MODELLING OF COMPLEX OBJECTS IN DISTANCE LEARNING SYSTEMS

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Abstract: *Technological progress and the modern reality leave a mark on the methodology and implementation of learning outside the classroom. The process of learning itself is very complex, it requires all entities involved in the process of learning to be addressed in a wide angle. The study focused on web-based distance learning. Approaches to describe the complex objects in web-based learning systems are discussed. Various modelling aspects, several learning strategies and some development trends in distance learning systems are discussed.*

„The purpose of education is to replace an empty mind with an open mind".
M.S. Forbs

Introduction

Forms and methods of learning are changing under the influence of new technologies and trends in contemporary reality. Traditional learning methods require considerable resources in terms of time, finance and participation of many people. Web-based distance learning enters more strongly in our lives as it requires less resource. The global network now is an integral part of the learning process. Many online available courses have been developed already. These courses provide benefits for self learning at a convenient time and place for the learner. Courses differ in their purpose, methodology and implementation. Their quality varies broadly depending on the content and availability of multimedia resources used to explain the training material. Despite advances in technology, it is still difficult to use all the power of the Internet to provide better integrated services for students. Efforts continue to overcome difficulties and challenges posed by both the complexity of the technology, the diversity of users, usage patterns, and the psychological aspects of traditional conservative learning systems.

Complex objects in web-based distance learning

Web-based distance learning (online, e-learning) is "a combination of content and teaching methods provided by elements of the computing environment, such as text and graphics, designed to build knowledge and skills related to individual learning goals or organizational work" [1]. The structure of such system contains distributed repositories, interacting information flows and learning processes. Developing of the web-based learning passes through defining requirements, conceptual models and semantics for the system.

Web-based learning aims at fulfilling of the following tasks:

- To provide the user with means for visualization of complex information objects and structured data;
- To provide the user with tools for effective and selective search;
- To store documents in various formats;
- To keep various multimedia and biometric data;

- To use traditional databases;
- To provide access to information from different sources.

Online distance learning is based on the exchange of data and messages between interacting applications in a distributed network environment. It sets a lot of requirements for security, reliability and scalability. One should not forget the respect of intellectual properties rights in the use of educational content.

In general the online learning can be divided into:

- learning conducted entirely online as a substitute or alternative to "face to face" learning;
- blended learning in which online learning components are combined or mixed with traditional "face to face" learning to increase its effectiveness.

Many theories for the design of educational systems have been developed. Some of them can be found in the studies [2], [3], [4]. Several of them use an idea of learning objects. The concept of learning object has been introduced in 2000th year [5]. The main idea of this concept in the web-based learning is to present educational content in the form of small pieces that can be used in different learning environments. Learning objects is related to "any digital resource that can be reused to support learning" [5]. As learning object the "*purpose, intent, meaning*" can be considered too [6]. Hence a special feature of online learning is a fact that the learner him/her self can be viewed as an object with its projection on the infrastructure of the learning system. Learners can be grouped and interact with the system recursively.

Logical and cognitive rationality of learning objects in web-based distance learning is discussed by von Brevern in [7].

Characteristics of learning objects

Learning objects open up opportunities that traditional materials cannot offer [8]. Every learning object is:

- independent;
- sufficiently rich and complex to achieve a specific learning outcome;
- contains the main components from:
  - proficiency of an effective education;
  - interactive elements through experience (activities);
  - element, reflecting the level of commitment.

It has to be mentioned that the information inside the same learning objects can be represented in several different ways. Furthermore, they have different pedagogical value depending on the context of use [9].

Modelling on web-based learning

Electronic courses are not limited to the provision of content only, they contain methods and learning systems in order to create an integrated educational environment that allows students to learn and practice in their educational activities.

Web environment of distance learning systems made it necessary to seek appropriate strategies for education that differ from educational strategies used in traditional environments. In [2] some strategies are indicated that are used in existing systems for e-learning. Presenting of learning material is a part of the educational strategy. Modelling of complex objects in a web-based learning is closely connected to the methods of their presentation and performance and therefore we can divide modelling into three big groups:

- Modelling of *educational materials*. This includes methods of providing and visualization of information and knowledge content;

- Modelling of the *learners*. It is necessary to consider the students' behaviour and cognitive performance of individuals;

- Modelling of the learning *process* itself. This is the most complicated aspect from modelling and realization point of view.

Let us consider in more detail these modelling aspects.

1. Modelling of educational materials

Digital repositories of learning resources are a central part of the web-based distance learning. These repositories maintain information that is shared between different objects taking part in the learning. Realization of this sharing is possible with the use of semantic technologies.

Complex data models, enriched with semantic descriptions perform the following functions:

- provide and store learning materials in an appropriate method for search and discovery;
- pack different parts of the learning materials into objects (courses or curricula);
- provide management of dictionaries, tests and assignments;
- support monitoring of the students activities;
- provide management of students' profiles and groups of them.

Several standards for the learning materials have been developed. For example the standards 1484.11.3-2005, 1484.12.3-2005 IEEE Learning Technology Standards Committee (IEEE-LTSC, 2005) define subjects as material, digital or otherwise, which can be repeatedly used and presented in a form suitable for references in e-learning [10]. These standards help developing repositories for online learning. Despite this established standards there are still difficulties with the application of these standards in providing collaboration on various systems and platforms (*interoperability*). Upon integration of web applications it is often necessary to combine different formats of heterogeneous data sources [11].

Potential collections of educational materials have a variety of data types, metadata standards, protocols and learning models. This requires cooperation at three levels: technical, organizational and rich of content.

Technical agreements refer to formats, protocols and systems for secure access. Aspects of content cover data and metadata; they include agreements on semantic interpretation of the information. Organizational aspects of the interaction include rules for ensuring access, preservation of the collections and providing services.

