THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE III, 2009, Vol.32, No.2, ISSN 1221-454X
ELECTROTECHNICS, ELECTRONICS, AUTOMATIC CONTROL, INFORMATICS

ON MODELING THE INSTRUCTIONAL CONTENT IN COMPUTER ASSISTED EDUCATION

Emilia Pecheanu, Diana Stefanescu, Adrian Istrate

Computer Science and Engineering Department
University “Dunarea de Jos” of Galati

Abstract: This paper presents a solution for conceptually modeling the instructional content in computer-assisted education. The different cognitive style of learners imposes different modalities of presenting and structuring the information (the pedagogical knowledge) to be taught. Conceptual organization of the training domain knowledge, with learning stages phasing, can constitute a better solution to the problem of adapting the instructional system interaction to users with different cognitive style and needs.

Keywords: cognitive style, structured instructional content, conceptual model, lattice-like model, authoring tool.

1. INTRODUCTION

Increasing the assistance capability of instructional environments has lately become an important study and research subject in the area of computer–assisted instruction.

The possibility of personalizing the educational process is the main demand in building computer-assisted learning systems for any form of education, continuous education and professional re-conversion included.

In many education forms the subject of study consists of heterogeneous groups of users; between these users there can be significant differences concerning the training level, age or internal goals pursued through study.

Consequently, the way the educational process is approached – the cognitive style – can be extremely different among the users who form the study groups.

Learners’ cognitive style leads to individual variations within the learning process: each person has his own way of thinking and, thereby, the acquisition of new knowledge is person-specific.

The concept of cognitive style ignores the knowledge content, emphasizing on the manner in which a person succeeds in the cognitive process.

Psychologists define the cognitive style as a combination of several psychological characteristics that serve as relatively stable indicators of the way the learner perceives, interacts with and responds to an instructional environment.

Following these indicators, about 70 models of cognitives styles have been identified, and 13 of them were categorized as major models, according to their widespread use and their influence on other cognitive styles models (Coffield *et al.*, 2004).

Some well known models (Curry 1983) categorize the learner cognitive style into four layers:

- Personality models - which focus on the personality traits of the learner and the way they influence the learning activities
- Information processing models – which focus on the process of acquiring, ordering and engaging with learning information

This paper was recommended for publication by Severin Bumbaru

- Social interaction models – which focus on collaborative aspects in learning activities
- Instructional preference models – which focus on the environmental and emotional preferences of the learners.

Whether stable or flexible, genetically determined or experience-related, all categories of cognitive styles have been proven to exert a major influence on efficiency in educational activities.

Considerable research effort has gone into implementing adaptive (depending on the cognitive style) instructional environments. A direction pursued by many systems designers is to build flexible, well defined models of the domain knowledge (the knowledge belonging to the training area), which is presented to users as instructional content. Differences between the users' individual cognitive styles should be reflected in the manner of structuring the domain-knowledge and in the manner of designing the user interface.

The organization model of the instructional content, which is tightly connected to the structure and the representation of the domain knowledge, has to provide the user with multiple views or presentation patterns of the concepts in the training domain (Larmat 1997). Studies and assessments of computer-assisted instructional systems (CAI systems) have shown that if they contain a structural model, they facilitate learning. A well structured architecture of the instructional content can also improve the efficiency of any guidance method the instructional system might use (Messing 1999).

Modern instructional theories, corroborated with representational properties of network-like architectural structures, leads to the idea that the domain knowledge might be organized in the form of "conceptual networks"(Nicola 1999).

A conceptual network's node has to contain a description of some domain's concepts (main ideas), and the links between the network's nodes should be kept for the multiple relationships between these concepts.

The modeling methods described herein might be adopted in order to build and to represent the knowledge space of an intelligent instructional system.

The resulting models integrate in a unitary structure the domain knowledge and the instructional knowledge pertaining to a CAI system.

The modeling methods have been mainly derived from Formal Concepts Analysis, (Ganter and Wille 1999) and Logical Concept Analysis, (Ferre 1999) and consist of a theoretical framework and a knowledge representation approach.

These methods have been developed and fully described in (Pecheanu 2004).

2. THE MODELING METHODS – THEORETICAL FOUNDATIONS

The key elements in modeling the domain knowledge of the CAI system are the Conceptual Unit, the Conceptual Structure, and the Conceptual Transition Path.

