Knowledge and Skills representation in Virtual Education

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***Abstract* - Goal of this article is to describe possible ways to design intelligent study materials. It describes material structure by adding descriptive attributes and behaviors through Explanation and Tests. Article discuses benefits of automatic study material adaptation in opposite to adaptation based on rules defined by authors. Here are described basic principles of study material design for different adaptation form of Study materials, and Testing techniques. In second part are discussed possibilities of usage Student Activity Protocol, study groups, absolvents and graduated students, and material designers to find optimal explanation for concrete student. Last part is oriented to skills and other nontraditional activity representation, which is produced out of virtual education environment. Article describes automatic storing ofl activity protocol, level of acceptance, memorization curve, knowledge consolidation for all situated in large context of receiving knowledge and skills, and their future use.**

Index education, intelligent, knowledge, representation, skill

INTRODUCTION

This paper is oriented to the possibility of designing intelligent study materials and knowledge engineering in education process. Goal of this topic is not to describe all available methods or practical implementation. Here is described a conception of use, and their contrasts with application differences based on different science domain and education styles. Most important roles in design process represent pedagogy, learning styles, concrete student capability and attributes. We can compare quality, associations, contents information about study materials. This article describes application possibilities from the author and student point of view. As a fundamental part of this article is described knowledge network and knowledge engineering. Here is described actual stage, conception of possible global solution, integration process for presence, distance and blended learning form of study.

INTELLIGENT EDUCATION SYSTEM KNOWLEDGE REPRESENTATION

Fundamental part of expert system, especially for education systems is knowledge base. Knowledge base description can be divided into two parts: a declarative system describes cognition, (in our case elementary terms, Mathematic is a science); procedural systems are based on rules, (If the course is mathematic, then it is a science). In our case is knowledge base divided into several parts, that are divided based on usability and contents. [5]

ROLE OF THE TEACHER

This part of knowledge base store information about teacher role. This is list of rules that defines explanation ways based on actual and expectant student knowledge. Commonly, explanation process is defined by algorithm with unchangeable list of rules. System makes same reactions for same problems. Producing an expert subsystem for the explanation process looks like interesting alternative. Using this module we can deduce and generate new rules for explanation process based on experiences (progress activities) of "virtual teacher". These rules are stored as a candidate for base enlargement. Rules are accepted or rejected by the base administrator. In this system we can define a few teachers (explanation algorithms) witch different attributes. Teacher can prefer different explanation procedure with different instruments. *Example: orientation to the example, visual representation, testing, orientation to facts, etc.* Students can choice from the list of available "virtual teachers" based on their own actual profile and requirements.

STUDENT PROFILE

One of the most important aspects for the correct adaptation is using of student profile for explanation and content adaptation. Student profile is build form the study procedure beginning, it must contain previous experiences, skills, and knowledge stored as a valuable values. Based on these values is adapt the content and explanation procedure. When this profile is not available, must be defined a process (common test based algorithm) that detect student basic attributes. These attributes are used for explanation and can be changed in time. Student profile can be divided as a global or internal profile. [6]

UNIVERSAL STUDENT PROFILE

First is definition of the Universal Student Profile (USP) that can contain all possible values and states, that can be representing by the profile. Universal profile must be represented in the implementation for storing all possible cases.
For current student we deduce profile intention that contains concrete values which describes their knowledge and attributes of the individual human. Profile intention can be divided based on content information.

GLOBAL STUDENT PROFILE

Here can be stored information about attributes, capability, skills, education styles, long and lifetime of the memory and other "static" attributes. These global attributes (GSP) of the student adapt study material based on their capability. This is relatively stable information. Changes in this information are sequential based on student capability growing.

COMMON STUDENT PROFILE

This information represents actual student knowledge based on current course. Profile describes list of terms that was presented to the student, their acceptance, adaptation, memorization, repeating, forgetting. This profile is dynamically changed based on actual student knowledge.

