УДК 681.3.06

ЭЛЕКТРОННОЕ ОБУЧЕНИЕ НА ОСНОВЕ СЕМАНТИЧЕСКИХ СХЕМ

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Всемирная Паутина (WWW, Вэб) обеспечивает возможность делать образование более комфортабельным и доступным для пользователей Интернета. Ведущие разработчики программного обеспечения электронного обучения сосредотачивают свои усилия, главным образом, на создании стандартов содержимого обучения и ассоциированного сервиса, а также на аккумуляции и хранении структурированного учебного материала. При этом форма учебного материала традиционно обязывает студентов концентрировать внимание в течение длительного времени для извлечения семантики и проводить много времени во взаимодействии с преподавателями. Учитывая, что в современном мире образование становится перманентной задачей, такой способ обучения не выглядит более релевантным.

С другой стороны, новые технологии машинно-читаемого Вэба позволяют автоматизировать процесс обучения и предоставлять семантику учебного материала в концентрированной и сжатой форме с помощью схем. Настоящая статья описывает подход машинно-читаемого электронного обучения на основе теории потребностей, общеупотребительной модели рассуждения и на основе нового метода представления предметной области.

Ключевые слова: *«Семантический Вэб»; «Связанные данные»; потребность; рассуждение; представление человеческого опыта; семантическая портативность и машинно-читаемое электронное обучение.*

Today's human-readable Web provides a possibility to make an education more comfortable and available for Internet users. Leading developers of e-learning's courseware focus their efforts, mainly, on the creation and recommendation of standards for learning content and associated services as well as on the accumulation and storage of the structured training material. Herewith, the verbal training material's form traditionally obliges the students to concentrate their attention during a long time for the extraction of the semantics and to spend much time in interaction with teachers. Given that in the modern world an education became permanent task, such learning approach ceases to be relevant.

On the other hand, new technologies of the machine-readable Web allow to automate learning activities and to provide semantics of e-learning content in the portable schemes. This article describes an approach of schemata based e-learning that is anchored on the theory of needs, on the model of commonsense reasoning and on the novel method of domain knowledge representation.

Key words: *Semantic Web; Linked Data; the need; reasoning; representation of human experience; need satisfaction domain; Linked Needs; semantic portability; and machine-readable e-learning.*

1. Introduction

In a century of high technologies a little that remains invariable. Technology of education didn't change during many centuries. Still a hundred years ago, the existence of numerous separate educational centers was caused by the low level of development of communication and transport, by language barriers, as well as due to deep cultural and national differences. Today there are no reasons to infinitely duplicate the same educational courses and arbitrarily rehash fundamental theories. Machine-readable knowledge representation techniques allow diffusing knowledge and experience of world experts via Internet. Software agents are able to test an understanding of training courses by students, to explain and to answer for questions.

In spite of this, everything remains as before.

For example, every university in the world, all programming courses, thousands of books provide knowledge of the programming language C. Thousands of teachers, thousands of different authors pose semantically the same training material. How much time and effort goes to create thousands of verbal forms of the same semantics! What prevents the spread the unique semantics, namely, semantics of C's author? Semantics of the C language, once represented in the portable form by its author (Dennis MacAlistair Ritchie), may exist as a basis training material for all who learn C. The machine-readable form grounds also an automation of teachers' activities, such as a testing (a verification of an understanding of training courses by students), an explanation and an answering to questions. In this case, the duty of a teacher will be a tutorship rather than a teaching.

Why would the creator of fuzzy logic Lotfi A. Zadeh not to make the same?

Why once and for all not to represent semantics of the theory of relativity under the text of the author?

Thanks to above-mentioned e-learning approach, students would receive a first-hand teaching material.

The following reasons ground a necessity of semantic portability of e-learning content:

The main task of learner is an extracting, an understanding and a mastering of the educational material's semantics.

"All of our generic knowledge is embedded in schemata" [25].

Human attention is transitional. The maximal stability of attention (i. e. temporal characteristic of attention, the duration of drawing attention to the same object) equal 12 sec that is enough for a mastering the scheme, but not enough for the reading or listening of the lecture.

To mastering of an educational material, a student must understand its place in the system of a subject domain and put its semantics into the system of his own preferences and knowledge about world.

Practicians in industry and academy must have opportunity to quickly master a missing knowledge anywhere and in any time.

A necessary of automation of learning activities.

Nowadays none education provides knowledge sufficient for long-term career. Scientific and technological progress is constantly changing conditions and nature of any professional activity. It is known that during 4–5 years the professional competence of a specialist after graduation from school is reduced by 50%. Refresher courses already not solve the problem.

The situation calls for learning on the fly. This implies that the learning must be available anywhere and in any time in the maximally portable form.

So, we see that not only academia but and industry needs a new mobile, qualitative and portable e-learning.

Markup Languages' conception allows annotating semantics of the represented knowledge. But it is not sufficient for the materialization of the above-mentioned e-learning.

A successful implementation of machine-readable e-learning requires universal framework for representation of causal-effect relations. Any significant information is an integrant of these relations.

Note also that semantics of the same training courses must coincide. Thereby any educational organization certified by UNESCO may be considered as a repository of educational semantics asserted by UNESCO. This means that any educational organization certified by UNESCO may provide the portable and convertible semantics of e-learning content.

Traditional representation of learning

content in the textual, audio- or/and video-form may be structured according to their semantic schemes.

This means that portable semantic schemes doesn't aim to substitute the traditional learning content, but their mission is to serve as semantic navigators in the educational space, as a basis for automation of learning activities and as a quintessence of learning content.

This paper presents an approach of schemata based e-learning based on the portable semantic schemes.

The rest of article is structured as follows: we review related works in the Section 2, define semantics of subject area in Section 3, discuss a role of subject area's representation in the learning (Section 4), define Need Satisfaction domain (its origin, its components) in Section 5, define schemata based cognitive learners' activity in Section 6, define an architecture of schemata based e-learning in Section 7 and summarize in the Section 8.

2. Background

The Institute of Electrical and Electronic Engineering (IEEE) is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity [28]. IEEE Learning Technology Standards Committee (LTSC) is responsible for developed a number of internationally accredited standards.