A Conceptual Unit is a group of related notions (concepts, basic ideas) belonging to the domain knowledge of an instructional system . A Conceptual Structure is a model meant to represent the domain knowledge of a teaching course.

A Conceptual Structure should map the cognitive structure of the domain knowledge, and should also reflect the pedagogical vision of the teacher-author of that course. The model has to allow for flexibility, i.e., to provide as many transition paths as possible in order to learn the domain's main concepts.

A Conceptual Transition Structure should offer various solutions to traverse a group of notions in the interactive course. As such, an educational software-system should offer its users a flexible support for the learning act (Pecheanu 2003).

A lattice-like model has been developed in (Pecheanu 2004) in order to stay as Conceptual Transition Structure for the training domain of a CAI system. The model, named COUL-M (COnceptual Units' Lattice Model) is able to represent, in a comprehensible way, the relations between the concepts of the training domain of a CAI system.

The model COUL-M is based upon the mathematical formalization of the relationships between the notions (concepts, main ideas) existing in the space of knowledge of a teaching domain:

1. precedence between notions or sets of notions, which specifies the presentation's order for the course's notions and
2. contribution between notions or sets of notions in presenting other notions during the teaching process.

The mathematical equivalents of precedence and contribution relationships are the Precedence Relation and the Contribution Relation. These relations have several properties permitting to transform them, by applying sequences of aggregation and decomposition operations, into one-to-one incidence relations.

The formal contexts and the formal concepts' complete lattice can further be built for these relations (Ganter and Wille 1999). Then, the pairs of sets (intension, extension) which compose formal concepts can be extracted from these formal contexts and the formal concepts' complete lattice can further be built (Ganter and Wille 1999).

The formal concepts are mathematical, abstract representation for sets of related notions within the teaching material of the course. The formal concepts' intension part (or the intension-sets of the formal concepts) will stand as the "Conceptual Units" related to the teaching material.

Several lattices of Conceptual Units, standing as a Conceptual Structures for the domain knowledge can be finally derived. Thus, the COUL-M model for the domain knowledge of a CAI system is defined as a complete lattice C_S generated by rewriting the relations between the notions of the course as relations of incidence where the formal concepts are abstract representation for sets of related notions within the teaching material.

The subposition operation (Ganter and Wille 1999) was applied in order to compose the formal contexts of the Precedence and Contribution Relations. The results of this operation were integrated into the model of representation COUL-RM, defined as a tuple (N, R_N, C_S, L_S), where:

1. N is a set of notions from teaching-domain of a course,
2. C_S is the complete lattice,
3. R_N is the relation of order within lattice C_S, established by set inclusion,
4. L_S is the set of elementary chains to traverse the lattice C_S, by respecting the order subconcept – concept.

Different types of knowledge referring to Instructional Objectives, Instruction Resources and Instructional Methods have been further integrated into the COUL-M model. The final model COUL-FM, (Conceptual Units Lattice – Formal Model) has been developed by integrating the KB's formal objects into the COUL-M model:

- the COUL-FM model is a complete lattice, isomorphic to the lattice of the interactive course's notions;
- since the lattice of course notions constitutes a representation of the links between these notions, as specified by the teacher-author of the course, the COUL-FM model possesses the same representational properties, due to the isomorphism;
- the elements of the COUL-FM model are the logical concepts of the complete lattice; each logical concept is a conjunction of disjunctive formulas;
- a logical concept is a conjunction of formulas, in the same way that a formal concept is a reunion of notions;
- an element of the COUL-FM model is a formally expressed description of the Instructional Methods that can be used to acquire a group of notions;
- an Instruction Unit is the formal description of the alternative methods that can serve to acquire the "new" notions in each sequence of instruction;
- the "new" notions within each sequence depend on what has been learned in the previous sequence (they depend on the selected path) and cannot be listed beforehand;
- an Instruction Unit is described using a formula that is derived, deductively, from the formula describing an Instructional Stage.

The COUL-FM model attempts to capture the semantic links between the notions of a subject of instruction and to corroborate them with the way in which the instruction can be carried out, taking into account the methods and resources that exist at a given time within the interactive course.

3. A SOFTWARE TOOL FOR MODELING THE INSTRUCTIONAL CONTENT

The COUL-FM model has been implemented by means of a software tool: a knowledge compiler named COUL-COMP (COnceptual Units' Lattice – knowledge COMPiler). COUL-COMP stands for an authoring system, able to help in modeling and representing the domain knowledge for a CAI system (Pecheanu 2004).