LIST OF ASSUMED KNOWLEDGE AND SKILLS

For all teaching units must exists list of received knowledge and classifications, that is described by this unit. Must be defined unique knowledge description standard containing their description, their categorization into knowledge and skills hierarchy, and their relevance in actual teaching unit.
Example: addition – operation of adding two numbers – fundamental mathematical operation – require to known this information.
For these base is most necessary knowledge terms unification, and terms sorting by similar characteristic. This operation is necessary for wrong sorting protection or duplication of same terms in different context. List of received knowledge and skills is stored in student profile or in the area of the new knowledge and skills.

RECEIVED KNOWLEDGE AND SKILLS

Education system must be able to store and work with new student knowledge. *Example: antecedent – student study concrete passage of the material, consequent – student have to know this passage and contained terms, but these is not guaranteed – here incomes knowledge evaluation procedure.* Commonly education system presents explanation theory and then automatically supposes the problem understanding. These concept works with virtual student profile (VSP). New knowledge is stored in this profile this knowledge is constantly evaluated. When the evaluation is successes then the term is moved to the common student profile (CSP). In the opposite case when student don't understand the term well, this term is removed from the set of new accepted knowledge and skills, or from the CSP as a forget procedure. Based on these information student must to study the term repeatedly.

TEACHING TEXTS, STUDY MATERIALS, AND EXTERNAL EDUCATION SOURCES

Important role in the education process represents information storing methods, that ca be served to student. Information must be divided into units - objects, which describe concrete information. Most difficult problems can be collected from many objects, in the opposite case object is elementary undividable part of explanation. We can represent the object as elementary nodes of the graph with oriented nodes that represents path of explanation procedure. These graph upgraded with questions as a special type of the object enlarged by question and answers which divide the explanation procedure. Previous conception of the programmed material building uses linear walk through study material. Branching operation is represented only by the questions. Based on the answer we can divide the explanation process. (Figure 1.).

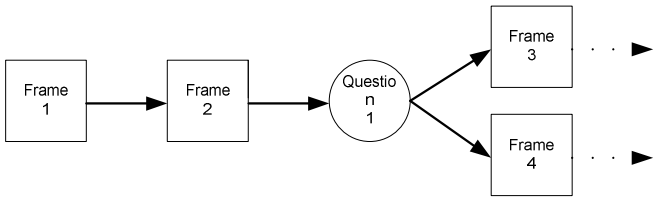

FIGURE 1 - EXAMPLE OF THE PROGRAMMED LEARNING

In the case of adaptive education is a previous described linear connection of the frames (= explanation objects) updated by the new associations. This information helps to adapt content of the material or to make a jump in the text based on student profile. Previous linear scheme is retained and upgrade by the new possibilities of branching with connection to the equivalent terms, additive explanation, finding the antecedents and consequents of the current term, possibility to reduce and remove known terms. Basic frame structure (Figure 2.) is enlarged by other connections and is consolidate the term of frame and question into one object called as element.

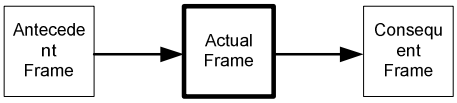

FIGURE 2 - CONNECTION SCHEME FOR THE FRAME IN PROGRAMMED LEARNING

REPRESENTING KNOWLEDGE NETWORK BY GRAPH

Knowledge network, list of elementary terms, and description of connections between then can be defined as common oriented graph, where the nodes represents terms and the edges represents antecedents and consequents connections. Graph structure can be viewed in several levels based on size of the nodes.
Most elementary view visualizes objects as the nodes. In this case nodes represent partial didactical aspects. Using nodes generalization we receive as a node full term representation, which contains several objects with different didactical sense.
Common element scheme (Figure 4.) describes possible inter-objects connection alternatives. Teaching units contains set of these inter-connected elements. This set is stored as oriented graph structure called as knowledge network.