It is known the following IEEE's published standards:

— 1484.1-2003 IEEE Standard for Learning Technology — Learning Technology Systems Architecture (LTSA);

— 1484.11.1-2004 IEEE Standard for Learning Technology — Data Model for Content to Learning Management System Communication;

— 1484.11.2-2003 IEEE Standard for Learning Technology — ECMAScript Application Programming Interface for Content to Runtime Services Communication;

— 1484.11.3-2005 IEEE Standard for Learning Technology — Extensible Markup Language (XML) Schema Binding for Data Model for Content Object Communication;

— 1484.12.1-2002 IEEE Standard for Learning Object Metadata;

— 1484.12.3 IEEE Standard for Learning Technology — Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata

— 1484.20.1 IEEE Standard for Learning Technology — Data Model for Reusable Competency Definitions.

All of them concern to the learning content representation and define requirements to architecture of learning content and means of access and assemblage. Courseware developers apply and integrate these standards. The leading world courseware developers are: Advanced Distributed Learning (ADL) Initiative [29], IMS (Instructional Management System) Global Learning Consortium [30], PROMETEUS: PROmoting Multimedia Access to Education and Training in EUropean Society [31], The Dublin Core: Metadata for Electronic Resources [32].

None of the above standards and organizations do not set the domain representation standard. Some of them ground machine-readable formats of knowledge representation (for example, Dublin Core grounds RDF in a sense), but none of them describes knowledge both in human-readable and in machine-readable form.

It is possible to assert that all efforts of world leading courseware developers are directed to serve educational organizations rather than to serve learners.

The idea to represent knowledge by schemes is known during a long time. The most known knowledge scheme formats are the following: Protégé, XML Schema, RDF, RDF Schema, OWL, Topic Maps, Mind Maps and UML.

XML Shema defines the structure of XML documents as well as extends XML with datatypes.

RDF allows describing data model for the objects "resources" and relations between them.

RDF Shema provides means for descriptions properties and classes of Web resources as well as semantics for generalization-hierarchies of such properties and classes.

Protégé and OWL are tools for the development ontologies of things by means of defining classes and relations between them.

Topic Maps is knowledge representation formalism that defines structures informational objects ordered by topics. Topic Maps totem is a traditional back-of-the-book index. Topic Maps

technology is an electronic version of index. Basis concepts of Topic Maps are *topic* (as an object or as a link), *association* (as a relation) and *occurrence* (as a case of usage, as an instance).

Success of any topic map depends on an ability of a developer to pick out the core objects and the most important relations between them. Thus a set of topics, associations and occurrences forms arbitrary. An arbitrariness of knowledge structure' composition is a common trouble of all above mentioned knowledge representation approaches. Reuse of knowledge systems that are made by means of these approaches and interaction between them, as a rule, lead to problems.

Developers often declare knowledge represented by means of these tools as a subject area's representation, but *in practice it always reflects their private point of view*. This is due to the lack of the subject area representation's formalism.

None of the above knowledge representation approaches do not represents knowledge both in human-readable and in machine-readable format, none of them do not represent domain knowledge objectively and none of them is not destined to satisfy needs of education.

At that it is necessary to note Topic Maps grounded TM4L — an environment for building, maintaining, and using standards-based, ontology-aware e-learning repositories. TM4L is based on the idea that concept-driven access to learning material implemented as a Topic Map can bridge the gap between a learner and targeted knowledge [19]. TM4L is aimed at facilitating the integration of already existing learning resources on the web.

Nevertheless, a cognitive visualization of learning objects is an urgent need of modern education. Whereas a verbal approach doesn't provide a concentration of knowledge, it is possible to concentrate knowledge by means of schemes and images.

There are many researches, which came to this conclusion (see, for example, [20; 21; 23; 24; 25]). A Schema is a structured cluster of concepts; it can be used to represent objects, scenarios or sequences of events or relations. The original idea was proposed by philosopher Immanuel Kant as innate structures used to help us perceive the world [26].

Richard Chase Anderson considered a schema as a main instrument of education [9]. And a schema is a cornerstone of his Schema Theory of Learning.

"Schemata can represent knowledge at all levels — from ideologies and cultural truths to knowledge about the meaning of a particular word, to knowledge about what patterns of excitations are associated with what letters of the alphabet. We have schemata to represent all levels of our experience, at all levels of abstraction. Finally, **our** schemata are our knowledge. All of our generic knowledge is embedded in schemata." [25].

We advocate schemata based learning process. By schemata we mean semantic framework that represents a causal-effect relation. This framework should ground a domain representation formalism that is understandable both for human and for machine.

This paper suggests e-learning approach that is built on such formalism.

3. Semantics of Subject Area

Linguistics defines semantics as a meaning of certain sign. Computer science defines semantics as a sense of a programming language sentence. In both cases semantics of any phenomenon is defined by a context of its usage.

Scientific knowledge is knowledge about causal-effect relations [1]. Therefore a scientific analysis of any phenomenon always starts from the investigation of its causes. This paper postulates that any domain knowledge is caused by a necessity of social needs' satisfaction.

It means that we consider domain knowledge in the network of social needs.

This implies that semantics of a phenomenon is defined by its role in the satisfaction of social needs, i. e. in the implementation of human activities.

According to D. A. Pospelov [2] a global goal of artificial intelligence is the creation of a meta-system which is able to generate all necessary scenarios of human activities. Thus domain knowledge representation should serve as a basis for the problems solution synthesis, for the comprehensive support and/or for the generation of new human activities.

Since human activities pursue socio-conditioned goals, we consider the domain knowledge as knowledge of the satisfaction of

social needs. Any subject area satisfies certain social needs or serves their satisfaction.

Semantics of subject area is an aggregate of its roles in a satisfaction of social needs.

Following the ADL's notation [3], we use the term "*content object*" generically to describe here any piece of content that can be launched for a learner.

