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Conceptual database model of a learning process

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ABSTRACT

The subject of this article refers to the choice of objects participating in the learning process, the objects attribute definition, the objects relationship analysis and the ER-model of a data base containing students results. Protocols based on relational tables as well as those resulting from an interaction between the tables and the learning tree, are described. The subject area semantics is taken into account.
Keywords: relation, relational databases, semantic, semantic networks, classes and objects, relation.

INTRODUCTION

Nowadays very intensive studies related to the presentation of the highly specific knowledge in the field of various disciplines are carried out. This leads to the emergence of some problems, e.g. how to present the testing results in the learning process and how can these results be linked to the corresponding subject area semantics aiming to find the "white spots" in the concepts and the structures constructed by the students. Simple statistics prevails in the majority of the currently available test systems. It provides information on the test results disregarding the relationship between the test units and the semantics of the subject area in case it is set in advance.

This paper suggests solutions for the following issues:

- Selection of the objects involved in the knowledge testing process;
- Selection of the attributes characterizing them and creation of the ER model reflecting the relationship between them;
- Generation of reports and records of the test results in the subject area;
- Proposition of a link between the relational and the semantic models. The relational model [1, 2] is used for data storage, while the semantic model outlines the semantic link and the relation between both models. Thus, the interdependences present can be found at certain point and the knowledge obtained by the student at a particular training stage can be analyzed.

Definition of the interaction mechanism con-

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cerning the relational tables and the relation model in the domain aiming to build the next training stage for the students who have passed the test [3].

The model is characterized by:

• Simple introduction of new relations between the objects and an option for extension of the subject area;

• Possibility for analyzing the relations between the selected topics;

• Easy software implementation using some of the existing development environments (e.g. MS Visual Studio 2012) [7].

ANALYSIS OF THE SUBJECT AREA

We will analyze the subject area in terms of the relational databases to create a formal scheme [1, 2] of the tables which will store the test results referring to the different subjects. We will examine the following objects and the relations between them:

- A student /Student/ passing certain stages of training and testing. The attributes that characterize this subject refer to:

• The number /StdNr/ which is unique to each Student and acts as a primary key. Its purpose is to define unambiguously the object participating in the relation;

• The faculty Number /FacNr/ is the faculty number of the student;

• The name and the Surname are presented by the attributes /Name/ and /Family/. These attributes include symbol strings;

• The group and the Study Year (Course) of the student are stored in the attributes /Group/ and /Course/; these fields contain non-negative integers.

- A learning plan. The objects of the /Learning Plan/ table contain the training plan of one or more students. The object is characterized by the following attributes:

The training Plan Number /PlanNr/, which is unique to each plan and acts as a primary key;

The plan Name /PlanName/, which refers to the name of the binary file containing training effects linked semantically in the form of an instructional tree /graph/. This field characterizing the object contains a symbol string.

The subject number /SubjNr / identifying uniquely the subject studied whose training plan has been generated. It is generally accepted that the study subjects are more than one.

- An expert. The objects of the Expert type / Expert/ contain information about the experts in the relevant study subjects, who have designed the training courses. This object type is characterized by the following attributes:

The expert Number /ExpertNr/ is a unique number of the expert who has built the semantics of the domain, the training course and the test impacts.

The name and the surname of the expert are set by the attributes designated as Name and Family. These fields contain symbol information.

The subject number /SubjectNr/ is the study subject in whose development the expert has been involved. It is worth adding that (i) one and the same expert can participate in the development of several subjects and (ii) one subject can be formally represented by several experts.

- A subject is the learning material to be formally presented in the training and testing system. The Subject is characterized by the following attributes:

• The subject number is a unique key /SubjectNr/ which defines the corresponding record in the relational table;

• The subject name /Name/.

- A topic /TopicRating/ object is a part of the learning material related to a specific study subject. Its attributes refer to:

• The topic number /TopicNr/, which is a unique key;

• The name /Name/, which gives the name of the topic within the study subject and represents an alpha-numeric string within the relational table;

• The rating /Rating/ includes the rating reached after a test related to a part of the learning material is passed.

