Designing the Virtual Design University

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Abstract: Universities are currently providing learning opportunities to students and teachers exploiting information and communication technologies to deliver their programs and provide tuition support. However, since architectural design education is unique, general models of e-learning are not applicable. Regarding a potential virtual design university there is therefore a particular need for a theoretical pedagogical framework. The objective of this paper is to present a theoretical basis for the design and implementation of a unique e-learning environment suitable for design learning and design teaching in the architectural and engineering domains. The ideas and the concepts are currently being implemented in the WINDS project. Three theoretical and methodological aspects that provide unique consideration for the construction of a virtual learning environment for design are presented and discussed: 1) A unique structure of design knowledge as required in virtual education; 2) A requisite pedagogic framework for virtual design education; and 3) A particular technology designed and implemented to support these aspects in WINDS.

1 INTRODUCTION

Universities are involved now in providing learning opportunities to students and teachers using information and communication technologies to deliver their programs and provide teaching support. Learning vendors and academic institutions support innovations in technologies which, in turn, aim to improve education. Many initiatives towards virtual universities are innovative in technological aspects that support distance education. There is a high level of competition for being the most technically "wired university" as manifested in numerous strategic plans for distance learning and online degrees programs. Virtual universities are responsible among other things for course and material development, production and distribution; and they are responsible for facilitating teaching and learning. Within the overall e-university framework e-learning environments provide among other things tools for authoring course material, for conveying this content to learners, for supporting teacher-student communication and evaluation.

E-learning environments are also providing new models for learning. They encourage such concepts as "open learning", "distance learning", "independent

study" and "cooperative learning". They support flexible and individual learning styles, cooperation among peer groups as well as between students and teachers etc. However, putting a course on-line does not accomplish such educational innovation automatically. This requires some theoretical pedagogical basis in addition to the learning technology. These new educational models are shaping the way learning environments are implemented and managed in the virtual university. In order to design satisfactory and effective e-learning environments for design the following issues are significant:

a) Technology may change and enhance the context in which learning and teaching are taking place, but without pedagogical principles and design models that underlie technology, e-learning will not be effective in design teaching. It is important to emphasize the role of a pedagogical and theoretical model of design.

b) Studio based learning is the most accepted traditional framework in most architectural schools in the world. E-learning environments, employing the web, computer applications and other multimedia should provide new modes for the representation of curriculum material and course structuring in order to support an electronic analogy to the problem-based learning of the design studio as well as providing for the delivery of related theoretical and scientific course materials.

WINDS (**W**eb-based **IN**telligent **D**esign tutoring **S**ystem) is a funded project of the 5th Framework of the EC Information Society Technologies Program. It is a research project that aims to build a comprehensive virtual university for architectural and engineering design. It includes 28 partners of 10 European countries. The WINDS framework aims to provide a framework related to curricula design and the production, delivery and evaluation of educational material in a virtual school for design. WINDS seeks to implement a unique learning environment in the domain of architectural and engineering design, to create a rich ensemble of courses, and to develop within the course construction a knowledge base. WINDS is currently in the last phase in which a re-evaluation of course implementation, the management system and course user interfaces are being re-designed.

The objective of this paper is to present the theoretical-pedagogical framework in WINDS emphasizing the following contributions:

1) The particular pedagogical framework for a virtual university for design education;

2) The implications of this framework for the way design knowledge is structured, organised and conveyed;

3) The particular way authoring and learning technology is implemented in order to support this framework.

The next section introduces the theoretical "Tri-Partite Ontology" framework. Following this problems of implementation of the theoretical framework in WINDS are presented. Section 4 introduces the ALE environment and the methodology for course design and development. The last section speculates about the role of the

Virtual Design University as a result of the WIND experience and its impactions for the future of design education.

2 A TRI-PARTITE ONTOLOGY

The theoretical framework of WINDS attempts to integrate the following three aspects: *pedagogical method, an approach to domain knowledge in design, and an approach the technology of distance learning*. Furthermore, it attempted to achieve synergy at the level of the design university by *creating a knowledge system out of the multiplicity of courses*.

2.1 Design Pedagogy

E-learning for design cannot be effectively implemented without an explicit pedagogical framework and guidelines. Theoretical models for teaching method and learning processes are essential. How materials are textually and graphically structured and presented to the learner, how knowledge is formulated in order to be accessible and memorable, what forms of knowledge enhance and support tasks of design, these are among the substantive questions of pedagogical method. These are other questions are always present in design education. However, their significance becomes enlarged in distance learning. Pedagogy is the medium for conveying knowledge without direct contact with the student.

