Learning Intelligent Collaborative Systems

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This paper proposes a collaborative learning model based on a semantic module detecting concepts that were not properly acquired during the learning process. A database structured is proposed which was designed based on the on-line collaborative learning and social networking requirements. The objective of the research is to implement an intelligent and flexible on-line intelligent collaborative learning system and to facilitate students in increasing their performance within on-line learning.
Keywords: *Learning, On-line Learning, Intelligent Learning, Database, Semantic Web*

1 Introduction

The Information Society has been developing as a new step in our social evolution, by intensively exploiting information in acquisition and exchange of all types of resources. The technological support on which the new ways of knowledge assimilation are based is determined by the convergence of three fields: information technology, communication technology and digital content production. The development of new learning and sharing methods represents an essential factor for increasing competitiveness, modernizing services and developing new ways of communication between individuals. From the perspective of chain consisting in data-information-knowledge, the modern learning processes can be classified in four categories, as shown in figure 1.

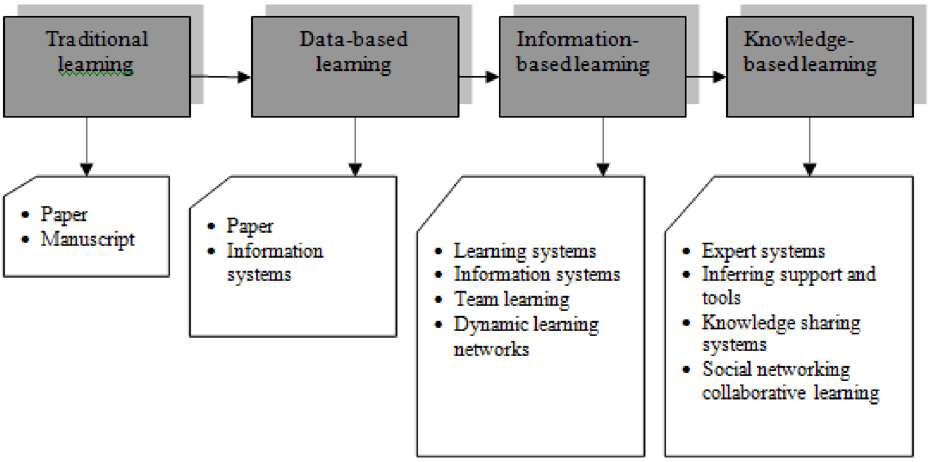

Fig. 1. The evolution of learning paradigm

In time, information systems and services for assisting learning followed various methodologies and models, in order to improve management effectiveness and efficiency of learning resources.

The paper is structured in several sections presenting the problem context, the proposed model and a SWOT analysis.

2 Problem context

The learning paradigm in the modern organization is not limited to a process of iterative understanding of a limited set of knowledge. New knowledge emerges or is produced frequently from various sources, be it direct acquisition or inferring rules.

Knowledge can be grouped in two categories: individual and organizational (corporate).

The new dimensions of learning in modern society are described in figure 2.

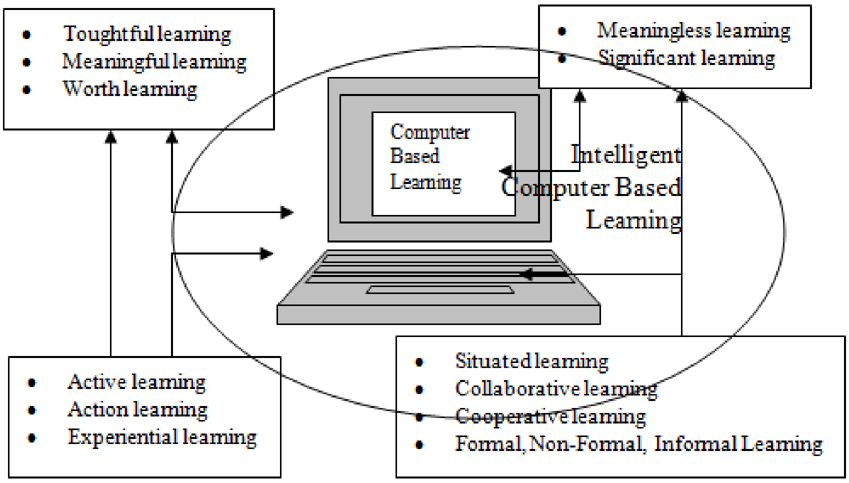

Fig. 2. New dimensions and types of learning in modern society

Collaborative learning *is a method of teaching and learning in which student's team work together to explore a significant question or create a meaningful project. A group of students discussing a lecture or students from different schools working together over the Internet on a shared assignment are both examples of collaborative learning* [1].

