A knowledge base approach to courseware design for distance learning

E. Kushtina[1], O. Zaikin[2], and N. Enlund[3]

[1] Technical University of Szczecin
[2] Royal Institute of Technology

1 Introduction

Recently, distance learning (DL) has made great achievements in the area of communication space development and the automatic administration of educational processes [1]. Considerably less attention has been paid to the particularities of didactic materials design for DL. The authors claim that a special methodology of didactic material design, based on a cognitive approach, has to be developed [8].

The cognitive process presumes the interaction of three components: teacher, student and didactic materials. In conventional teaching, the teacher plays the role of a knowledge engineer. He/she extracts knowledge from the initial material and creates a cognitive scheme, corresponding to the aims of teaching and the level of the students' basic knowledge. As shown in fig.1, the teacher is a mediator between the student and the didactic material in conventional teaching. He/she is initiator, organizer and manager of the learning process corresponding to the aims of the teaching. He/she creates and keeps in mind the cognitive scheme of the subject and, in accordance to it, passes the knowledge to the students. This means that the quality of the learning process depends entirely on the teacher's ability to design the cognitive scheme of a subject.

In DL, which to an extent can be considered learning without a teacher, the student is forced to assimilate the didactic material on his/her own. Nevertheless we would like to achieve the same effectiveness in the learning process that exists in conventional teaching methods. New information technologies and telecommunication networks provide the possibility of direct contact between student and teacher at a distance. In this case, however, the following problems appear. Which is the role of the teacher? How must the didactic material be modified?

If conventional methods are used in the DL telecommunication space, the cognitive process does not change, and the interaction between student and teacher proceeds in an online dialog. This can raise the effectiveness of the learning process due to the effects of individual teaching, but makes teaching very expensive.

A further increase in teaching effectiveness in the telecommunication space can be achieved only through a change in learning process organization. In DL conditions, the cognitive scheme of a subject has to acquire formal representation and can be accessible for all students independently of the teacher. This means that the cognitive scheme has to move from the teacher's mind to become a part of the didactic material. The knowledge approach, used for expert system construction, can be applied to cognitive scheme design.

DL does not reject the conventional sources of knowledge, such as manuals, monographs, articles etc. Nevertheless, there are new special requirements on didactic material design for the conditions of DL. Let's define such materials as 'courseware'. Courseware, accessible to students through the Internet, can be used for independent learning without a teacher. The basic element of courseware is a conceptual scheme that describes the notions and their relations. Thus courseware provides access to new knowledge at the notional level.

DL changes the roles of the teacher and the didactic material in the learning process. The didactic material acquires the features of a knowledge base and the teacher performs only the functions of consulting and student knowledge evaluation. This means that the teacher participates in courseware design as knowledge engineer and tests the students' received knowledge.

As is shown in fig. 1, the cognitive process in DL consists of two steps. In the first step, the teacher performs the role of a knowledge engineer and creates the cognitive scheme of a subject. In the second step, she/he performs the functions of consultation and evaluation of student knowledge. The didactic scheme of the subject.material has to include two parts: information about the subject and the conceptual

2 Stages of the learning process

Let us examine the process of courseware design and its role in DL in order to define the principles of its creation and modes of presentation. Formally, the learning process can be described by the system of models of extraction, acquisition, interpreting and evaluation of knowledge [6]. The learning process can be represented as a set of sequential models (fig2).

1. Conceptual model of the learning subject. The teacher designs the conceptual model of the subject, using existing monographs, textbooks, and articles as well as his/her own knowledge for the given subject. It is a product of the acquisition and updating of objective knowledge about the subject. This does not depend on individual peculiarities of the students. When designing a conceptual model, a teacher combines the roles of a knowledge engineer and a subject expert.

1. Basic model of student knowledge.This defines student knowledge prior to the learning process and can be represented as a set of production rules. It allows us to evaluate the readiness of a student to accept new knowledge.
2. Motivation model The teacher creates a motivation model for a certain contingent of students of some age, sex and social position. An analysis of these factors by the teacher gives the possibility to estimate the readiness of the contingent to achieving the given aims of teaching. The motivation model is a set of production rules, formulated by the teacher or an expert methodologist.
3. Adaptive conceptual model This is a conceptual model of the learning subject, adapted to the basic model of student knowledge.
4. Learning efficiency model This model describes the modes of learning and testing of student knowledge, for example deductive games. An expert methodologist chooses the most efficient modes of learning and testing at each specific case.