- Test History as an object features the impact of the tests passed by the student. Here, the test impact means a set of tasks performed by the student in relation to one or several topics and their assessment stored in the TopicRating table. The test impacts are stored in the system as binary files partially matching to the tree, which formalizes the domain and the relations within it. Its attributes refer to:

• The test Number /testNt/ is the number of the test passed and is involved in the formation of the complex key which is used for sorting the records within the table;

• The test name /FName/ is the name of the binary file containing the test impact which is stored in the respective disk area the disk area. The argument contains an alpha-numeric string;

• The subject number /SubjectNr/. This argument acts as a secondary key and contains the subject number with which it is connected;

• The date /Date/. This argument stores the date on which the test has been carried out by the student. The values of the argument are involved in the formation of the composite key for sorting the records;

• The subject /SubjectNr/. It acts as a secondary key and is a part of the composite key for sorting the objects in the relation.

- Learning history /LearnHistory/. The purpose of Learning History object is to store all training plans concerning the study material and to sort them by date. The arguments that characterize this object are as follows:

• The student number /StdNr/. This argument contains the unique key of the students and is involved in the formation of the composite key, which is used for sorting the records;

• The number of the training plan generated by the system or proposed by an expert /PlanNr/. It contains the unique keys of the training plans accomplished by the student and is a part of the composite key sorting the records in the history of the student;

• The date /Date/ refers to the date of training according to the training plan provided by an expert or generated by the system. The Date is involved in the formation of the composite key used for sorting the records;

• The subject number /SubjectNr/ argument refers to the subject, which is connected with the training plan accomplished by the student. This unique number is also involved in the formation of the composite key used for sorting the records.

- Topic Rating /TopicRating/ objects are generated within the testing process and include the student rating. The arguments that characterize the objects are:

• The student number /StdNr/ is a primary key which identifies uniquely the person participating in the learning process. It is necessary for analyzing the gaps in his/her knowledge by using the semantics of the subject area;

• The number of the topic /ThemeNr/ whose knowledge has been tested. This number is unique within the subject training and is set by the expert in the course of designing the instructional tree. This argument is involved, together with the arguments StdNr and SubjectNr, in the formation of the complex composite key identifying uniquely the corresponding record.

The name of the topic /Name/ values are stored in the instructional tree corresponding to the generated test and are dynamically derived during the test.

The subject number /SubjectNr/ value is the unique key for the subject studied and is extracted during the test.

The values of the argument /Rating/ reflect the success of the person tested and are used to analyze the gaps in his/her knowledge. A query can be formulated concerning the objects of this relation. It refers to the students who followed the plans of the particular study subject.

- SubjExpert object is intended to determine the correspondence between the studied disciplines and the experts who have developed the training courses. It is characterized by the following arguments:

- The number of the person who has compiled the training course;
- The unique key /ExpertNr/ or the expert who has generated the training plan;
- The subject number /SubjectNt/.

ANALYSIS OF THE RELATIONS BETWEEN THE OBJECTS IN THE TRAINING FIELD

Only the relations required for the database canonization [1, 2] will be examined. The value ranges of the attributes characterizing them should be defined and the completeness and consistency conditions imposed by the formalized subject area should be clarified. The semantic relations between the topics in the studied subjects are set by the experts as an instructional tree, a training plan or plans for conducting tests.

The objects of the Student /Student/ type are in relation with the objects of the Learning History /LearnHistory/ and the Test History / TestHistory/ type. In the first case the student is connected with the Training History objects by the relation "has a training history". The relation implies that a student may have several training histories, e.g. one history for each study subject. On the other hand, several students may have identical training histories, if they have passed the same study plans (curricula). A set including several plans for a study subject forms the training history of the student in this subject.

For these reasons the cardinality of the objects in this relation is N:M. On the other hand, the existence of a relation requires a link between two objects of both types. The training stories can be N at most as a number of students or a student can have no more than M histories coinciding with the number of all generated and accomplished training plans. Thus the number of the objects participating in the relation is defined as 1:M and 1:N for both cases, respectively.