Cooperative learning *is a specific kind of collaborative learning. In cooperative learning, students work together in small groups on a structured activity. They are individually accountable for their work, and the work of the group as a whole is also assessed. Cooperative groups work face-to-face and learn to work as a team* [1].

The formal learning is learning that takes place within a teacher-student relationship, such as preschool learning, school learning, high school or university.

The non-formal learning is organized learning outside the formal learning system. For example: learning by coming together with people with similar interests and exchanging viewpoints, in clubs or in (international) youth organizations, workshops.

The informal learning is the category that implies nonsystemic learning through everyday experience, regardless of context and source (home, school, workplace or any other place where the individual engages in interactions with other members of the same group). Informal learning is part of the daily work and routine, influenced by external or internal impulses and strongly related by informal knowledge exchange ([2]). Nowadays, as computer-based communication invades this routine and becomes a way of life, informal learning tends to integrate computer-based processes. Informal learning has several features:

- is mainly inductive;
- is stimulated when there's a need for increased learning speed;
- does not emphasize knowledge accuracy ([2]), but rather the diversity of sources and their reputation;
- the knowledge acquisition is not necessarily explicit and formalized, but knowledge is often applied real-time on a pragmatic level;
- is associated with implicit learning and tacit knowledge ([3])

Methods of informal learning

Merriam et al. ([4]) synthesize three ways of learning, which differ based on intentionality, awareness and time, as follows:

- self-directed learning, using the computer as a tool;
- incidental learning, using the computer as

an assistant;
- socialization and tacit learning, using the computer as an environment.

3 Related works

Several models for intelligent e-learning systems have been proposed throughout the literature. In [5] the authors propose a formal concept analysis methodology for developing learning models based on an a priori knowledge corpus. [6] provides a comprehensive overview of the evolution of metadata in e-learning applications from standards to specialized representations. One of the closest related approach is [7], where students mistakes are exploited in an e-learning recommender environment in order to control acquired knowledge within a learning agents framework. Compared to these studies, our approach is grounded on basic RDF assertion semantics using a relational-knowledge mapping system that clearly delimits acquired and unacquired knowledge concepts for each student. This provides input for a potential recommendation system by extracting the status of learning concepts from RDF graphs. The collaborative aspect is defined by the teacher's involvement in modeling the concept graphs, with respect to the assessment of student knowledge for a certain knowledge context.

Collaborative learning is, first of all, a philosophy of interaction and lifestyle. More specifically, it designates a methodology of learning and a certain interaction structure which tends to follow a common goal.

The collaborative learning mechanisms, as described by Kegan in 1998 [8] are reflected in figure 3.

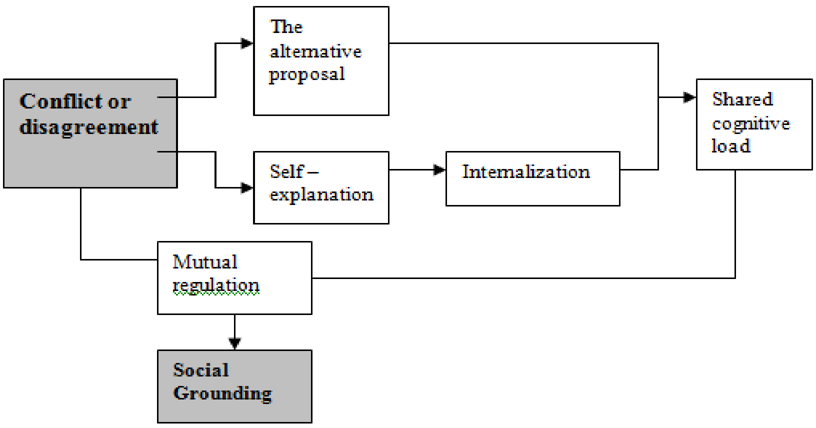

Fig. 3. Collaborative learning mechanisms

Even before 1960, before personal computers changed the education paradigm, researchers investigated the effectiveness of collaborative / cooperative learning.