The network contents:

- **Term (element)** – elementary part of explanation, contains one term definition with possibility to evaluate received knowledge, and term understanding
- **Equivalent terms** – list of equivalent terms for the current term, allows scaling up set of possible results

(outputs) consequents and antecedents, and is possible to select other ways of explanation

- **Antecedents** – set of antecedents for a current element. It can not be only (only one edge distance) direct antecedents, but also antecedents of these antecedents etc. History depth and direct connections of antecedents is determined by edges attributes
- **Consequents** – this is direct continuous of actual element, it is set of continuous elements
- **Results** – list of all not only direct consequents for an actual element. This is set of all possible results deduced by current element. When is necessary to deduce more that one element as an antecedent for some consequent. For the elements in the set of antecedents this cannot be a result. Exception of this state is equivalent terms. There is possible to be a result for the previous antecedents
- **Predication** – evaluation of actual state and reducing or adding missing direct consequences

Example: Consequent of the current element is a term which a student understands from previous teaching process, this term can be reduced

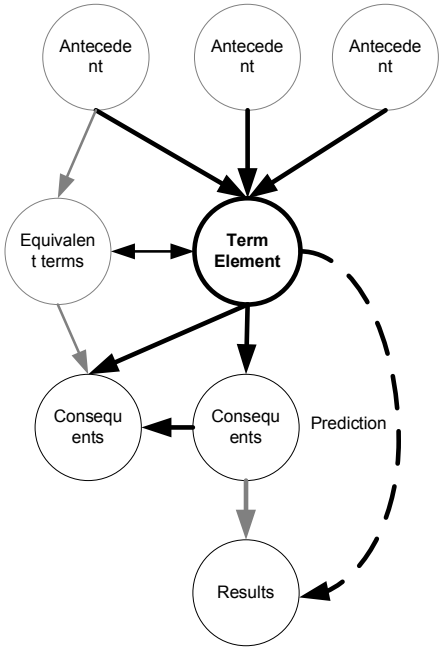

FIGURE 3 - ELEMENT SCHEMA

BASE AND DEDUCED EDGES

Edges (object association, connections) are divided into two basic groups. First group represents **basic edges** that are generated by the author of the study material and education process designer. This edge has a highest priority and can by changed only by material designer. [2]

Deduced edges represent set of consequents and antecedents. Deduced edges are generated by the system and are valuated. When the deduced edge scale up the priority that is equal to basic edge, author is informed abut it. This state represents two factors:

- **Explanation error** – students, virtual teacher, or the study material has a wrong interpretation of current element, based on this is produced wrong deduction (=understanding) of current part of the study process. This situation must be eliminated by changing teaching unit structure.
- **New explanation strategy** – system find new explanation strategy that is commonly faster that current designed explanation procedure. Designer can accept this solution and give them highest priority for use

In the system must be defined deep level of antecedents and consequents respected by system.

CYCLIC PROBLEMS, COLISION SITUATIONS AND THE STATE OF UNCERTAINTY IN A KNOWLEDGE BASE

In the system can income the situations, when is produced cyclic explanation operation. This state is limited by repeating constant that present maximal loop count for same information. Student build list of received term, by the testing process is the received terms moved to understand terms. Terms that are understood are not necessary to repeat. Other types of term are terms for remembering, this terms are divided for the term of short life or long life usage. For the term of long life usage is better to use multiple repeating for better memorization of current term and problem.

Collision situation may be income in two ways. First collision is in situation when we select explanation path for elementary objects. This problem is eliminated by defining edge order. For this order do not exists edges with the same priority. By this order is selected edge with highest priority. For different style can the edge received different priority. Second collision can be started by de level of virtual teacher. Here must be also set the priority of evaluated terms.

Most relevant problem is uncertainty state. This state is characteristic by problem that is now available strictly answer that the student understand current problem This state is commonly seen in testing and repeating situations, when the student produce inexact results. For these problems are necessary to change knowledge network by typing additional evaluation elements.