In its direct relationship to knowledge acquisition, pedagogy also has significant implications for curriculum structure as well as for course design. Domain knowledge in design may be considered an articulate body of knowledge shared by a group, in this case the design professions. In a virtual university *this articulate body of knowledge can come into being as the result of a collectively shared ontology of design*. In the WINDS approach *the pedagogical form of individual courses contribute to the constellation of knowledge which is the university*.

2.2 Design Knowledge

The new media enables and encourages the centrality of knowledge creation, acquisition, and dissemination. As a design community we have not yet succeeded in establishing the intrinsic requirements of the medium with respect to the organisation, structure and presentation of design knowledge. Currently, there exists no conventionally accepted knowledge representational model that can become the basis for mapping this kind of knowledge. A “course shell” is a particularly significant problem, if knowledge is to be mapped, *or asynchronously assembled,* by the “virtual community” of the domain.

WINDS explicitly encouraged the creation of a knowledge base as part of the course authoring process. The format of the knowledge base was embedded as a function of the course authoring process. This format was *designed to support the development*

of relationships and structures of knowledge on the part of individual learners. That is, in addition to defining design knowledge specifically in terms of forms of knowledge, WINDS also *defined knowledge acquisition and evolution as the growing understanding of structures of knowledge*. The learning environment was designed to help teachers to prepare their materials in sympathy with these ideas.

2.3 Learning Technology

Constructing a framework for course design implies that the learner is being given access to learning material that supports knowledge needs in a given problem situation. Learning technology must enable the construction of effective pedagogical material for the designer/learner. It should be *designed to enable and support a modular structure of didactic material within the dependency network among the university course modules* that allow the dynamic definition of special curricula according to the designer/learner needs.

In the following section the theoretical framework that support these issues will be introduced and the way it has guided the implementation of the WINDS e-learning environment will be presented.

3 THEORETICAL BASIS AND IMPLICATIONS

When dealing with educational technology there is a strong link between the pedagogy and the possibilities of technology itself. An e-learning environment for design cannot be effectively implemented without an explicit and integrated tri-partite framework as we have presented it. The following theories have provided the theoretical foundations for WINDS: constructivism, precedent-based design and the ICF formalism, associative learning and conceptual mapping. Furthermore, the relevance of these theories to pedagogical approaches in design education as well as to the cognitive aspects of learning is significant (Oxman 2002).

3.1 Constructivism

Constructivism is the dominant learning approach in online courses. The philosophy behind constructivism is that the learner constructs his own knowledge based on his experience and relationship with concepts. Learning implies that new cognitive structures are acquired. Constructivist theories of learning (Kolb 1984) propose that the learner is not conceived of as a passive recipient of knowledge but is an active participant in the process of learning. This can be taken further in creating an environment in which the learner can select and adapt knowledge according to his needs. Constructivism is reflected in WINDS in the method for the using the design curricula through which knowledge can be accessed and acquired. In WINDS, the *acquisition of the body of concepts* from a syllabus is considered as means to facilitate meaningful learning. Organisation of courses and the provision of a

template that renders their concepts explicitly help to organise knowledge and to structure it. Furthermore, as far as problem-based learning is concerned, conceptual structures are dependent upon the context in which they are used. The learner, in fact, identifies a context in which the structure of the concept map is constructed. Given a certain class of assignment the student learns to identify concepts that are relevant to various problem contexts. This constructs a body of theoretical and instrumental knowledge.

3.2 Associative Learning and the ICF Formalism

WINDS has adapted the ICF formalism (Oxman 1994). In this formalism, *issues* stand for high-level goal statements, or starting points in the design process, *concepts* refer to domain-specific methods of achieving certain issues. In WINDS each course undertakes the decomposition of holistic course knowledge into separate chunks. A typical chunk than, provides explicit linkages between issues, concepts, and a related form in any course description, or part of it. Similar to the original ideas of the ICF, the relationship between these chunks should not be thought of as a strict hierarchy, but rather as a semantic net. A single issue may be addressed by different courses, just like a single course may address different issues.

The implementation of the ICF ideas in WINDS enhances the capability of cross-contextual indexing by exploring the conceptual net of indices in the courses. *Content may be acquired by knowledge chunks*, rather than by holistic courses. Conceptual links in the semantic network can connect different chunks from different courses. From any index, related chunks can be retrieved which in turn, call up their content chunks in specific courses. The course semantic network structure functions as a lexical basis for search and navigation. A further attribute of the semantic network structure is the ability to identify linkages between design ideas and concepts that were not originally apparent, but can be established by navigating the connections in an associative manner between design ideas.