The relation related to /TestHistory/ is built in a similar way. It includes the objects Student /Student/ and Test History /TestHstory/. The cardinality of this relation is N:T, where N is the number of participants in the learning process, while T is the number of the test plans in the different subjects. The minimum number of the participating objects is 1 again as the maximum number of students participating in the training plans is N. The maximum number of the test plans is determined by the number of the subjects studied and the test plans in each subject. The test history for each student is determined by the number of the training plans that he has accomplished because at least one test plan is generated from each training plan. Thus, the number of participants in the relation "has a test history" is defined as 1:1 and T:N. This is seen at the end of arcs in Fig. 1 connecting the relation with the objects on which they are based.

The relation between the training history and the training plan has the cardinality M:L. This means that one training plan may be included in M available training histories. It cannot participate if it is just generated or not yet accomplished. On the other hand, a training history exists only if it includes at least one generated training plan for at least one study subject. This is reflected by the record L (0, M) and M (1, L) in Fig.1.

The /SubjExpert/ object reflects the affiliation of the experts with the subjects studied and which is why it enters the relation /Expert on Subject/. It enters also the relation /Subject belongs to Expert/ together with the subjects connected to a particular expert. Thus, the number of experts E, the number of the records placing the accordance between experts and subjects K, and the number of the subjects studied S determine the cardinality of the object participation in the two relations. The minimum number of experts participating in two relations is 1 because at least one expert is required for their existence. The number of

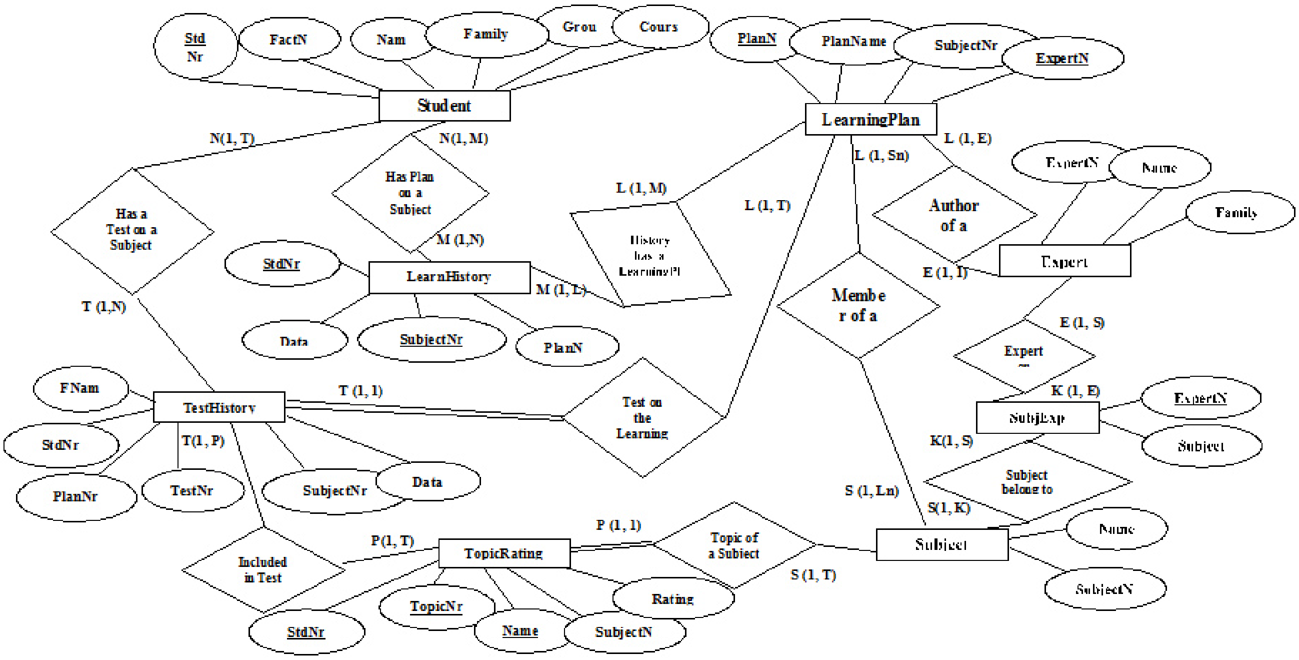

Fig. 1. A conceptual ER-model of the „Training“ domain.

experts is not limited, but at least one expert must exist for each subject.