PREDICTION IN EDUCATION PROCESS

Education system can based on student profile solve the reducing or detailing of the explanation procedure. This solution is based on step prediction with removing equivalent terms that are necessary for students. Process of prediction removes the redounded terms form explanation part but not from evaluation part of a study procedure. Prediction is also based on student memorization capability called as an index of forgoing information.

INTEGRATION OF EXTERNAL SOURCES INTO KNOWLEDGE NETWORK

To the expert education system is necessary to add external sources. External sources are practical examples and students tasks realized out of education system. All these activities must be must be put into system additionally. System must support manual adding of the external source information into student profile for a concrete student.

STRUCTURE OF STUDY MATERIAL

The adaptation of text content for students require most universal model. Adaptation process can be realized in for basic domains: **acquisition of correct study program (course)**, based on requirements for future knowledge acquisition, correct module selection based on actual student knowledge, with possibility to remove well known modules or ability to promote modules with missing knowledge which could not find in actual course, **reducing or complementing teaching units** based on received knowledge, **teaching units adaptation based on presented object significance** – object significant for education, descriptive object, object with association, final terms, terms preamble, and other dividing.

Possible previous described education elements could have many different attributes in several points of view. Goals for this realization is to publish most common model, which is able to record previous described attributes for a future evaluation.

As well as the standards are used for content description or system use individual way of education, is necessary to formulate some additional information and connect it to the teaching material content.

Adaptation process is divided into the two basic parts. First part describes **how to adapt** (adaptation function based on student profile and education requirements) and second **what to adapt** (correctly structured and described study materials).

BUILDING OF KNOWLEDGE NETWORK

Education knowledge network is an oriented graph scheme, which is connected to the study materials, and represents actual student position using information understand by computer. In this network are marked term antecedents, consequents, and other attributes which is necessary for evaluation. When the problem is not understood well, system can provide different explanation way, system can evaluate previous terms, which are necessary for actual term understanding. In opposite way we can produce support, which part of study material can student study after successfully finish current problem. [8], [9]

A basic requirement for knowledge network building is simplest design process. Evaluation rules can by typed by every author, without any requirements for special skills. Author should be able to define own knowledge and term hierarchy (described in this article) or use some existing knowledge domain.

We can build knowledge network by tree ways (Figure 4.): First way is adding to the study materials metadata with content description. Second, building knowledge network terms (metadata) and in next step we insert education content. Both two ways represent **systematic approach** for design and building of study materials. Author can use own teaching scheme, which is supply by study material or an ability for adaptation.

Third, **combined additive approach** realizes study material building with adding new item into content and adaptation description together. This way is often used with new areas of education and is followed by many mistakes.

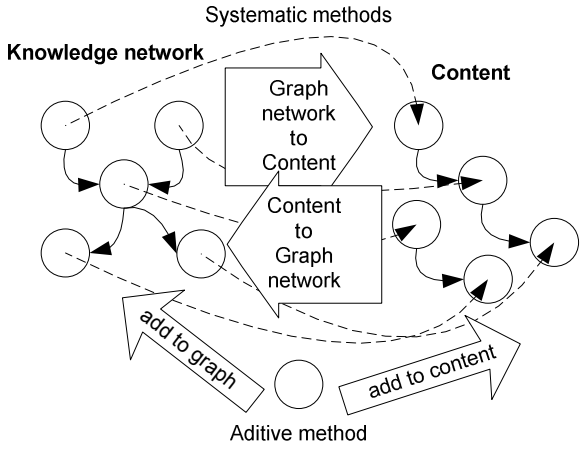

FIGURE 4 MATERIAL BUILDING SYSTEMATIC AND ADDITIVE METHODS

Access without restrictions
Problem oriented access (based on content meta-data)
Access defined by author (based on author experiences)
Common optimized access (based on paths used by previouse students activities evaluated by statistical methods)
Access based on previouse knowledge (using current student profile, results, and previouse terms, for future adaptive process)
Access based on individual capability (using current student profile, capability and skills, memorization skills and learning styles)