Koschmann [9] identified several approaches, which integrate traditional teaching methodologies with computerized support:

a. *Computer Assisted Instruction*

Features:
- behaviorist approach;
- learning means memorizing facts;
- the domain knowledge is decomposed in atomic facts exposed to pupils in logical sequence, through instructions and exercise.

b. *Intelligent Tutoring Systems*

Features:
- cognitive approach;
- learning means mental models;
- teachings is a process of model generation and description.

c. *Logo*

Features:
- constructivist approach;
- pupils build their own knowledge;
- teaching is a process of defining a stimulative environment which can be explored and discovered through observation and reasoning.

d. *Computer Supported Collaborative Learning*

Features:

- pupils communicate and collaborate;
- pupils are organized in learning communities of various structures and granularities [10]

Intelligent collaborative learning systems are a CSCL example from the area of artificial intelligence because it emulates actions of a human mediator, providing answers to pupil input, analyzing problem solving strategies and comparing pupil actions with pre-programmed models of correct and erroneous understanding. The synergy between intelligent systems and CSCL is illustrated in figure 4.

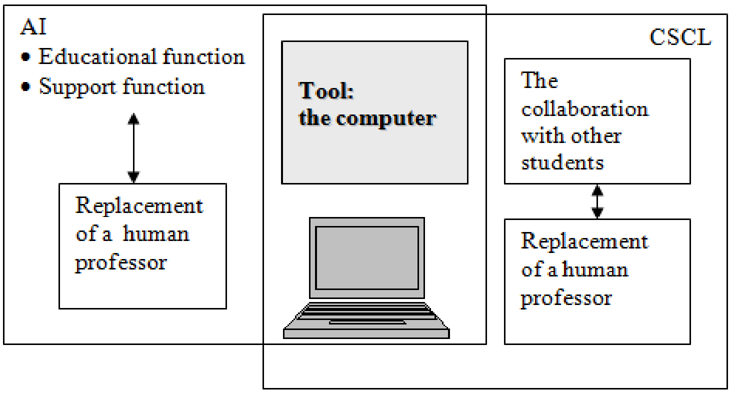

Fig. 4. The synergy between intelligent systems and CSCL

The computer becomes a cognitive tool for social-driven learning. CSCL emerged as a reaction to previous attempts of involving technology in education and previous approaches for understanding the collaborative paradigm in a learning science context.

The computer's role in the learning process is illustrated in figure 5.

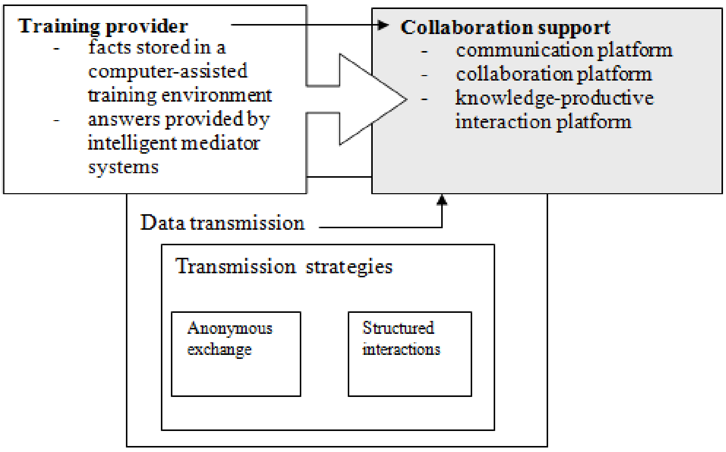

Fig. 5. The computer's role in training

4 The proposed model

This section is dedicated to describing the architectural solution and some design and implementation details for a proposed model of collaborative learning systems.