On the other hand, a record should exist for every expert to ensure the integrity of the relation Expert on Subject referring to the experts. Therefore, K varies from 1 at least to the number of the existing experts. Taking into account that a teacher can be an expert in more than one subject, the number of records in this relation will be greater than the value S. The relation Subject belongs to Expert is considered and analyzed in a similar way. In this case the number of collating records can be greater than the number of the taught subjects provided that one subject is taught by more than one teacher. In this case an indexing is done on both keys to improve the search in the relation.

The relation /Member of a Plan/ reflects the involvement of the subjects studied in the training plans.

The number of training plans L and the number of the subjects S determine the cardinality of the object participation in the relation. The relation exists if at least an object each type exists. This determines the minimum number of objects. The maximum number of objects in the relation is determined by the number of subjects and by the number of generated training plans. It should be taken into account that for one subject several training plans can exist depending on the number of the experts in the domain and the starting level of the training.

The relation /TopicRating/ combines the objects of the Subject type with a topic of the subject referring to a test to be carried out.

Let S subjects and P topics participate in the relation /Topic of Subject/. The participation of the topics in the subject is complete, which means that if there is a topic, it is connected to a given subject. This is visualized by the double link between the object and the relation. The minimum and maximum number of subtopics in one subject is 1, which in turn means that a subtopic may participate in one subject only. On the other hand, not less than one subtopic can participate in one subject and the maximum number of the participating subtopics is limited to the number of available topics. These considerations determine the record, the cardinality and the participation of the objects in the relation.

The objects Training Plan and Test History are connected with the relation /Test on Learning Plan/. Each of the developed training plans can serve as a basis for generating a test in the subject because the tests and training plans have an identical tree structure.

Let us assume that the number of the plans and the tests that make up the training history are L and T, respectively. The minimum number of the plans used for generating a test is 1 because if there is no training plan, a test could not be generated. The minimum number of tests required for the existence of a relation is also 1. On the other hand, any plan can be used for generating tests, whose number is limited only by the participating topics and the possible semantic connections between them. In all cases, the maximum number of the tests generated from one plan will be not greater than T. On the other hand, each test is created only with the use a single training plan, although their number for a given subject may be greater than one. These considerations determine the cardinality, the maximum and the minimum number of the objects participating in relation L (1, T) and T (1, 1). The participation of objects like Test type one in the relation is complete.

The objects of the types Training Plan and Experts in the Domain participate in the relation Author of Training Plan. The cardinality as well as the minimum and maximum number of the participating objects are L (1, E) and E (1,1). This means that E experts may participate in the preparation of the plans, if L is the number of the participating objects for plans, while E is the number of the experts. However, one plan can be drawn by one expert only in the domain. The relation included in the test refers to topics covered by a specific test plan. If it involves P topics and T test plans, the cardinality as well as the maximum and minimum number of objects participating in it refer to T(1, P) and P(1, T). The latter values are determined analyzing these objects.

PROTOCOLS AND ANALYSIS OF THE TEST RESULTS

The common operations in relational algebra are applicable to the ER model shown in Fig. 1. The following protocols are designed in accordance with them:

A protocol showing the correspondence between the experts and the taught subjects. It is built using the relational operation which joins objects from the tables Expert, SubjExp and Subject. Then the result is projected using the attributes Name and Family from the first table and Name from the third table.

$$\text{Res} \leftarrow \pi_{\text{Expert.Name, Expert.Family, Subject.Name}} \quad (1)$$

$$\mathbf{(SubjExp} \underset{\text{ExpertNr}}{\bowtie} \mathbf{Expert, SubjExp} \underset{\text{SubjectNr}}{\bowtie} \mathbf{Subject)}$$

The normal joining of the tables SubjExp and Expert is performed using the attribute ExpertNr, which is a primary key in the second table. The Subject table is joined to the attribute SubjectNr, which is a key attribute of it.