FIGURE 5 LEARNING UNITS ACCESS TYPES CHARACTERISTIC

Based on going through methods we can setup knowledge network into several states (Figure 5.):

- **Passing without restriction** – knowledge network is full available, without ability for content adaptation.
- **Problem oriented passing** – is represented in graph network as an optimal way how to fast understand all required problems. Because is possible to define then into levels of relevancy is available to find few explanation ways in units based on problems: show just necessary terms, show all terms, show terms from previous units for repetition, etc.
- **Passing defined by author** – this position is a sequential explanation list manually defined by the author, based on their experiences represented best way in actual teaching unit
- **Individual optimal passing** – [3], [4] is next explanation variant that contains human factor from the student point of view. Based on statistical evaluation of passing through process for individual student we can be watch optimal explanation way that can not by identical with supported explanation ways (authors experiences, or paths generated by system) This process can be affect by previous groups of student and can not be correctly used for current student. For actually logged student we

can design optimal path using their own previous success, failures, student score, and inspected modules (units).

This way is called as:

- **Education based on previous knowledge** – memory skills, education styles, and other possibility provides
- **Education based on individual skills** – this variant of explanation can be combined together. When is used "correct system", then is possible to combine and statistical evaluate of this methods

METADATA FOR KNOWLEDGE CLASSIFICATION USAGE

For the knowledge classification is required attributes dictionary innovation, which helps with term evidence. Terms can be token form common domain of knowledge classification, or we can build this domain by self.

For the elementary terms we store:

- **Term identification** – unique identification of current term. This ID must be unique for all elements in system
- **Term type** – define if this term used in area received knowledge or skills
- **Term source** – define if the term is received form knowledge classification vocabulary or is defined only for actual course
- **Science discipline** – source area of science
- **Antecedents of current term** – list of immediate antecedents (terms) that are required to know before we study current term
- **Consequents of current term** – list of immediate consequents (terms) that are deduced from current term
- **Results of current term** – list of common in future derived consequents that are able to derive from current term (not only direct derivation)

METADATA REQUIRED FOR CONTENT SELECTION AND EXPLANATION WAYS DEFINITION

Metadata which describes and affects decision making for future explanation are added to basic knowledge classification. They can support selection of next explanation steps, or can define own ways in decision making process. This attributes can define by author of the knowledge network. Second way is using protocols of student activities. **Metadata for future decision** are divided into **static** (strongly defined) and **dynamic** (changed in time). Strongly defined information is received from study materials by author. Dynamic information is received form students activities.

Static attributes of elementary objects:

- **Term dynamic attribute** – it is connection between concrete object and elementary term. It can be motivation, example, explanation, alternative explanation, practical application, knowledge verification, questions for term, task fro term, memorization, common consequent
- **Term priority** – Term importance in current course, priority can be defined as numeric row with stable dividing (ex. 0-5), where 0 represent highest priority, priority strictly required for term understanding
- **Type of the object** – describes the type of the object, explanation, evaluation, etc.
- **Term or terms description** – describe content of current object relevantly to the list of terms (one object can describe few terms but is recommended to use single object for single term)
- **Explanation method** – describes which type of education method is used for term explanation
- **Visual method** – describes type of content divided by memorization instrument (visual, memory, hearing memory, etc.)
- **Term signification** – common classification of significant terms with global point of view, required in other courses
- **Explanation method** – define the type of explanation oriented to the education style, and memory types

Dynamic attributes of elementary objects:

- **Consequent recommended by author** – next explanation step, defined by author based on own best experiences
- **Consequent recommended by system** – list of several objects (often 5), sorted by counting hierarchy, on the first position is situated most counted object
- **Count of first invitation by student** – ratio the first inspection compared with all inspection for all students with rights for access to this component (can be stored as two values number of all student with access and number of students which inspect this object as first)
- **Average inspect count for one student** – this evidence contains information how many times was term in average inspect by one student, this information is stored as one number for all students, and one number for current student
- **Common term antecedents** – list of previous terms from when was inspected current term
- **Number of answer for question** – how many times was answered for current question
- **Number of correct answers** – count of correct answers
- **Number of wrong answers** – count of wrong answer

Dynamic attributes can be received immediately by storing new values: count of use, action offer, type of question and answer accuracy. Second way is to use batch process. Both methods can be supported. Immediately store process is used for on-line education and batch process is used for external students. External students send the information about study process by batch, when they are connected to the central system.