The compiler COUL-COMP is able to lexically and syntactically check the correctness of a "program", i.e., a set of specifications written in COUL-SL language (Conceptual Units' Lattice - Specification Language) and to output the following results:

1. the formal contexts for the precedence and contribution relations between the concepts in the system,
2. the list of resulting closures and formal concepts,
3. the list of attributes of the formal concepts and the learning paths derived from the specifications of the knowledge in the system (Figure 1.).

The lattice-like COUL-M model is able to represent, in a comprehensible way, the relations between the notions in the training domain of a CAI system. Furthermore, the COUL-FM model includes knowledge about the targeted instructional methods and the existing instructional resources. The COUL-FM model attempts to capture the semantic links between the notions of a teaching subject and to corroborate them with the way in which the instruction can be carried out, taking into account the methods and resources that exist at a given time within the interactive course.

The compiler COUL-COMP is a computational representation of the COUL-FM model, able to extract pedagogical prescriptions from the model. The COUL-FM model can be integrated in any computer-assisted instructional system including large collections of instructional documents.

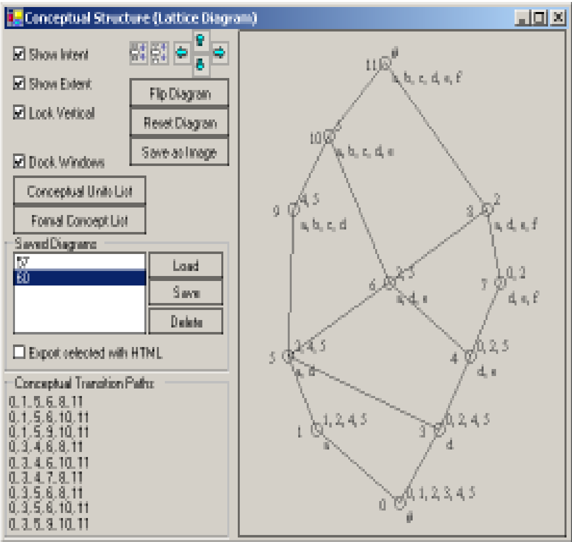

Fig.1. The lattice-like model of the instructional content.

4. CONCLUSIONS AND FURTHER DEVELOPMENTS

The lattice-like COUL-M model is able to represent, in a comprehensible way, the relations between the concepts of the training domain of a CAI system. Furthermore, the COUL-FM model is including knowledge about the targeted instructional methods and the existing instructional resources.

The compiler COUL-COMP is a computational representation of the COUL-FM model, able to extract pedagogical prescriptions from the model. The COUL model can constitute o low level layer for various types of training systems.

The model is providing some essential elements for developing adaptive training systems: a mapping of instructional methods and pedagogical resources over a conceptual structure of the domain knowledge. The COUL-M model can be integrated in any instructional environment including collections of unstructured pedagogical resources.

5. REFERENCES

List of references arranged alphabetically according to first author, subsequent lines indented. Do not number references. Publications by the same author(s) should be listed in order of year of publication. If there is more than one paper by the same author(s) and with the same date, label them a, b, etc. (Morris *et al.*, 1990a, b). Please note that **all** references listed here must be directly cited in the body of the text.

Coffield, F., D. Moseley, E. Hall and K.. Ecclestone (2004). Learning styles and pedagogy in post-16 learning. A systematic and critical review, Learning and Skills Research Center, UK

Curry, L. (1983). An organisation of learning styles theory and construct, Annual Meeting of the American Educational Research Association, Montreal, Canada

Ferre, S. (1999). Systemes d'information logiques, IRISA, Rennes, France

Ganter B. and R. Wille (1999) *Formal Concept Analysis –Mathematical Foundations*, Springer Verlag, Berlin

Larmat, J. (1997). *Genetica inteligentei*, Editura Stiintifica, Bucuresti

Messing, J., (1999). The Use of Teaching Strategy Control Features in Computer Assisted Learning Courseware, Charles Sturt University, US

Nicola, I. (1992). *Pedagogie*, Editura Didactica si Pedagogica, Bucuresti

Pecheanu, E. (2004). Conceptually Modeling the Domain Knowledge of an Computer assisted Instructional System, PhD Thesis, Galati, Romania

Pecheanu, E., (2003). Content Modeling in Intelligent Instructional Environments, *Proceedings of KES 2003*, **Vol. 1Part II** 1229-1234, Oxford ,UK