Several reports are created using this mechanism. For example, the names of the teachers presenting a given subject can be extracted by pointing out the name /a primary key/ of this particular subject. In such a case the result obtained on the ground of formula (1) application should be restricted. The records fulfilling the introduced condition requiring the coincidence of the value in the SubjectNr field with the predetermined value Nr, a key for the subject, will be sorted out.

$$\text{Res} \leftarrow \sigma_{\text{SubjectNr = NR}} (\pi_{\text{Expert.Name, Expert.Family, Subject.Name}} \quad (2)$$

$$\mathbf{(SubjExp} \underset{\text{ExpertNr}}{\bowtie} \mathbf{Expert, SubjExp} \underset{\text{SubjectNr}}{\bowtie} \mathbf{Subject))}$$

The query referring to the subjects taught by an expert in the domain is carried out in a similar way.

$$Res \leftarrow \sigma_{ExpertNr = NR} (\pi_{Expert.Name,\ Expert.Family,\ Subject.Name} (\mathbf{SubjExp} \underset{ExpertNr}{\bowtie} \mathbf{Expert},\ \mathbf{SubjExp} \underset{SubjectNr}{\bowtie} \mathbf{Subject})) \tag{3}$$

In such a case the result obtained on the ground of formula (1) should be restricted and the records fulfilling the condition that the value in the ExpertNr field has to be equal to the predetermined value Nr, the primary key for the table Expert, will be sorted out.

The experts in the subject area are those that usually create training plans in the form of a dynamic tree structure stored as a binary file.

The objects of the LearnPlan type reflect this as every expert must create at least one training plan for a subject within the scope of his/her competence. The reports are built using a common joining of the relations LearnPlan, Expert, Subject.

$$ResPl \leftarrow (\mathbf{LearnPlan} \underset{ExpertNr}{\bowtie} \mathbf{Expert},\ \mathbf{LearnPlan} \underset{SubjectNr}{\bowtie} \mathbf{Subject}) \tag{4}$$

The application of the restriction operation to the relation obtained by a common joining of the three objects results in answers to the question what subjects and whose training plans have been compiled by a given expert. The full participation of the experts, the subjects and the plans in the training process can be simply obtained through a projection on the relevant attributes of the new relation (5).

$$ResPl \leftarrow \pi_{Expert.Name,\ Expert.Family,\ Subject.Name,\ Plan.Name} (\mathbf{LearnPlan} \underset{ExpertNr}{\bowtie} \mathbf{Expert},\ \mathbf{LearnPlan} \underset{SubjectNr}{\bowtie} \mathbf{Subject}) \tag{5}$$

The information on the plans and subjects created by a particular expert is extracted as the restriction concerning formula (6) is applied to the relation obtained.

$$ResSub \leftarrow \sigma_{ExpertNr = NR} (\mathbf{ResPl}) \tag{6}$$

The application of the restriction in respect to the subjects provides information on the existence of training plans and the subjects to which they refer.

$$ResSub \leftarrow \sigma_{SubjNr = NR} (\mathbf{ResPl}) \tag{7}$$

Several training plans may exist for a given subject. Each one of them applies to an individual topic or multiple topics which are semantically connected. The semantic link is created by the experts in the field.

The training history can be traced using the records stored in the LearnHistory relational table. The necessary information is derived from the relation obtained as a common joining of Student, LearnHistory and LearnPlan. The joining between the first two relations is made using the attribute StdNr, while the second and third relations are joined by PlanNr. An information concerning the students, the training plans and the subjects they study can be obtained by sorting over the first key and projecting which involves the attributes FactNr, Name, Family, PlanName, SubjectNr, Data. These actions are represented by the following relational formula:

$$ResHis \leftarrow \pi_{FacNr,\ Name,\ Family,\ PlanName,\ Sbject,\ Data} (\mathbf{LearnHistory} \underset{StudentNr}{\bowtie} \mathbf{Student},\ \mathbf{LearnHistory} \underset{PlanNr}{\bowtie} \mathbf{PlanNr}) \tag{8}$$