In WINDS associative learning is supported by provision of the “index” tool. It is a knowledge organiser that enables identifying the occurrences of terms despite their syntactic differences. Individual courses are placed within the overall WINDS concept index at a particularized level of detail. For each course numerous entries of conceptual content are introduced to the index. This supports free navigation through the training material and enables cross- referencing through the conceptual network. Learning to *read the network of associated concepts* adds to learning gained through traditional expository material. This promotes individualized learning and the support of diverse learning styles in which each student can navigate and explore multiple paths to support his ideas during the conception of a project. The approach also enhances the future re-usability of knowledge modules.

3.3 Conceptual Mapping

Concept maps derived from Ausubel’s learning theory (Novak 1991). A concept

map is a special form of diagram for exploring knowledge, sharing and gathering information. It was proposed as a tool to develop an understanding of a body of knowledge. In fact, they contribute to a constructivist learning model and in a number of pedagogical tools suitable for e-learning. The fundamental idea is that learning takes place by assimilating new concepts and propositions into existing conceptual frameworks held by the learner. According to this approach incoming information is organised and processed by interaction with long term, existing knowledge. Concept mapping is a tool for organizing and representing knowledge. Similar to the ICF formalism, they include concepts, and relationships between concepts indicated by a connecting line between two concepts. Sometimes these are called semantic units, or units of meaning. Concepts may be general in a particular problem or situation, or specific, according to the learner needs. The ICF is a particular form of concept mapping suitable to design problems. After a preliminary conceptual map is constructed, cross-links can be sought. These are links between different domains of knowledge on the map that help to illustrate how ideas or domains are related to one another. Once students begin to focus on cross-links, they learn about conceptual relationships and larger conceptual structures. When the process is done well, concept mapping is a means to achieve high levels of cognitive performance in education.

4 E-LEARNING IN WINDS

Traditional approaches that provide an authoring environment for knowledge content are based on the construction of single course modules. In WINDS knowledge is constructed as a structure of *conceptual content modules* that provides a conceptual mapping designed to support design thinking in a typical studio situation. The content modules are related to the conceptual content of design problems, issues and types in such a way that they can be re-used and combined according to the needs of the learner. This way the content material embedded in course modules provides an explicit structure of knowledge that can be acquired as part of the learning process. Learning is both the acquisition of modules of knowledge as well as exercising their implementation in design processes.

The systems approach is designed to serve the modular structure of didactic material and the dependency network of the university course modules that enables the dynamic definition of special curricula according to student needs. This allows the construction of very effective pedagogical material for the student thinker/learner in the situation of the digital design studio. The WINDS SHELL supports associative linkages based on the Concept Index Tool and was developed by DMG, Germany. It assists in self-navigation in the knowledge environment. This tool was developed for the automatic indexing of texts and related images in the WEB. The use of indexes in WINDS accommodates two types of learning objects: learning units which are textual and CAD models. A concept in WINDS can be expressed as a text associated with a 3d model of a real object or vice versa. The management of digital images and 3-d objects is implemented through "Collaborate" – a tool developed by Nemetcheck. The tool allows for linking between textual concepts in the E-Learning

shell and digital images in a 3-d platform.

4.1 The ALE System

From pedagogical point of view the contribution of the learning environment in WINDS (ALE = Adaptive Learning Environment) (Specht et al. 2001) is to provide a strategy which allows both the teacher and learner to support dynamic linking between learning objects. This strategy provides *flexible learning objects* that can be re-used in various learning contexts and can be shared among the different courses in the curricula. It also supports the construction of personalized courseware according to learner needs. The ALE system contains three modules: authoring (teacher), learning (student) and content management (administrator).

4.2 Course Authoring

The basic components in WINDS are learning objects. Learning objects are defined as course modules that can be shared and re-used in other courses. "Course Index" in the WINDS authoring tool allow the authors to build learning units in a specific hierarchy. They can be used, combined and recombined in various ways. The learning objects include the following:

a) Course units: course title elements that are the highest in the hierarchy;

b) Learning units: course sub-titles which are used in order to structure the course material;

c) Learning elements: chunks of information, created as a sequence of re-usable basic data components;

d) Index terms: the basic terms of the conceptual content and the language vocabulary of the course.

