor to provide expert interpretation. They look for an instructor who is both a taskmaster and a guide. They want their performance to be measured by external criteria.

- **Convergers** – (thinking) abstract generalization and conceptualization, beyond the personal experience, active experimentalists. Their force is the practical application of ideas. They prefer the things from the persons and they have the possibility of focusing in a concrete problem. They compare how it fits into our own experiences. A high score in abstract conceptualization indicates an analytical, conceptual approach to learning that relies heavily on logical thinking and rational evaluation. These individuals tend to be more oriented towards things and symbols, and less towards other people. They learn best in authority-directed, impersonal learning situations that emphasize theory and systematic analysis. They are frustrated by and gain little from unstructured "discovery learning" approaches such as exercises and simulations. Case studies, theoretical readings and reflective thinking exercises help this learner.

- **Accommodators** – (doing) active experimentation and concrete experience, consequently are willing to take the risks. They solve problems intuitively. Their force is the possibility of be adapted immediately in the circumstances. They feel comfortable with the persons but can present adventurer or impatient. They think about how the information offers new ways for acting. A high score in active experimentation indicates an active "doing" orientation to learning that relies heavily on experimentation. These individuals learn best when they can engage in such things as projects, homework, or group discussions. They dislike passive learning situations such as lectures. These individuals tend to be extroverts. They want to touch everything (kinesthetic or tactile). Problem solving, small group discussions or games, peer feedback, and self directed work assignments all help this learner. They also like to see everything and determine their own criteria for the relevance of the materials.
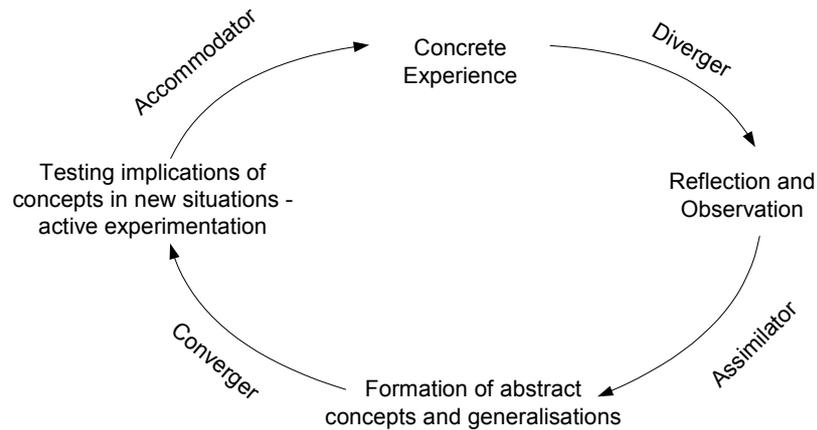
Figure 1. Kolb's learning styles

ADAPTIVE HYPERMEDIA DESIGN PROCESS

According to most hypermedia design models [e.g. Garzotto et al. 1995; Scwhabe & Rossi 1995; Isakowitz et al. 1995] the key features of a hypermedia application can be described in terms of four main design dimensions:

- the **content** (in the education domain, the educational material that the learner can explore in the application);
- the **navigation** and **interaction** capabilities by which (s)he can explore the content and interact with it;
- the **activities** in which the user can be engage and by which (s)he can modify the content and navigation structures (e.g., by marking some interesting material, by collecting material in personal "lessons") or the user representation (e.g., by answering some questions or tests);
- the **lay-out**, i.e., the concrete presentation on the screen of all the previous features.

   The design properties of a hypermedia application can be described as a combination of design attributes along the different dimensions, as seen in Table 1. The question that this research approach tries to answer is which "values" each design attribute should have in order to comply with the learning style of an individual. Moreover, how should one document this answer so that it can be easily understood by designers, theorists and practitioners, and peer-reviewed evaluated?

Table 1*: Design Properties/Dimensions

Design dimensions	Question about…	Design properties	Examples of design property "attributes"
Concepts and Content	Which educational material should the application provide?	*Concept types*	Fact, phenomenon, example, theory, principle, demonstration, consequence, application, comment, etc.
		Relationship type	Precondition, assumption for, consequence of, example of, application of, details for, etc.
		Object structure	- Rich structure (composite objects, with clearly identifiable components) - Poor structure (simple objects)
		Media types	- Visual: image, video, animation, diagram, - Sound - Text
Interaction	Which interaction style?	**Interaction Style on active media**	- Active (full control) - Couch potato (passive)
Navigation	Which navigation style?	**Navigation topology**	Possible "navigation patterns" to explore collections of objects or interrelated objects (Isakowitz et al. 1995), e.g.: - Guided tour - Index - All-to-all - Hierarchy
Activity	Which operations and activities can the learner be engaged with?	**Operation/Activity Template**	- Mark topics of interest and collect them in a personal bag - Answer questions posed by the system - Fill in assessment questionnaires - Participate to collaborative activities
Lay-out	Which lay-out properties for contents and interaction elements? (e.g., navigation/operational buttons, etc.)?	**Composition style**	many/few content elements in the same page
		Colors	many/few colors
		Media formatting	Big /small size, etc.
		Interaction placeholders	- Textual - Iconic