When a restriction is applied to the result obtained, the data can be specified, e.g. the data for a specific student and the training plans he/she has accomplished, i.e. the history of his/her training can be extracted:

$$ResHis \leftarrow \sigma_{StdNr = Nr} (ResHis) \tag{9}$$

In case of restriction on the attributes Student

Number and Subject Number we get the training history for a specific student in a specific subject. This is achieved by using the following relational operations:

$$ResHis \leftarrow \sigma_{StdNr = Nr1\ AND\ SubjectNr = Nr2} (ResHis) \tag{10}$$

No.1 and No.2 are values of the two secondary keys used for the filtering.

Data concerning all students who follow a specific training plan is obtained in case the following relational operation is performed:

$$ResHis \leftarrow \sigma_{PlsnNr = Nr} (ResHis) \tag{11}$$

For the sake of clarity, the relations between the objects Training History and Subject are not shown in Fig. 1, but they are taken account of through the presence of the attribute features characterizing them.

The relations and reports related to the objects from the Test History table are built in a similar way. In such a case a common joining of the objects from the relations Student, TestHistory and LearnPlan is performed. For the first two tables StdNr is used as an attribute of the operation, while PlanNr is used as an attribute for the second and the third table. Furthermore, a training history is obtained for every student in every subject as the test date is extracted in case projection containing the attributes FactNr, Name, Family, TestName, SubjectNr, PlanName, Data is performed. Sorting should be made using the complex key containing the attributes StdNr, SubjectNr and PlanNr. The following relational formula is valid:

$$ResTest \leftarrow \pi_{FacNr,\ Name,\ Family,\ PlanName,\ Subject, TestName,\ Data,} (\mathbf{TestHistory} \bowtie_{PlanNr} \mathbf{Student},\ \mathbf{TestHistory} \bowtie_{StudentNr} \mathbf{PlanNr}) \tag{12}$$

Thus, information on the tests generated from a specific training plan linked to a specific subject and a specific student can be traced. A report concerning the relation obtained through a projection is produced with the application of the following restriction conditions:

$$Res \leftarrow \sigma_{StdNr = Nr1\ AND\ SubjectNr = Nr2\ AND\ PlanNr = Nr3} (ResTest) \tag{13}$$

The values of the keys used for performing the operation are entered externally.

The report related only to the student and the tests in a specific subject is generated using the following relational operations:

$$Res \leftarrow \sigma_{StdNr = Nr1\ AND\ SubjectNr = Nr2} (ResTest) \tag{14}$$

This is actually the test history of the subject. The history of the tests in all subjects for one person is given by the operation:

$$Res \leftarrow \sigma_{StdNr = Nr} (ResTest) \tag{15}$$

The sorting in this case must be made using the complex key involving the attributes StdNr, SubjectNr, PlanNr and Data to trace the chronological order.

During the test a relation outlines the success of the students following individual topics of the training plan is created. This results in the TopicRating relation. It takes into account the belonging of each topic to the subject studied and enables the definition of the overall success rate of every student in this subject. The table is the basis of the the adaptive generation of the training plans and the tests related to them. Let’s examine the common joining of the two tables TopicRating and Subject. It is performed using the SubjectNr attribute. The result is the Res relation over which the necessary projection, restriction, sorting and summation of the values are done in order to obtain the success rate of a student in any subject. These actions are performed with the application of the relational formula Projection operation:

$$\text{ResTopic} \leftarrow \pi_{\text{Subject.Name,, TopicRating.Name, TopicRating.Rating}} (\textbf{TopicRating} \bowtie_{\text{StudentNr}} \textbf{Student, TopicRating} \bowtie_{\text{SubjectNr}} \textbf{Subject}) \quad (16)$$

The restriction over the projection is required to calculate the success rate of a student in a particular subject:

$$\text{Res} \leftarrow \sigma_{\text{StdNr = Nr1 AND SubjectNr = Nr2}} (\text{ResHis}) \quad (17)$$