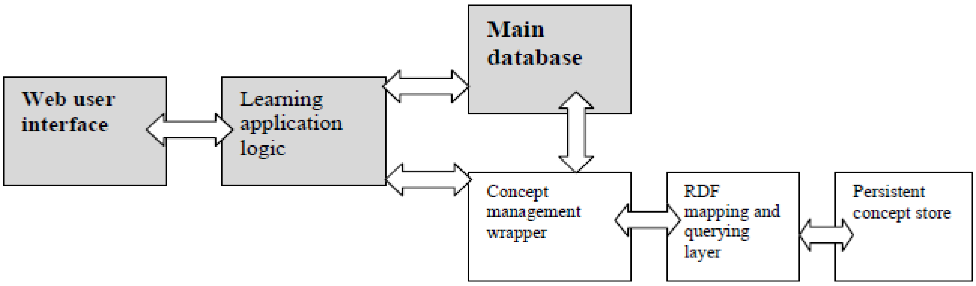

Fig. 6. The general architectural solution

As the general; architecture diagram shows, a classic e-learning system is extended with a concept management system based on the RDF data model and related querying layers and wrappers. A learning concept network is defined by merging graphs defined both by the teacher's underlying topic-level ontology and the student concept-level evaluation.

After an initial login procedure, the user interface elements from figure 7 would be provided to the teacher:

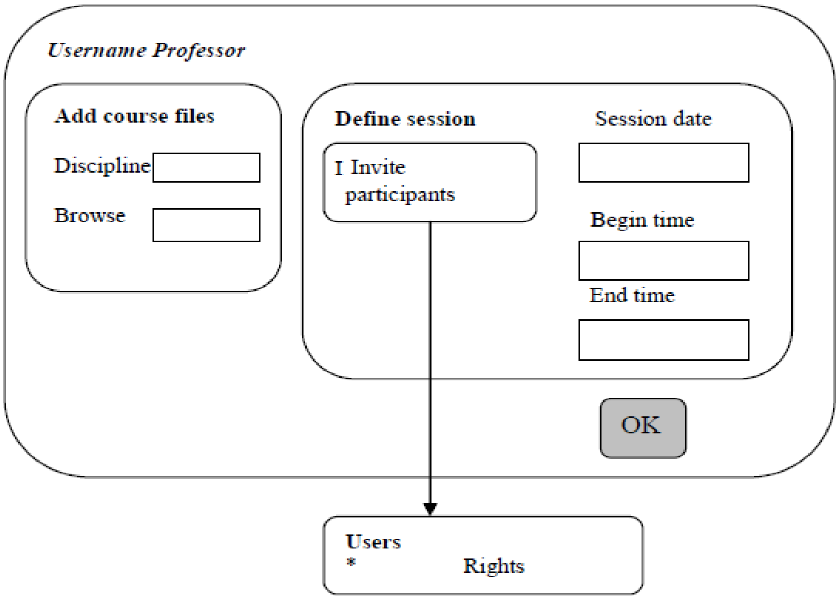

Fig. 7. The teacher's user interface

The teacher user interface specification is presented in figure 8.

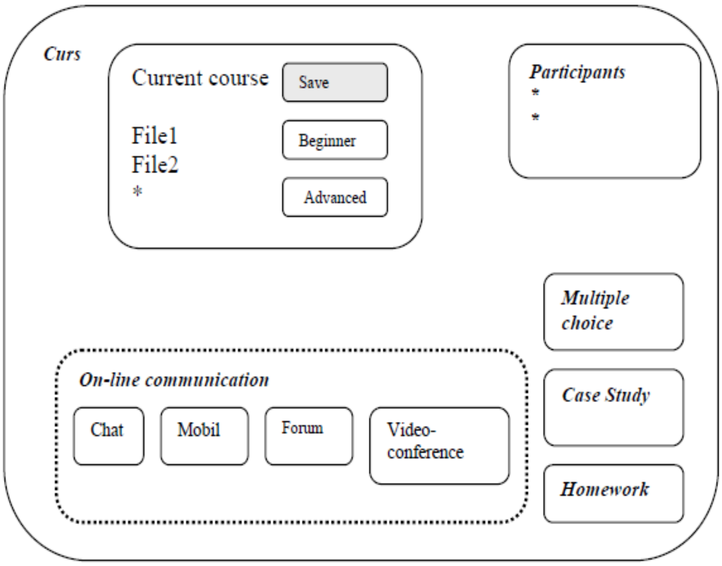

Fig. 8. The Course Window

The student form specification is modeled as follows in figure 9.