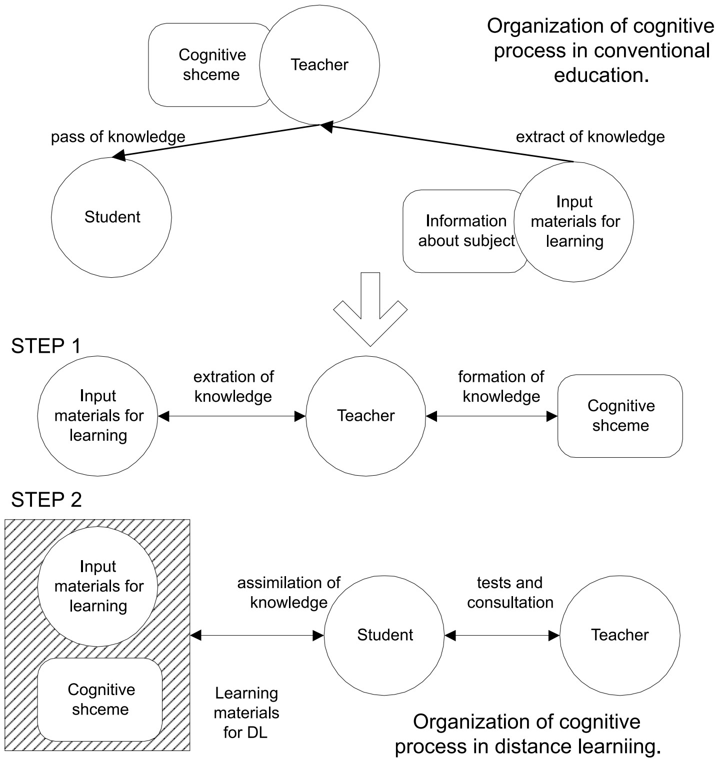


Figure 1 Components of learning process.:

1. Model of student's accepted knowledge This is a model of the student's objective knowledge about the subject. It reflects the student's abilities of interpreting and manipulating the basic notions, and also the operational skills which a student can develop after learning.
2. Testing of the student's accepted knowledge The tests related to the courseware depend on the aims of teaching and the chosen test methods. The teacher for each student contingent carries them out. These problems are examined in [2], [7] in more detail.
3. Evaluation of the total learning process The module 'evaluation' is intended for the estimation of total learning process quality. It includes such measures as:

- percentage of students successfully carrying out the tests during the teaching period,
- number of personal consultations given to students during this period,
- system costs, reduced to cost per student,
- number of students continuing the education,
- number of students successfully certified by other organisations

Independent experts carry out the comparison between the results and the aims of the learning process as well as the overall evaluation. The modification and correction of teaching aims is carried out in accordance with the evaluation results.

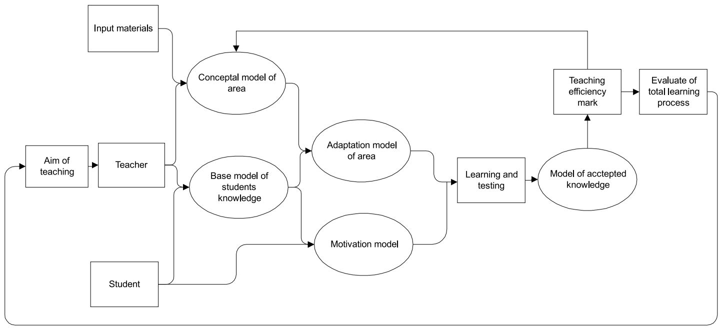


Figure 2:Diagram of creation and evaluation knowledge.

All elements of the scheme in fig.2 have their place and expression in conventional teaching. However, in the conventional teaching process they exist only as informal, continuous processes, active within the teacher's mind. The results of these processes are knowledge and teacher skills that can be formally represented as:

1. expert systems that reflect an experience transferred to less qualified teachers,
2. teaching methods that reflect knowledge of the domain area, transferred to students.