Any content object, which belongs to mandatory program of professional education, contains knowledge applicable for certain step (and for certain situation) of professional activity. *Semantics of context object is defined by its place in the representation of subject areas.*

In other words, *a contribution of certain content object to the implementation of a professional activity we define as semantics of a content object.*

Any professional activity, satisfying certain social need, as a rule, requires applying knowledge that belongs to different domains. Thereby the main task of every learner is a semantically driven linkage of mastered knowledge in the form of scenarios of professional activity. For this purpose a learner must extract semantics of all studied content objects. A traditional education system is not oriented to help him in the achievement of this purpose.

Existing repositories of structured content objects [4] can facilitate a restoration of the lost (or badly acquired knowledge) or a obtaining of missing teaching material.

But in any case a student must collect a final semantic puzzle by himself in accordance with certain scenario of a professional activity. Frequently, a student mines a scenario of a professional activity by himself too. It occurs because a teaching material even describing a directly certain professional activity, bases on knowledge and experience of its author and also because an author cannot take into consideration a competence of every student, his motivation and his personal professional experience.

Scenarios of professional activities are key semantics of curriculum as a whole. These scenarios define place and semantics of any used knowledge.

The aim of everyone learner is a mastering the accessible general scenarios of professional activities as well as knowledge and skills that are necessary for their realization. Traditionally, the scenarios of professional activities are studied on the final stage of learning. If to change this tradition, a student will be aware about pragmatics of all learning components in advance of their detail studying. It will raise his motivation and will give the necessary vector for his cognitive activity. In any case, to facilitate an education process, a learner must follow a map of subject domain, which describes contributions of learning content's objects to professional activities.

Implemented as software, top level of this map must be provided by schemes of professional activities and top-down levels must contain semantically-structured learning content.

Traditional education (including modern e-learning) successfully creates the illusion of "learning". *In fact, learning is always — strictly an individual cognitive process, in which the learner must understand the semantic essence of the new knowledge and incorporate it into its knowledge about the studied domain and about the world.* Traditional education only provides this process by necessary training and laboratory equipment. E-learning approach, presented in this paper, facilitates and accelerates the training process and reduces its dependence on teachers to a minimum. Herewith, existing teaching materials will be semantically structured. Their mission is an annotation of elements of semantic schemes by text-, audio- and video-information.

4. A Role of Subject Area's Representation in the Learning

Despite the seeming obviousness, the term "subject area" does not have a clear formal definition. Research in knowledge representation field is still not resulted by a coherent theory of domain representation. Absence of domain representation's standard entails a relative-arbitrary drawing up of curriculums, which are influenced only UNESCO's standards and norms in education [5].

Relative arbitrariness of curriculums as well as absence of accurate criteria of efficiency of professional training eventually lead to failures of graduates on a labor market and, as consequence, reduces number of enrollees. To succeed in the market of education, curriculums should lean against the proven formal representation of subject domains. Each course included in the curriculum, must contribute certain meaning to

this representation. A course is a kind of content object. Therefore *semantics of any course should contribute to the formal representation of subject domain.*

A formal representation of subject domain should cover all professional activities.

Since any professional activity satisfies a social need, subject domain representation should be subordinated a certain hierarchy of social needs, and, as we mentioned above, *semantics of any domain is its contribution to the satisfaction of social needs*.

Semantics of courses, contained by a curriculum, must constitute semantics of subject domain. Therefore, the curriculum should be established in strict accordance with the formal presentation of the subject area. Figure 1 shows knowledge that defines a creation of a curriculum

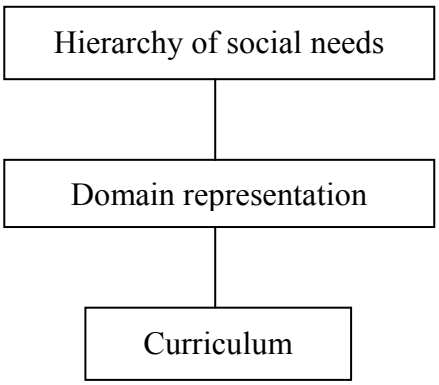

Fig. 1. Origin of a curriculum

Any course, in turn, should be represented by a structure that logically binds its components. *Semantics of any component is defined by its place in this structure.* Subordination of domain representation to hierarchy of social needs is a leading determinant at creation of the uniform domain representation standard. *This standard should be standard of description and satisfaction of a social need.*

The curricula created according to the formal description of subject domain, executed according to the universal standard, will make educational process as much as possible sated and effective.

At present time, as many centuries before, the structure of any content object depends on professional experience and preferences of its author. As a result, students are forced to adapt to the manner of learning content's presentation by an educator. This circumstance, being multiplied by the number of courses, significantly complicates the process of Learning.

Developed once by Apple Company, menu-like user interface became common standard of a programming that allows creating friendly and intuitive interfaces. As a result, user easily adapts to new software. *Putting into operation of the content object representation's standard will lead to similar effect.*

Cognitive ability of learners should not be exploited for the purposes that are weakly associated with the semantics of the curriculum. Note that, as we defined above, *semantics of the curriculum as a whole is equal semantics of a subject domain*.

It is necessary to add that authors of courses, as a rule, leave a substantiation of their professional position behind frameworks of a teaching material. *As consequence, the learner is compelled to restore independently a representation of the educator's experience from its isolated fragments.*

This is another vector of the cognitive activity of students, which we consider as unnecessary burdens that impede the process of Learning.

As we mentioned above, Learning is strictly an individual process. It depends on a student's motivation, on his cognitive ability, on presence of professional experience, on features of national culture and nurture, etc.

The main task of Learning's organizers is to simplify and facilitate as much as possible the mastering of a content objects by students.

Formation of curricula and writing of separate courses *on the basis of the uniform standard of subject domain's representation* undoubtedly is necessary for assistance to students in mastering the Learning content.

5. Need Satisfaction Domain

At present time the computer science community recognizes to a greater extent than ever a necessity of domain knowledge representation. ERP researchers conclude that a perspective of this class of software is related to the comprehensive detailed awareness of all enterprise's life cycle.