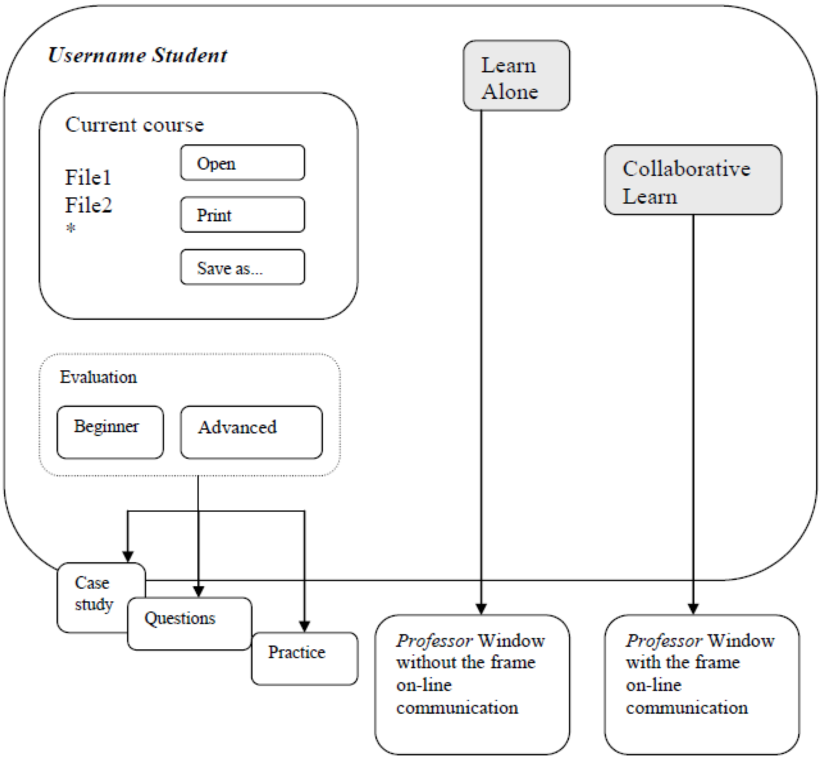

Fig. 9. The Student's Window

Database structure

The model is driven by a relational database with 11 tabels. The structure of these tabels are:

ACCOUNTS (**<u>E-MAIL Adress</u>**, Type, Password)
PROFESSOR (**<u>IDProfessor</u>**, Name, Department, Title, E-Mail Adress)
STUDENT (**<u>IDStudent</u>**, Name, Class, RegsitrationNo, Birth_Date, E_Mail Adress)
SESSION (**<u>IDProfessor</u>**, Begin_date, End_Date, End_Time, Room)
PROF_COURSE(IDProfessor, IDCourse)
STUD_COURSE (IDStudent, IDCourse)
COURSE (**<u>IDCourse</u>**, Course, Type)

COURSE_FILES (IDFile, Path, IDCourse)
EVALUATION (IDCourse, Evaluation Type, Questionnaire, Case_Study, Laboratory)
EXAM_FILES (**<u>IDCourse</u>**, Path, IDEvaluation)
MESSAGE(**<u>IDMessage</u>**, IDProfessor, IDStudent, Date, Text)

The relationships have been defined in order to meet several requirements:

- to support the registration and login of the users;
- to support searching based on a full text index and course filtering/browsing;
- to support message exchange
- to support rights and privileges for various types of users;
- to support graphical interfaces for various types of users.

The tables are linked according to the schema from figure 10.