For each learning object a corresponding set of index terms are displayed. The *index unit* includes the body of relevant index terms that are predefined by the author. The indices are used as annotation tags. Interrelated heterogeneous course contents are experienced as the learner finds an individualized path through the learning materials. The WINDS course index component maintains the index terms together with their respective descriptions, synonyms, different types of relations (is_a, part_of, related_to, etc) between terms, occurrences in the course materials as well as external documents. The student can access all this information about a specific term by choosing it in the *index frame.*

Figure 1 shows an example of a possible structure of a course unit of a course on virtual architecture (Oxman 2002) in the context of the WINDS authoring environment. Figure 2 presents an interactive screen for authoring in WINDS. In order to view the learning objects, the authoring environment provide a navigation tree to see an overview of the curriculum. The content catalogue contains the curriculum structured as learning objects. All learning objects in a course unit are

linked dynamically by the underlying index defined by the course author. The index reflects the conceptual understanding and the conceptual language used by the domain. Each course has its own index terms. Any index can be imported and exported and can be used in other courses and applications. By cross linkages to the index term the student can browse other learning objects and external documents.

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content catalogue

course authoring

(course unit) *Virtual Architecture*

(learning unit) *Cyberspace (learning unit)*

(learning unit) *Mapping cyberspace*

(learning unit) *Information architecture*

(learning unit) *The virtual and the real*

(learning unit) *Virtual Architecture*

(index term) *Liquid*

(index term) *Flux*

(index term) *Mutability*

(learning unit) *Virtual types*

(index term) *Virtual museum*

(index term) *Virtual shopping*

(index term) *Virtual banking*

(learning unit) *Virtual places*

(index term) *Social interaction*

(learning unit) *Virtual technologies*

(index term) *Avatar technology*

Index (synonyms) *cyberspace=Information space*

Relations (is-a-kind-of) *Virtual architecture is-a-kind-of cyberspace*

Documents *(http://www.artmuseum.net/vangogh/gateway.asp/)*

Figure 1 A Structure of a Course Unit in the WINDS Authoring Environment

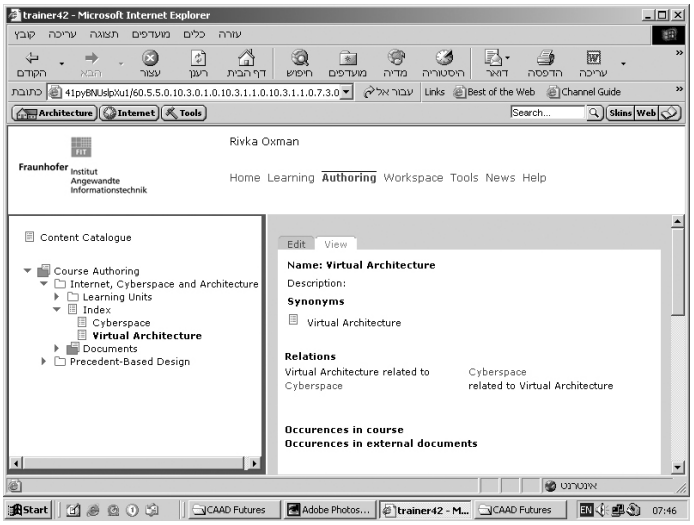

Figure 2 An Interactive Authoring Screen in WINDS

There are two basic ways in which learning can take place in WINDS. The first mode is expository learning and the second mode is exploratory learning.

In expository learning, the learner follows the curriculum and explores single courses through *an organised framework of learning units*. Within this mode learning by discovery is also encouraged by the manipulation of index terms and their *interconnections into other parts of the whole curriculum* that contains expository education material. In exploratory learning the learner explores alternative structures according to his needs. By browsing from learning elements to index terms, to external documents and back to index terms the student can develop an individual path, based on his particular interest and needs.

The exploratory mode provides for an important use in the design studio situation. Indexing can be employed as a mechanism for navigation within the course material and among that of other courses. In this way navigation can be used as a search and exploration mechanism for design ideas, analogies, metaphors, and precedents. This mode of cross-contextual indexing within the WINDS university-wide curriculum thus supports both direct search and associative search. As such it is highly characteristic of cognitive reasoning in design. Furthermore, navigation can support two important modes of explorations: from textual concept to textual concept, and secondly from concept to image, from text to graphics.

5 SUMMARY AND CONCLUSIONS

WINDS has been a unique experimental effort that coordinated the development of the virtual university through the efforts of numerous individuals in separate

locations, diverse professional domains, and multiple cultures and linguistic backgrounds. This effort was denote as the social construction of knowledge (Oxman 2002) and was possible due to the adoption of the "tri-partite" methodology. Technology follows pedagogy may be seen in retrospect as the WINDS motto. In this paper we have attempted to present the tri-partite ontology as the basic pedagogical contribution of WINDS, and have attempted to explicate the ontology. It represents a strongly conceptual and ideational approach to knowledge, knowledge formulation and the acquisition of knowledge in design learning. That, in itself, is quite unique; it is also, perhaps, the message in the medium.

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