Semantic Web activity's evolution has led to the awareness of this need:

"One facet of the Semantic Web vision is

the hope of better organizing the vast amounts of unstructured (i. e. human-readable) information in the Web, providing new routes to discovering and sharing that information. RDFS and OWL are formally defined knowledge representation languages, providing ways of expressing meaning that are amenable to computation; meaning that complements and gives structure to information already present in the Web. They go a long way towards supporting that vision, *but the story doesn't end there*. To actually apply these technologies over large bodies of information it's required the construction of detailed "maps" of particular domains of knowledge, in addition to the accurate description (i. e. annotation or cataloging) of information resources on a large scale, much of which cannot be done automatically" [6].

Domain knowledge representation is an urgent problem of modern IT.

Proponents of any given domain conceptual model use (consciously and sometimes unconsciously) only those knowledge that are not contrary to their conceptual model, rejecting (or minimizing) knowledge that does not match their vision. In other words, they use a kind of psychological defence mechanism from knowledge that is not consistent with their domain model [2].

Conceptual differences entail the problem of truth of knowledge and trust to the results of its application.

Experts with a different experience describe the same phenomenon in different ways. Since the motivation of represented knowledge, as a rule, is not described (or is not clearly described), this results in disorientation of users.

The lack of universally accepted definition of the subject area adversely affects the quality of knowledge representation and leads to arbitrariness in the representation of its form and of its content. The available domain knowledge definitions are the following:

— "Domain knowledge is generally essential in the successful application of Knowledge Discovery and Application methods" [33];

— "The facts, procedures, processes, and rules of thumb of a domain that is an area of human activity presumed to contain expertise and knowledge suitable for the basis of an expert or knowledge-based system" [34];

— "More particular, in software engineering, *domain knowledge* is knowledge about the environment in which the target system operates" [35].

Some authors, for example, Eric Evans [7] consider domain model as a structure-class model of entities. They investigate its properties and relationships and, importantly, ignore the rest. DDD (Domain-driven design) community focuses on the core domain concepts and on the completeness of concepts' classification. By domain knowledge they mean a layer of software.

Other authors and programmers consider that domain should describe what ideas are included in the subject area, what is the subject (i. e. entity that has an independent behavior), what is an object (i. e. entity that has the properties — attributes and forced behavior), in what processes the objects interact; when, how, why, and what are exchanged; what situations are constituted by subjects and objects.

In this paper we consider knowledge as a tool of thought. And as a tool, it has one main goal: as much as possible to be in line with its destination.

The social needs form, ground and constitute all fields of knowledge. Any domain knowledge grows and ramifies in course of any social need's achievement. Therefore Human activities that achieve any social goal play a key role in the formation of corresponding domain knowledge, and thus domain knowledge representation must contain such activities descriptions. *Herewith, contributions of any domain entity to the satisfaction of social needs define its semantics.*

Knowledge, which is used for the satisfaction of certain human need, as a rule, belongs to different domains.

In pursuance of the human common sense, we unite knowledge which represents all known ways of each need's satisfaction to the separated areas of experience and we name it *Need Satisfaction Domains (NSD)*.

5.1. Needs and problems

A need (*definition*): A need is a necessity (motivated, poorly motivated, insufficiently motivated or unmotivated) to obtain something, necessary for maintenance of ability to live of the individual, of a social group, of a society.

A need is internal initiator of the reasonable activity.

A problem (*definition*): A problem is an inability to satisfy a need due to an inadequacy or insufficiency of resources as well as due to an inadequacy of an activity aimed to the need satisfaction.

Figure 2 shows an origin of reasonable activity.

5.2. Need driven mind activities

When a human consciousness detects a need, his mind initiates a reasoning process (hereafter *reasoning*), which searches in the memory an analogous situation. If an analogous situation isn't found, the mind initiates a thinking process (hereafter *thinking*).

The thinking (*definition*): The thinking is a mind activity aimed to creation new approaches (or strategies) of a human needs satisfaction in the new conditions.

If preconditions of any need are similar to preconditions, for which an approach of the need's satisfaction already exists (i. e. a current situation is known), the mind initiates reasoning.

The reasoning (*definition*): The reasoning is an activity of mind, responsible for operations with an available (both private and general) experience.

5.3. Thinking and reasoning

Nature of the thinking is unknown as yet.

The reasoning presents four procedures, namely: *an understanding, a search, a semantic sorting* and *a management*.

An understanding (*definition*): An understanding is a mode of reasoning, which glues together a detection of current situation and its origin, its derivative needs, ways of satisfaction of these needs as well as possible after-effects.

A search (*definition*): A search is a mode of reasoning, which uses information about actual need with the purpose of discovering data that are necessary for the given need's satisfaction.

A semantic sorting (*definition*): A semantic sorting is a mode of reasoning, which places data according to the accepted semantic framework.

A management (*definition*): A management is a mode of reasoning, which is responsible for the planning of obtaining and allocation of available resources for the need's satisfaction and for the control the need's satisfaction process itself.

5.4. Need driven producing and accumulation of knowledge

Figure 3 shows a need driven producing and accumulation of knowledge.

Current need initiates a reasoning activity aimed to produce a scenario of satisfaction of this need. If the reasoning doesn't cope with this job, the thinking process steps in. Thinking, together with reasoning, produces a scenario of the need's satisfaction and supervises its execution (they process, in particular, emergency situations (the problems) by generating and executing problem-solving scenarios). The need satisfaction's