The aggregation of the values from the Raiting field in the result obtained forms his/her success rate.

$$\text{Total} = \sum_{\text{Rating}} \text{Res} \quad (18)$$

ADAPTIVE GENERATION OF TRAINING PLANS AND TESTS

The adaptability of the system is provided by the information stored in the **TopicRating** table. It is used to generate the training plans of the subject and the topics where the student has a low success rate. This is done by taking into account the semantics of the subject area. The adaptability is one of the features of the modern intelligent systems for training [4 - 6]. The process flows as follows. Let us assume that the test results in subject S_i show refer to insufficient knowledge. This means that the number of the points collected for some of the topics is not enough. The success rate for a given topic is formed as a sum of the points which refer to the tasks assigned to the student. Let D_{ij} is the j-th topic belonging to subject S_i and multiple tasks T are assigned to this subject:

$$t_{jn} \in \mathbf{T}_{ij} \quad (19)$$

where t_{jn} is the n^{th} assignment related to the topic D_{ij}. Then the current success rate RT_{ij} is formed as a sum of points obtained for completion of individual tasks Rt_{jn}.

$$RT_{ij} = \sum_{j=1}^{j=n} \mathbf{R}t_{ij} \quad (20)$$

If the accumulated success rate RT_{ij} is lower than the one specified as an attribute of D_{ij}, a new training plan and a test corresponding to it have to be generated. This requires identifying the knowledge gaps of the student in order to adapt the plan to his/her current knowledge. For this purpose, the success rate of the student shown on the topics found in **AND** and **OR** sets on the node of the instructional tree relevant to the topic is traced back. The poor success rate in one of the topics found in the **AND** set is a reliable criterion that it should be reconsidered. The poor success rate in all topics in the **OR** sets means that they should also be included in the new training plan. The topics from the **AND** set are placed in the tree nodes prior to these from the **OR** set during the dynamic generation of a training plan. This takes place only after the current topic of insufficient success rate is included. The inclusion of the nodes is done along with their predecessors from the tree. Thus the subject domain is formalized.

The generation and accomplishment of the new plan for filling knowledge gaps is followed by the formulation of the respective test impacts. This is done in view of the requirement which states that the number of the points collected through accomplishment of the tasks should be greater than the value specified for the respective subject. The selection is made at random.

This can be achieved relatively easy since the plan and the test impacts have an identical data representation as a dynamic tree structure.

CONCLUSIONS

A high degree of adaptability is embedded in the system taking into account the semantics of the subject domain. Thereby an interaction of two different concepts of representation and processing of information is implemented. These are the relational concept for storing data referring to the work of the students and the experts in the subject area and the tree structure reflecting its semantics.

One of the many possible solutions in respect to adaptive management of the training process is presented providing a possibility for external intervention of the expert and creation of training and test plans at his/her own discretion.

REFERENCES

1. A. Heuner, G. Saake, Datenbanken - Konzepte und Sprachen, An international Thomson Publishing Company, 1997, ISBN 3-8266-04-4.
2. R. Elmarsri, S. Navathe, Grundlagen von Datenbank-System, Addison - Wesley, 2002, ISBN – 3-8273-7021-3.
3. P. Karampiperis, D. Sampson, Adaptive Learning Resources Sequencing in Educational Hypermedia Systems, Educational Technology & Society, 8, (4), 2005, 128-147.
4. S. Russel, P. Norving, Artificial Intelligence a modern approach. 3rd ed., Prentince Hall, ISBN-13: 978-0-13-207148-2, New Jersey, 2010, pp. 1132.
5. N. Nilson, The Quest for Artificial Intelligence, Standford University, USA, 2010, pp. 707, ISBN:9780521122931.
6. N. Nilson, Introduction to Machine Learning, Standford University, USA, 2005, pp. 179.
7. A. Kühnel, Vusual Studio C# 2012 das umfassende Handbuch, Callileo Press, ISBN 978-8362-1997-6, 2013, pp. 1402.