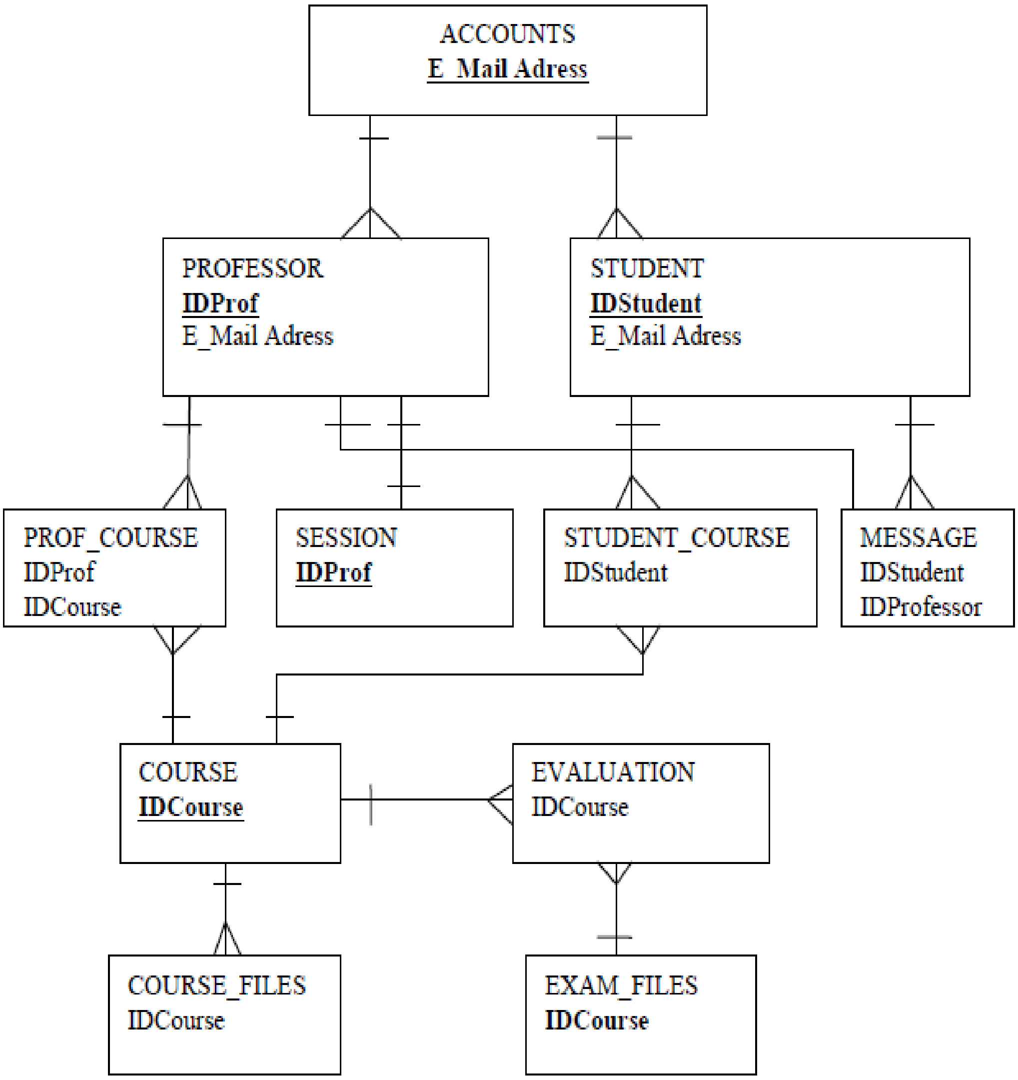

Fig. 10. The presentation of the relationships between tables, using entity-relationship diagram

For example, we made a capture of the window in which are reflected the relationships between the tables (see figure 11).