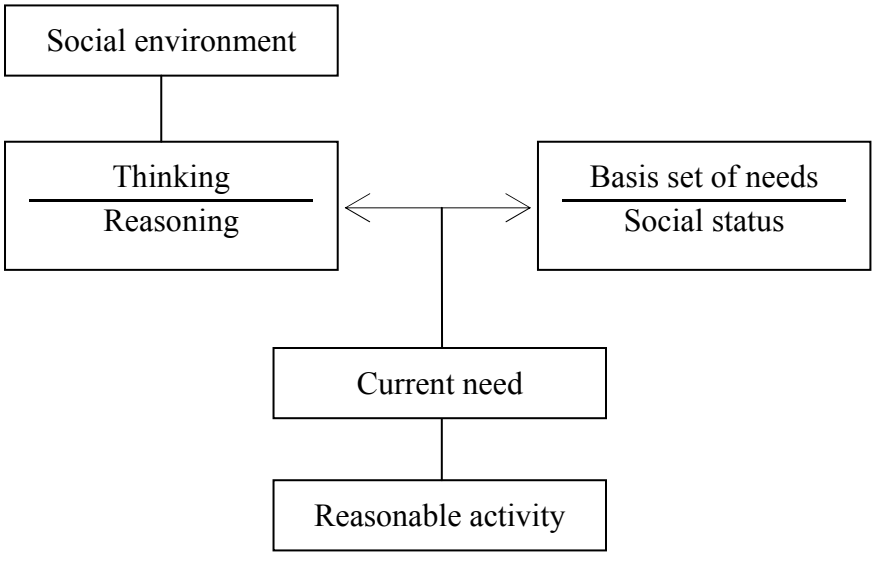

Fig. 2. An origin of reasonable activity

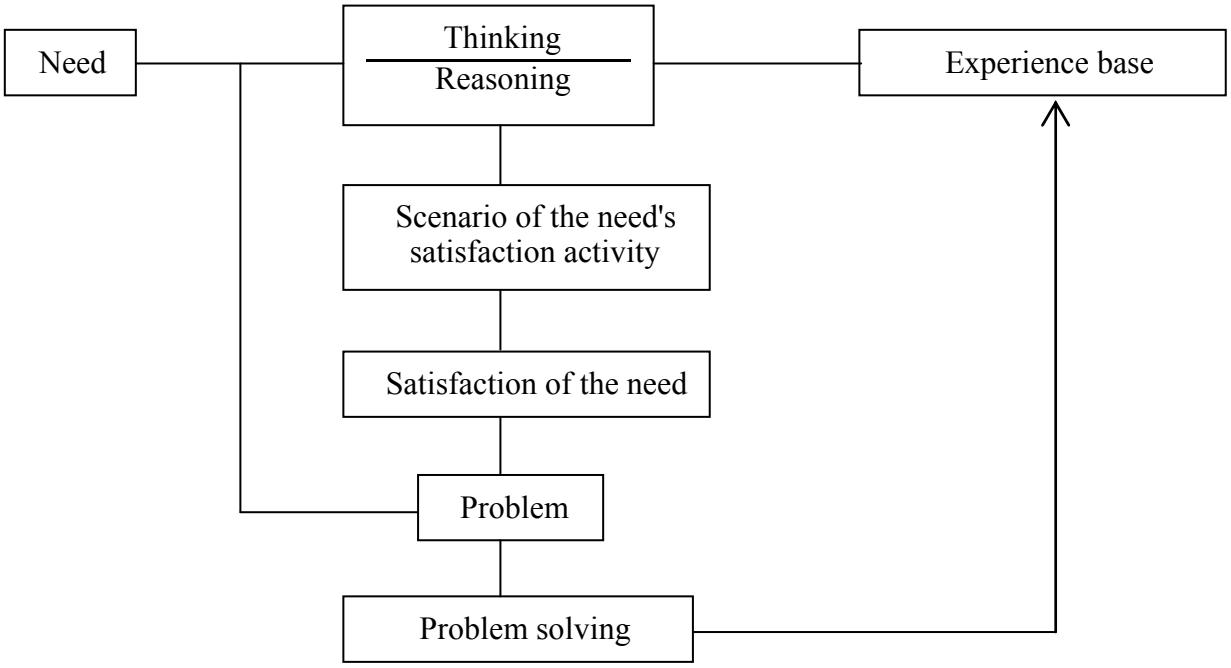

Fig. 3. Need driven producing and accumulation of knowledge

activity executed successfully or unsuccessfully, is stored in the Experience Base.

5.5. Need driven reasoning

Figure 4 details a reasoning process that is initialized by recognition of need.

This schemata is unique core schemata of experience that specifies a top-conceptualization of reasoning (*the top reasoning ontology's tree*).

The reasoning may start from recognition of the need, and/or Current state and/or Causer and/ or available resources and/or Symptoms of the need.

Further reasoning recognizes available resources and/or methods of their obtaining.

Knowledge of the given need, of Symptoms of the need, of Current state, of Causer and of available resources is considered as input for a search of an adequate Need Satisfaction's method.

5.6. The basis hierarchy of needs

Human needs are arranged hierarchically [8]. Root nodes of a hierarchical tree needs are basic needs of human survival.

Figure 5 demonstrate an interpretation of Maslow's Hierarchy of Needs that motivates a development of subject areas.