METADATA FOR SPECIAL PART OF STUDY MATERIAL

In previous two chapters was described metadata for the objects. From this elementary attributes we can deduce information for teaching units, modules, and complete courses. By adding some description attributes we can adapt these groups of elements. In the teaching units we can evaluate list of terms. For better terms understanding we can

evaluate protocol of events. This knowledge can be aggregate for modules in complete courses.

KNOWLEDGE CLASSIFICATION

Actually are knowledge (terms) classification realized separately for courses, modules, and teaching units. This approach reduces redundancy of the same terms with different courses. Here is not available unified terminology for different science disciplines or courses, especially when goes about terms with same characteristic and sense. Based on this incomes problems can develop and maintenance unified conception that can lead students to understanding required terms.

Here is initiative to build unified classification of knowledge with different science discipline or publish some methodology to building them. Classifications cam be represented as oriented graph described in previous chapter, where the nodes will represent basic terms. Terms will content information of their antecedents (what we can know or what we can do to understand current term) and consequents (what we can study after we understand current term). System can store basic line of explanation for current domain (discipline). Other connection will be realized as interdisciplinary associated terms. Example: When we understand the integration term, we can use it in physic or electro-technical disciplines, to understand other terms.

From previous situation methodical of unified classification has been used in many areas and domains. For our usage is most common problem business production and service classification for commercial subject activities list.

Elementary activities are generalized into higher logical units, other way by detailing classification we receives elementary activities for current organization.

For individual terms in this graph structure can exists different ways of an explanation. These methods as the instance of current term represent process of optimal problem understanding algorithm.

HIERARCHICAL KNOWLEDGE CLASSIFICATION

In content of unified knowledge classification we use a term hierarchy. We start with elementary terms ant try to grow to the much more difficulty term. Terms interconnections are realized by oriented edges, there we use top-down mechanism to derive difficulty terms form the simplest. Bottom-up approach is used for finding antecedents of current problem (term) solving. [7]

TERMS UNIFICATION AND THEIR ORDER

I the classification must be guarantee term unification. One name can represent still the same term with same explanation. Problem is coming with different science disciplines. Here are different terminologies that use same word for different things. This problem can be eliminated using negative edges, which will connect two terms with the same name bud different explanation and will represent information that this terms are not in relation.

BUILDING OF COMMON KNOWLEDGE HIERARCHY

Building of common knowledge hierarchy requires research centers which can evaluates and judges if the term is relevant for current area of research. These commissions will works on interdisciplinary problems and conflicts. Because fundamental terms and knowledge are “stable” these activities will work on the border of science.

First phase, hierarchy can be build by authors as a first instance of electronic content designer. Visualization of structured graph with terms and connections between them involves student complete review about course contents and helps with orientation in the problematic.

Access in level of complete modules, courses remove typical education phenomenon, when separated courses build in students minds “islands of knowledge” independent on other courses and problems. Goals of learning are to build global overview and association between similar science disciplines. When we use hierarchical knowledge classification we can guarantee association and interoperability.

CONCLUSIONS

Actually is project in developing stage, previous described approach is not one possible way in this area of study material description. Here is necessary exact definition of evaluation characteristics. Still in progress is problem solving - about evaluation, decisions making, and priority order for optimal way of explanation, and selection process. Now here are defined structures for data storing process. There must be stored information about materials, units, and association between them. Additional part of research is in area of education styles, and their application as a virtual teacher, that manage material explanation process. [1]

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