Under DL conditions, the student is taking the knowledge about subject without direct teacher contact. This means that conventional teaching methods have to be transformed into the DL formal outline and have to be accessible to students in the telecommunication space.

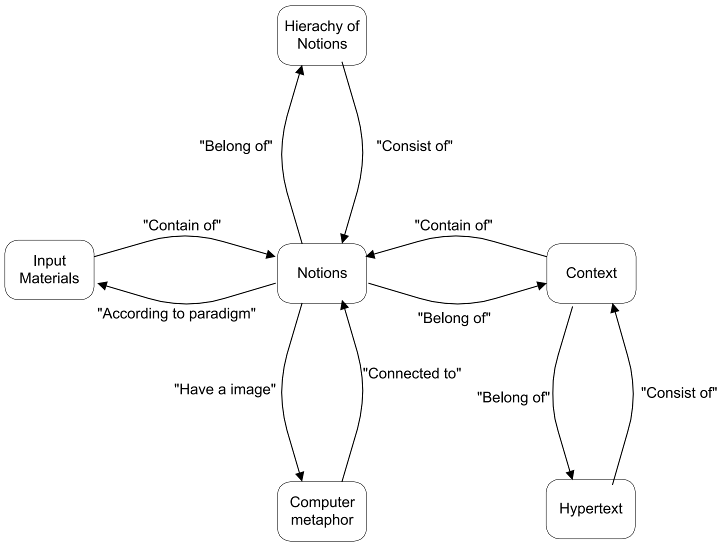
3 A cognitive approach to conceptual model design

Currently, the following methods of didactic material preparation is used in DL:

1. Creation of fulltext databases with hypermedia extensions, compiled from existing books and manuals.
2. Learning scenarios with elements of testing.
3. Combinations of both methods.

The approach proposed in this article uses the elements of all three methods and is based on the union of categorial and imaginative mentalities in the framework of one learning module (courseware). The first one operates on notions and the second on 'gestalts'. Courseware design is the construction of a network structure. The nodes of the network are fundamental notions of the learned subject. Each of these is related with others.

The description of each notion, i.e. the notion' context, has to reside in a dictionary. Since the context of any notion can include other notions, the dictionary has a hypertext structure. In courseware, each notion is related with a computer metaphor, which realises the image representation of the notion, i.e. the 'gestalt'. Moreover, each notion has to refer to the original source. All notions belong to one paradigm. A general diagram, illustrating the proposed approach, is shown in fig. 3.



The set of all didactic material, represented in the diagram, reflects the content of the conceptual model. Let us examine the structure of the diagram: each notion, used in the courseware, belongs to a hierarchy of notions. The hierarchy, in turn, can include only these notions (relationships of the kind *'belong to'-'consist of').* Furthermore, the computer metaphors, connected with notions and using multimedia effects, reflect the essence of notions through relationships of the kind *'have image'-'concerned to'*. Each notion is given a detailed definition in the dictionary through relationships of the kind *'contain of'-'belong to'*. Since other notions can enter the notion definition, the dictionary is realized as a hypertext, using relationships of the kind *'belong to'- 'consist of'*. Lastly, the sources chosen as initial material have to belong to one paradigm of knowledge and are connected to it by relationships of the kind *'contain of'- 'according to paradigm'*

The main components of the conceptual model are hierarchy of notions, dictionary and computer metaphors, connected by hyperlinks. In its simplest case, the network of notions has a hierarchical structure. There are two kinds of relationships between notions in a hierarchical structure:

- the class-subclass relationship (a kind of),
- the whole-part relationship (a part of).

The number of levels in the hierarchical graph defines the depth of notion extension. This in turn depends on the aims of teaching and on the basic model of student knowledge. A notion does not exist in the conceptual model if it already exists in the student's basic model.

4 Requirements on courseware design

The principal part of a courseware is the conceptual model [4]. The design of the conceptual model has two aims:

1. Providing knowledge integrity within the frame of the courseware. This means that the conceptual model must not comprise any notion isolated from other included ones.
2. Presentation of knowledge, supported by courseware. This is necessary because the conceptual scheme plays the role of a cognitive map for the student's independent learning. The presentation of new notions and their relationships with earlier assimilated notions prepares the students for logical perception of new knowledge [3].