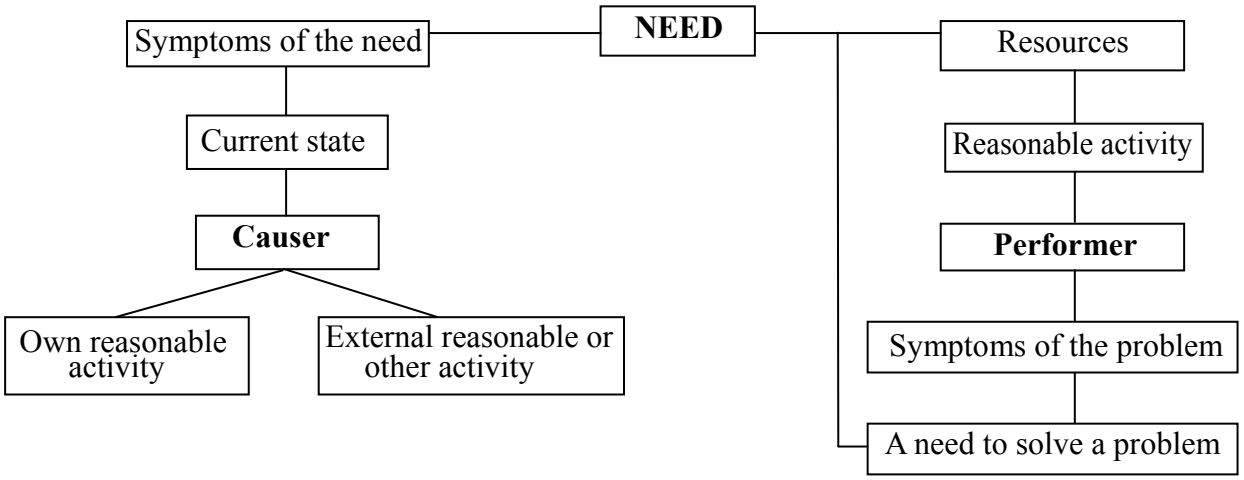

Fig. 4. Schemata of a need driven reasoning process

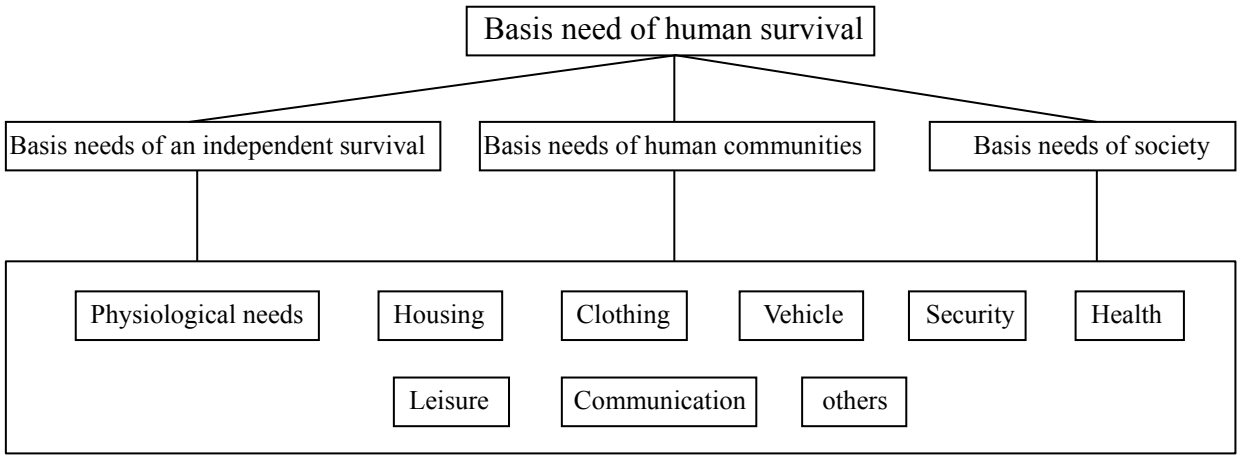

Fig. 5. The basis hierarchy of needs

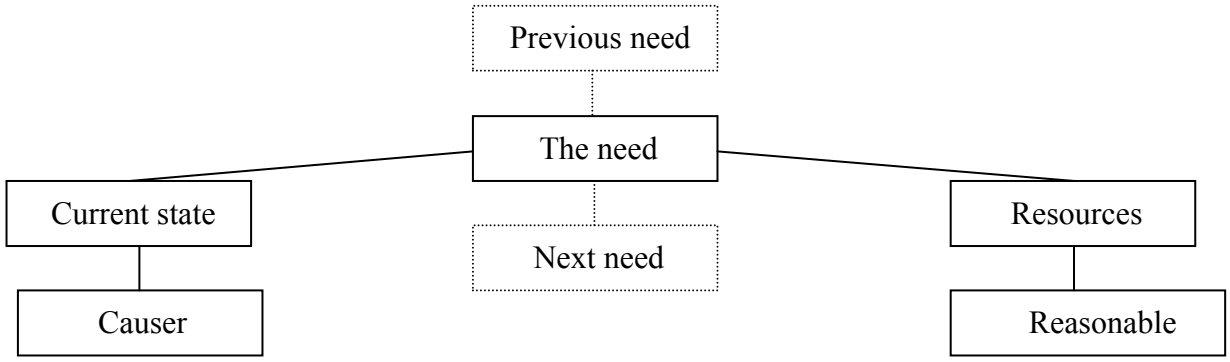

Fig. 6. Inheritance of a need

5.7. Inheritance of needs

Any need inherits a motivation of other need (that is hierarchically above) and expands its semantics. Any place in hierarchy of needs looks as presented in Figure 6.

5.8. Types of needs

If available resources are insufficient or the reasonable activity cannot start without certain conditions and recourses, it is necessary to provide missing resources and conditions.

A derivative need (*definition*): A derivative need is a need to obtain something that is necessary for the need's satisfaction.

A compound need (*definition*): A compound need is a need composed of number of needs.

In case of inability to satisfy a need due to an inadequacy or insufficiency of resources as well as due to an inadequacy of an activity aimed to the need satisfaction, a performer is faced with the need to take steps to correct the current situation. Thus, it is a new form of derivatives needs, called operational needs.

An operational need (*definition*): Operational need is a need to solve the problem.

5.9. Example of needs' hierarchy: The Treatment

Experience Base accumulates all cases of treatment of disease depending on the patient's condition and available medical resources.

6. Schemata Based Learner's Cognitive Activity

"E-learning platforms are software-controlled learning infrastructures that attempt to replicate what teachers do in the face-to-face classroom" [36].

This sentence reflects popular belief that Learning, above all, is activity of education organizations. As we mentioned above, e-Learning is a cognitive activity of learners. Furthermore, both a direct interaction and an