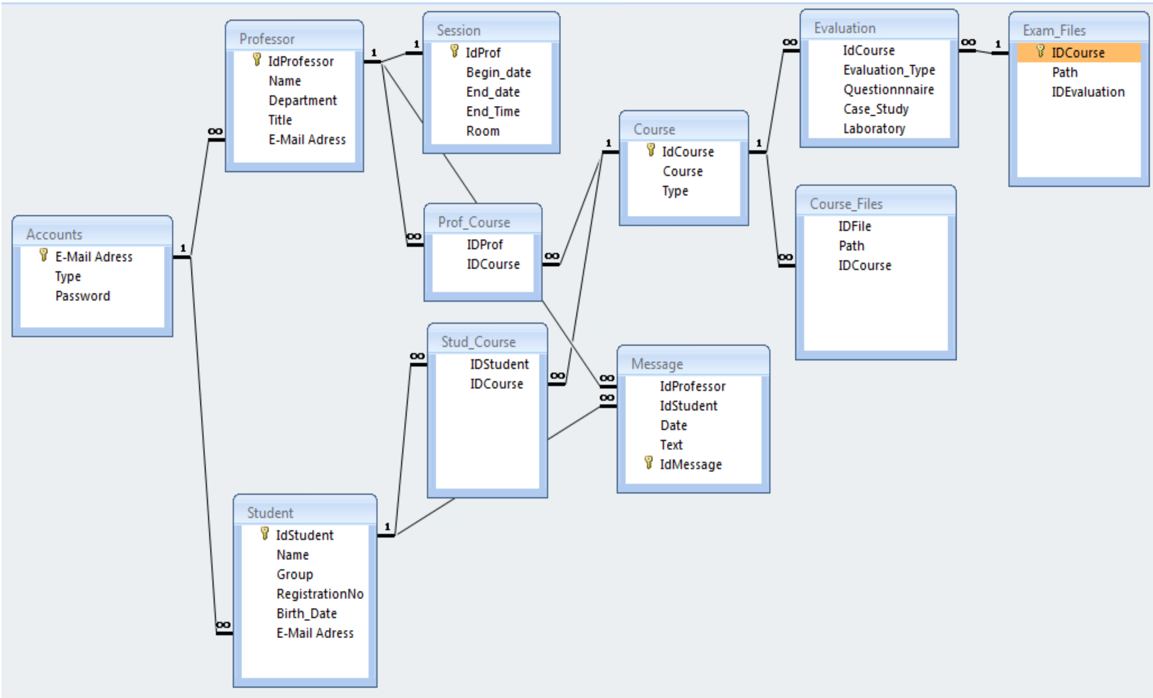

Fig. 11. The database relationships

The database is mapped on an RDF repository describing relationships between concepts involved in the evaluation process. The evaluation table is based on the assumption that each transaction (question) is mapped to one or more concept and a correct answer validates the student knowledge against those concepts. After an evaluation session, the student will have covered a certain part of the concept graph, while incorrect questions will reveal the limit of his „knowledge domain”. Subsequent training sessions will automatically emphasize and recommend the study of concepts out of that domain. In order to work, the courses must be backed up by an RDF concept graph repository, stored in a persistent way. The usual solution for this is a hybrid data-knowledge base in which the RDF triple structure is mapped to a database structure. Most semantic libraries allow this, and also our technology of choice, Python backed up with RDFLib[11]. From within the proposed system, the stored graphs will be accessed and queried through SPARQL queries and the object-RDF mapping layer provided by SuRF[12].

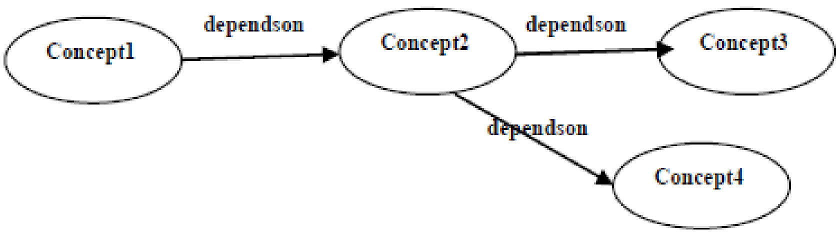

Fig. 12. The concept graph

The concept graph is not to be confused with a class hierarchy. Instead, it is rather a mapping of how concepts reflected by learning objects depend on each other’s understanding in order to support a consistent and coherent serial acquisition of the information. Also, the graph is not a domain ontology as it would not be feasible to setup repositories or ontologies for each subject that is taught during the e-learning program. The graph is a representation of the logical dependencies between the topics and notions within a certain discipline. It is created by each teacher for each course using a visual environment such as IsaViz, which in turn

exports it in a variety of RDF serialization formats, N3 being preferred for simplicity.
The above graph would be stored using N3 as follows:

```
<#concept1> <#dependson>
<#concept2> .
<#concept2> <#dependson>
<#concept3> .
<#concept2> <#dependson>
<#concept4> .
```