DESIGN PATTERNS

Systematic and disciplined approaches must be devised in order to overcome the complexity and assortment of educational hypermedia and achieve overall product quality within specific time and budget limits. One such approach is the use of design patterns [Alexander et al. 1977], so that these systems are not designed and implemented from scratch, but based on reusable design experience gained over several years of trial-and-error attempts. Therefore good design can be made explicit, and available to the whole community of designers, so that it becomes common practice. In this way, designers of new or existing educational hypermedia material, especially inexperienced designers, can take advantage of previous design expertise, the tacit knowledge of other practitioners and designers and save precious time and resources.

Pattern Name: Designing Learning Tasks in a hypermedia environment for a "Diverger" Learner
Problem: Learners characterised as Divergers (Reflective observer/Concrete Experience) are motivated to discover the relevancy or "why" of a situation. They like to reason from concrete, specific information and to explore what a system has to offer, and they prefer to have information presented to them in a detailed, systematic, reasoned manner. Thus the instructional problem is "How can I design an educational hypermedia material in order to address the needs of a **"diverger"** learner"
Solution:
> *Content Issues*
  o Create a study plan. For each learning task highlight its goals. They want to know how the learning material relates to them personally (experiences, interests, and in the future).
  o Provide "the big picture" about a topic with references to their personal experiences and examples
  o Do not lecture them.
  o The material should be short either text-based, observations (videos, pictures, shapes, figures) that make sense for their current level of knowledge, motivation and experiences
  o Provide material that simulate lab work so that they will have hands-on experiences
  o Provide them with a variety of case studies so that they can see situations from many perspectives
  o Give them tasks for organizing relationships between a variety of similar case studies into meaningful wholes
  o Include exercises-problems at a high level of detail with guidelines for solving them step by step.
  o Organise field work on topics highly related to his/her interests
> *Navigation and Interaction Issues*
  o Use "Guided tour" (see "Index Hypermedia Pattern" (Isakowitz et al. 1995))
  o Support "bottom-up" processing of learning (simple to complex, inductive process, a stimulus or a specific information that will activate the intellectual processing)
> *Activities Issues*
  o Offer learners tasks for searching for information evaluating current information
  o Allow student to brainstorm in interacting with peers in small groups. Be their motivator
  o Give them tasks for reflection especially through talking and feeling. Give them time for reflection
> *Lay-out Issues*
  o Text will be given in small chunks
  o The style of writing should be highly specific
  o Use a lot of pictures, figures, shapes will illustrative captions
  o In the different pages, highlight relevant topics and make links to hints

Figure 2: The "Diverger" Learner Pattern

The idea of using patterns as a mean for documenting design practices of hypermedia applications is not new [e.g. Rossi et al., 1999; Grazotto et al., 1999]. However, the idea of using design patterns for educational hypermedia is new. In our approach, the problem component of a design pattern is described by an instructional goal (e.g., a learning preference that the designer, or the application, needs to address); the solution component describes the desired design properties that the application should have, concerning its types of content, its organization structures, and interaction or navigation capabilities.

By its very nature, any design pattern is intrinsically heuristic, being founded on design practice. In our patterns, we try to capture the experience achieved in traditional educational frameworks and reported in the literature of pedagogy, cognitive science, and instructional design. These disciplines provide us with models for describing instructional approaches that work well (at least in some authors' opinion) for some specific learning preferences.

Our pattern, as shown in Figure 2, attempts to translate "traditional" instructional design solutions in terms of hypermedia design properties for the "Diverger" type of learner. It should be noted, that this pattern approach is not tightly coupled with any ideology about learning-cognitive styles. Instead, we tried to provide the reader with an example for illustrating our idea.

The approach presented in this paper, provides an innovative framework for planning teaching and learning activities and it can be usefully employed as a guide for designing adaptive hypermedia learning material, evaluating the proposed instructional practices, as well as understanding learning difficulties, vocational counselling, academic advising and so on [Nanard et al., 1998; Tennant 1997].

ACKNOWLEDGEMENTS

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