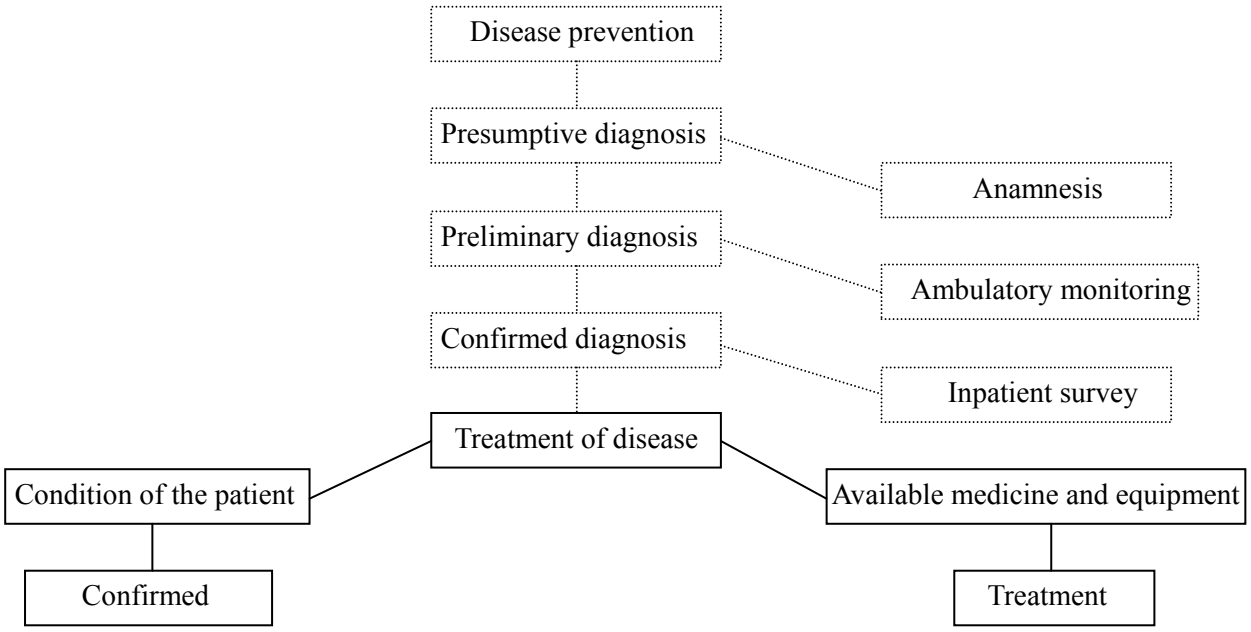

Fig. 7. Example of needs' hierarchy: The Treatment

imitation of teachers any more doesn't correspond to modern rate of information interchange.

Given a speed of changes in a modern information field and a conforming situation in the education market, we advocate learning process on the basis of the specialized courses tailored to meet the professional activities of the customer or his life activity as a whole.

Labor market requires a providing of professional knowledge and skills that are relevant at the moment. Learning itself becomes rather oriented to requirements of industry than academy. Thus Learning becomes more and more demanded by people with strong motivation, people that are forced to learn on their own.

Given that the Learning has always been strictly a private process, it should be noted that the modern actuality obliges more not to ignore this circumstance, and openly to base on it new methods of formation.

A necessity to quickly "capture" professional knowledge forces learners to direct their cognitive activity under represented by Figure 4 schemata of a need driven reasoning process (hereafter *Schemata*).

In pursuance of Schemata, learners investigate the following:

A set of social needs that chosen profession satisfies;

Definitions of needs and different states of environment that leads to necessity of needs' satisfaction;

Symptoms of needs;

Resources that are necessary for the needs' satisfaction;

Different scenarios of the needs' satisfaction depended on different initial conditions.

In other words, a motivated learner investigates NSD.

6.1. NSD ontology

Schemata represent semantic framework that provides the following levels of NSD ontology:

The general NSD's scheme include basic variants of initial conditions, embedded hierarchy of subordinate needs (derivative needs and compound needs) and magistral scenarios of the need's satisfaction;

Separated schemes of initial conditions and corresponded satisfaction scenarios;

Ontologies of subordinate needs' satisfaction scenarios;

Ontologies of operational needs' satisfaction scenarios;

Ontologies of separated components of above listed schemes, i. e. ontologies of causers, current states, symptoms, resources, etc.

Level NSD ontology, which we name NSD Zero ontology (hereafter NSD Zero) is of special interest.

NSD Zero ontology consists of determining the need, including determining the need, synonyms, semantic coordinates and a list of subordinate needs.

By semantic coordinates we mean ontology of close-in surroundings of investigated need in the hierarchy of social needs.

Semantic coordinates, for example, of Ambulatory monitoring (Figure 7) are as following: Ambulatory monitoring is a derivative need of the need Preliminary diagnosis.

6.2. Casual structure of need satisfaction domain

In according to [12–16] Figure 4 demonstrates Schemata of Human experience that drives a discovering a need's origin (Causer), a discovering a current state that is caused by Causer, a discovering a symptoms of the need, a discovering a Need that includes ad of a need and a structure of the need, a discovering available resources, a discovering a scenario of Reasonable activity that satisfies the given need and a treatment of possible problems.

Following Mario Bunge [1] by *causality* we mean "constant and unique performance". This implies that cause (C) is a process, which transforms an antecedent (A) into an effect (E):

$$CER = C(A,E),$$

where CER stands for Cause-Effect Relation.

In application to Need Satisfaction Domain (NSD) [13] this means the following:

An antecedent of cause-effect relation that grounds NSD includes Causer, Current state, Symptoms of the need and Resources;

An effect of cause-effect relation that grounds NSD is Need;

A cause of cause-effect relation that grounds NSD is Reasonability activity and a treatment of possible problems.

CER-triple can be interpreted otherwise, namely, a Performer executes Reasonability activity using Resources with the purpose of a need's satisfaction. In the form of subject-predicate-object expressions this means: Performer is a subject, "Reasonability activity using Resources" is a predicate, and a need is an object. Such interpretation of NSD allows representing it in RDF-form. Thus Linked Needs [13] becomes a part of Linked Data [27].

As a rule, an implementation of Reasonable activity leads to other needs. Figure 4 shows that Causer's activity entails Reasonable activity (i. e. another causer). Thus a causal linkage of NSDs grounds Linked Needs.

7. Schemata Based Organization of e-Learning

In according to Schema theory of learning [9; 10; 11] scheme is a key instrument of Learning.

There are the following characteristics of schema according to Anderson [9]:

— schema is always organized meaningfully, can be added to, and, as an individual gains experience, develop to include more variables and more specificity;

— each schema is embedded in other schemata and itself contains subschema;

— schema changes moment by moment as information is received;

— they may also be reorganized when incoming data reveals a need to restructure the concept;

— the mental representations used during perception and comprehension, and which evolve as a result of these processes, combine to form a whole which is greater than the sum of its parts.