Libraries such as RDFLib provide means of:

- parsing such a graph:

```
import rdflib
from rdflib.graph import
ConjunctiveGraph
graph=ConjunctiveGraph()
graph.parse(„graph-
file.nt”,format=”nt”)
```

- storing it in a persistent datastore

```
store = rdflib.plugin.get('MySQL',
Store)('mystore')
a =
store.open("host=localhost,passwor
d=admin,user=admin,db=mystore",
create=True)
graph =
rdflib.ConjunctiveGraph(store)
```

- querying it by triple matching or by SPARQL queries; new graphs can be built, seralized and stored if the SPARQL query results in a new graph:

```
results = graph.query(‘ CONSTRUCT
?conca <#dependson> ?concb
WHERE {
      <#concept1> <#dependson>
?conca .
          } ’)
```

The object-RDF mapping layer provided by the SuRF library facilitates the manipulation of RDF triples in an objectual syntax:

`<#subject><#predicate><#object>`
translates to
`<#object><#attribute><#value>` and can be expressed in the object-oriented qualification syntax of the host language, Python in our case:

```
object.attribute=value
```

As the open world assumption permits it, after a student evaluation, the concept graph is automatically expanded with properties that express if the student acquired a concept or not, depending on a preset evaluation scheme. Using CONSTRUCT queries, the graph of unacquired concept is extracted and further study on file resources linked (also through RDF) to those specific concepts is proposed during the next sessions.

5 SWOT Analysis

Strong points:
The improvement of the human resource quality:

- continuous development of teaching skills, by assimilating skills related to on-line training systems and on-line course development;
- teachers can, in turn, promote and integrate their on-line experience with other projects and teams where they are involved;
- higher efficiency and, if carefully managed, effectiveness of the educational process;
- specific experience gain regarding on-line evaluation methods: questionnaire, multiple choice test, student project;

Weak points:

- resistance of some teachers against modern learning technology;
- weak involvement of some teachers due to relaxed terms of usage;
- weak involvement of some students due to the lack of self-motivation;
- the cost of technology;
- possible software glitches or usability issues, with no human assistant to rely on in a real-time manner discouraging the users;
- the variety among starting skills for students, which raises a specific requirement of adaptively.

Opportunities:

- e-learning improves auxiliary skills both for trainers and pupils, related to the use of technology; the experience and the skills will prove helpful in other contexts;

- e-learning organizations can easily join a great diversity of European projects focused on e-inclusion and more efficient learning systems;
- e-learning is in itself an occasion to bring together specialists for various fields and define new methodologies and applications;
- e-learning provides higher dynamics in professional development by decreasing the educational time resource consumption.

Threats:

- e-learning and distance learning seems to be related to a more superficial approach from students who are accustomed to traditional learning and have problems with defining self-motivation mechanisms;
- on-line learning changes the business model of education on all its levels and must be carefully managed;
- e-learning is subject to technological obsolescence and it is highly dynamic from a management perspective;
- there's a need for automated arbitration systems such as [13] for student evaluation processes;

6 Conclusions

Our model targets training providers and consumers who want to overcome spatial limitation. It provides on-line content management, within a collaborative environment based on communication channels and a module for semantic management of taught concepts and topics. Besides the traditional social learning elements, the model involves emerging technology in order to define a „separation of concerns”-type of mapping, allowing programmers to manipulate RDF triples in a object-oriented manner and allowing teachers to integrate their own concept graphs, visually defined through IsaViz, with a persistent concept graph store through the simple N3 serialization format.

Acknowledgment

This paper presents research supported by project CONTO PN II 91-037/2007 financed through the National Research Authority, managed by Prof. Dr. Nitchi Stefan.

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