In comparison with the content of conventional manuals, the conceptual scheme provides a visual representation of learning material semantics and gives the possibility of multiple transitions through hypermedia links, from the vertex of the conceptual scheme to computer metaphors and notion definitions in a dictionary. It assures the integration and visual representation of the student's abstract and image-based mentality as well as the stimulation of connecting different kinds of memory: logical, associative, motor, visual, etc.

On-line interactive work with a conceptual scheme gives the possibility of 'finding out' familiar notions, to detect their relationships to new notions and to get an image representation of them.

Therefore, the aim of teaching is to define the role and view of a conceptual scheme that can be used as an initial step in new material learning and in subsequent steps of knowledge consolidation. The presentation of knowledge gives the student the possibility to understand the aims of learning. The aims of learning must be described so that the student understands what he/she will be able do after learning completion. More exactly, under what conditions will the professional activity be realized? What are the social implications of this activity?

It is known that each professional activity includes three main components, relating in different ways to each other [5]:

1. Cognitive activity, being the gathering, manipulation, and interpretation of notions, as well as the deduction of new notions, using them for analysis of new knowledge or new situations.
2. Psychomotor activity, being the training of operations with real or virtual objects, given by simulation, and the timely reaction to changes in the conditions of this activity.
3. Emotional activity, being the active control of the value orientation scale during the realisation of professional activity. Emotional activity using new knowledge has to improve the value scale, based on the motivation model.

Actual professional activity includes all three components. However, depending on activity area and intelligence level, these components carry different weights. Corresponding to the relative weight, the emphasis in courseware design is either on accuracy and detail of the hierarchy of notions and the dictionary or on computer metaphors. The skill of manipulation and construction of new notions is very important for professional scientific or engineering activities. In this case, the computer metaphors enforce a logical mentality and supplement it by image presentation of virtual situations. Alternatively, for operational skills of working with machines and devices, it is very important to create a virtual environment intended to develop psychomotor and visual memory.

Appendix

1. DL is a further development of the cognitive approach to learning without teacher.
2. Learning without teacher requires a change of content and structure of the didactic material in form of 'courseware' and of the teacher's role in the learning process.
3. The teacher plays the role of a knowledge engineer during conceptual scheme design and the role of a knowledge evaluator of the students' assimilated knowledge.
4. The principal component of courseware is the notion hierarchy, providing integrity and presentation of learned knowledge.
5. The role of hypermedia relationships and computer metaphors depends on the aims of teaching and the kinds of professional activity carried out after teaching.

References

[1] Bolter J., Grusin R.,1999, " Remediation- understanding new media". The MIT press, Cambridge.

[2] Crowder N., 1991, Inristic and extristic programming -In: Programmed learning and Computer-based Instruction, Proc. Conf. On Application of Digital Computers to Automated Instruction, N.Y., p. 58-66

[3] Enlund N., 2000, ”The production of presence -Distance Techniques in Education, Publishing and Arts”- In: Proceed. of International Conference 'Advanced Computer Systems', Technical University of Szczecin, Poland, p.44- 49

[4] Kushtina E., Lifshits A., 1998“Telelearning and networking in the aim of social support”In: Proceed. of Congress on European Co-operation in Higher Education Information Systems EUNIS'98, Prague, p. 139-142

[5] Kusthina E., Barcz M.1999, ”Distance learning organization for small countries in north-west of Poland” -In: Proceed. of Congress EUNIS'99, Helsinki, University of Technology, Espoo, Finland, p.281-283

[6] A. Mowshowitz,1997”Virtual organizations”, Communications, nr.9

[7] B. Skinner,1961, Teaching machines, v. 205, no.5, p.91-102

[8] O. Zaikin et al.,1999In proceed. of First Publishing Congress ”Problems of continuous professional education in printing and publishing using distance learning”, Wroclaw, Poland, p.127-134

[9] O.Zaikin, A. Dolgui 'Simulation model for optimization of resources allocation in the queuing networks'-In: Proceed. of IMACS Symposium on Mathematical Modelling 3rd MATHMOD, Argesim Report no.15, Vienna, 2000