For presenting of semantic description [12] for learning materials some extensions of metadata standards for educational purposes can be used (ISO/IEC 19788 - Metadata for learning resources). For example, an extension of the *Dublin Core metadata set* [13] may include the following fields: level of interactivity; difficulty; learning context; duration of learning; roles of the end user; etc. Different sets of metadata can be based on the core set of metadata. The use of fixed metadata is not required, since flexibility is distinctive and necessary feature of the distance learning.

2. Modelling of the learners

Modelling of learners has to take into account indicators of their behaviour. The learning style can be represented according to different models to support personalisation in different ways. Ideally, these models in a web-based learning should include:

a). full set of preferences for learning style;

b). implicit and dynamic modelling method of the learner;

c). dynamic approach to adapt to different types of behaviour.

This area is in the field of research yet. For example, identification of several learner characteristics results in a set of customizable compound rules is proposed in [14]. Adaptive e-learning model based on learner's personality is presented in [15] where the Myers-Briggs Type Indicator's (MBTI) personality dimensions are used. A framework for learner modelling that reflects the constructionist learning approach is discussed in [16]. The research [17] defines a RDF-based representation of knowledge models and reusable SPARQL-based query patterns that can be used by Learner Modelling to calculate and infer learner profile elements.

Recent developments in the field of semantic modelling have led to a renewed attention with focus on ontology-based e-learning systems [23]. Authors of this research describes learners' model ontology as a stage for creating personalised e-learning systems based on learner's abilities, learning styles, prior knowledge and preferences.

3. Models of learning process

As a possible approach to modelling the learning process, the paper proposes ontological modelling of learning. It is recognized the importance to describe semantically not only the content but also the knowledge of learning process. When considering learning as a *process*, it is necessary to involve different types of ontologies [18].

The role of context and ontologies in educational process modelling is discussed in [19]. It is pointed that educational process modelling seeks to represent the complex interactions in multi-actor learning environments (Fig. 1), with the view that the sequence and types of interactions can be equally as important as the sequence and types of content.

A symbolic system *{C, T, P, F, A}* is considered as an ontology, where *C* is the set of concepts, *T* - a thesaurus, or partial order on the set *C*, the hierarchy of relationships, "subclass" and "super-class"; *P* - the set of predicates (properties); *F* - a function that assigns to each element of *P* an element from the set of C (considering them in *T*); *A* -is a set of axioms of the ontology. A hierarchy of concepts and relationships is represented as a graph *G = (N, E)*, *N* - the set of nodes, *E* - the set of branches, $N=\{n_1, n_2,\ldots n_n\}$, $E=\{e_1,e_2,\ldots e_m\}$. The graph can be described using XML Schema Datatype (XSD). Process ontology is available in the streams of data as implicit patterns.

Process is an intersection of time, topic and context to describe situation. They can have sub-processes, as well as components, consisting of objects and data. Processes are a higher level of abstraction than objects and data. This allows getting more information beyond the data only.

Using ontologies it is possible to construct structured e-learning process models. It can be done through discovering process models from distance learning system event logs.

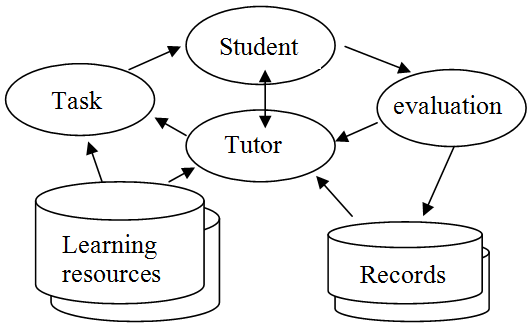

Fig. 1. Objects, actors and processes in web-based learning

Definitely it is not trivial, but within the analysis of event logs, a process can be defined. Thus the structured process models can be automatically constructed.

Trends

New technologies require the development of new strategies for online learning:

- The approach to learning has to be focused on studies or research and exploration;
- Learning has to be focused on using the content as a means to build knowledge and develop critical thinking skills;
- Presentation and modelling of learning materials has to be a part of educational strategy – web-based learning sites to be presented in three dimensional terms: content in dependence on the context and structure (Fig. 2).

Efforts are directed to developing an intelligent learning environment that adapts to the learning style of each student [3]. Development of information technologies such as Augmented Reality provides new opportunities in education [21].

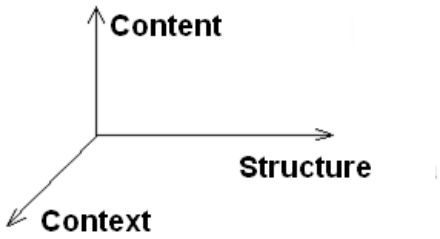

Fig. 2. Content in dependence on the context and structure

The upward trend in ubiquity and heterogeneity of learning services and resources demands for a formal and systematic approach to solve tasks on online distance education. The process-ontology can provide an appropriate philosophical foundation to integration problems. Ontologies can be used twofold: for data integration from several sources and for intelligent systems operations.

Ontological modelling of complex objects in distance learning may have several advantages despite of its inherent difficulties. It allows implementing sharing and integration information from heterogeneous resources; package low level objects into high level objects; representing and archiving learning objects.

Conclusion

Well-organized learning environment can improve the quality of education. Beside that a lifelong learning is vital to individual and national prosperity. In this respect it should be emphasized:

- web-based learning objects open opportunities that traditional materials cannot offer;
- learning objects and their content is not a knowledge, but they engage students and generate various processes of learning and practice;
- recent observations of many researchers emphasize that the critical thinking, skills for problem solving and communication skills are more important than just knowing the solely content.

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