Replacing the "schema" to the Schemata in the above-mentioned meaning, keeping in mind the technologies of machine-readable Web (include Linked Needs based technologies [12–17]) and considering Learning as the investigation of NSD, we come to the Schemata based architecture of e-Learning that consists of following components (Figure 9):

Schemata based search of information and solutions (both manual and automatic);

Automatic generation (or manual assembling) of courses in response of a customer's specification of missing knowledge;

An investigation of NSD (both by means of Schemata based search and by means of manual navigation over *NSD map*) as well as by means of *Schemata based simulation mode*;

Schemata based explanation mode;

Schemata based testing of mastered knowledge (both embedded to the NSD investigation process and as an examination).

Hear NSD map stands for Schemata based system of semantic schemes that represents

all levels of NSD ontology and correspondent textual-/audio-/video-content objects to generate, visualize, structure, and classify a needs related knowledge, and as an aid to Learning, to organizing NSD ontology and NSD constructive knowledge (causers' and performers' activities), solving problems, making decisions and writing;

Schemata based simulation mode stands for the system engine mode that simulates a satisfaction of given need under initial conditions specified by customer.

Any component of Schemata based architecture of e-Learning contain embedded Schemata or/and textual-/audio-/video-content objects (i. e. resource named Plain text).

Note that Educators (i. e. an interaction with tutors) are an optional resource of Schemata based e-Learning that should be demanded anywhere and in any time.

8. Conclusion

Moderne-learningdoesn'tusetothefullextent the cognitive abilities of learners. Furthermore, lack of content objects representation's standard as well as lack of domain representation's standard disorient learners and make difficult their cognitive activity.

Using Schemata as domain representation standard and applying it by means of modern Web technologies for objectives, declared by R. C. Anderson in his Schema Theory of Learning, Rumelhart and others educational psychologists, we solve above mentioned issues of education.

Schemata based e-Learning may serve as foundation of Global e-learning system that will involve leading world experts as authors of Schemata and huge amount of Internet users as learners.

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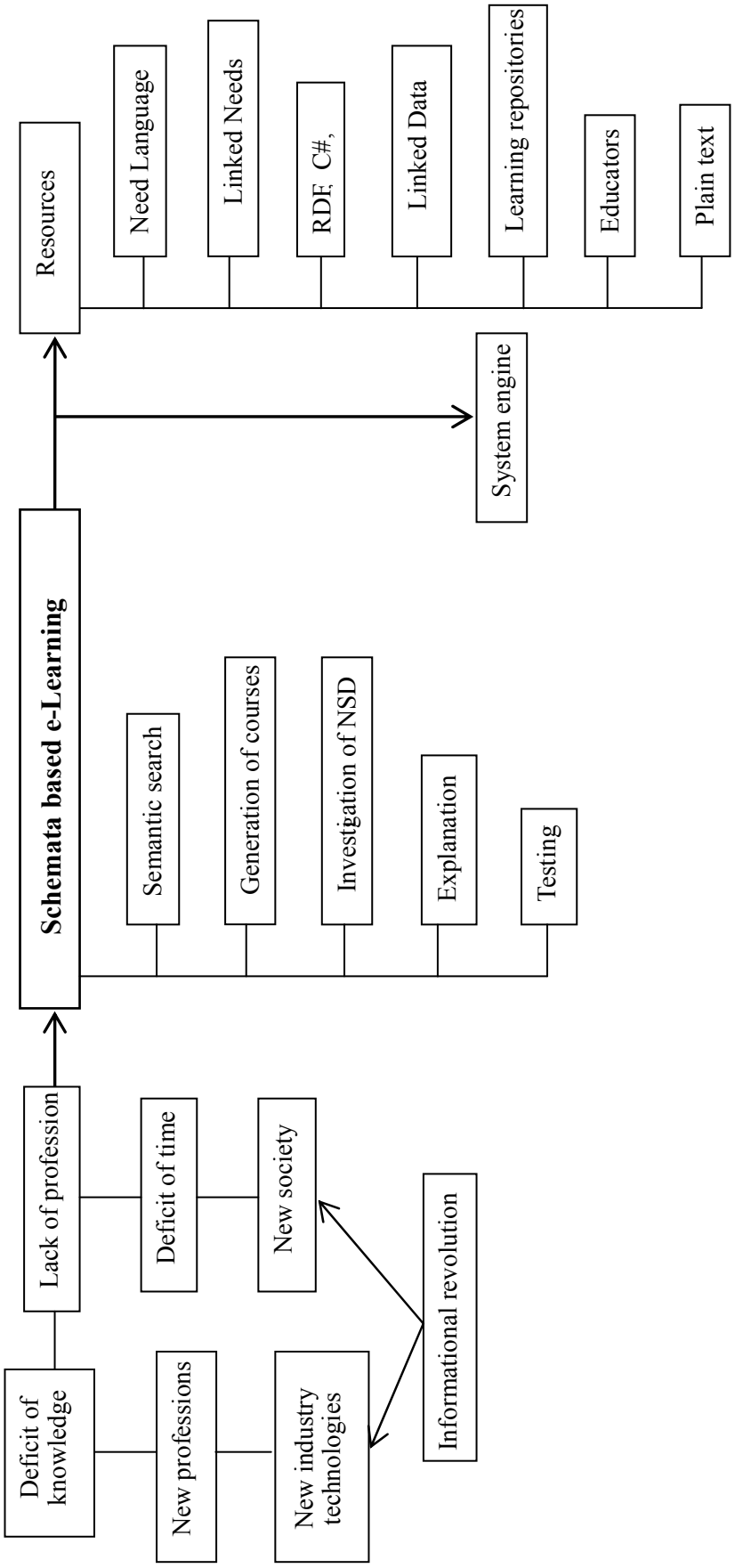

Fig. 8. Schemata based architecture of e-Learning

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Поступила в редакцию *16 июля 2011 г.*

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V Всероссийский симпозиум по экономической теории
(Екатеринбург, 26 – 29 июня 2012 г.)

Секция экономики Отделения общественных наук РАН, Институт экономики УрО РАН, Центральный экономико-математический институт РАН, Институт экономики РАН, Уральский федеральный университет имени первого Президента России Б. Н.Ельцина, Уральский государственный экономический университет, Российский фонд фундаментальных исследований и Российский гуманитарный научный фонд при информационной поддержке «Журнала экономической теории» и журнала «Экономическая наука современной России» извещают о проведении V Всероссийского симпозиума по экономической теории.

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