Evaluation of the Project Management Competences Based on the Semantic Networks

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The paper presents the testing and evaluation facilities of the SinPers system. The SinPers is a web based learning environment in project management, capable of building and conducting a complete and personalized training cycle, from the definition of the learning objectives to the assessment of the learning results for each learner.
The testing and evaluation facilities of SinPers system are based on the ontological approach. The educational ontology is mapped on a semantic network. Further, the semantic network is projected into a concept space graph. The semantic computability of the concept space graph is used to design the tests.
The paper focuses on the applicability of the system in the certification, for the knowledge assessment, related to each element of competence. The semantic computability is used for differentiating between different certification levels.
Keywords: *testing, assessment, ontology, semantic networks, certification.*

1 SinPers – an Innovative Learning System in Project Management

The SinPers system is an e-learning platform in project management, centered on the learner and based on advanced technologies. The SinPers system is proposing to solve some present limitations of the e-learning systems, especially those referring to the flexibility/adaptability of the learning process assisted by the computer and to the promotion of the traditional didactical method. Within the SinPers framework, the personalization issue was solved by adopting innovative solutions in three main domains:

a. the modeling of teaching-learning process: specification of users' roles, learning or / and support activities, learning environment composed by learning object and services, training method, properties and conditions for activities start / end;

b. digital content modeling: specification of the concepts and domain structure, defining learning objects according to these concepts and with the semantic relations between concepts, specification of the objects metadata;

c. learner modeling: separation of the static properties from the dynamic ones acquired during the unit of learning unrolling

The assessment and evaluation of the individual knowledge is a major aspect of the learning personalization and, as will be seen, affects all three models.

The digital content of SinPers "Project Management" course is structured as a collection of distinct learning objects (LO). Their reuse in different contexts and (re)sequencing in different learning paths requires the adoption and definition of three essential elements:

- domain ontology (the structure of concepts and the relationships between them),
- metadata describing the properties of the learning objects.

Knowledge is represented on different levels of generalization. On the lower level are the LOs, defined as entities, which may be used, reused or referred in the learning process specified previously. These are logical containers, which represent resources deliverable through the web, like lessons (HTML pages), a simulation (Java applet), a test (HTML pages with evaluation forms) or any other object provided through web having learning as goal.

The learning objects can have two destinations (*figure 1*):

- expositive objects (lesson with different structures and interactivity levels);
- assessment objects (tests, questions).

Metadata is a collection of attributes of the objects from the previous level, which are describing the object type (text, slide, simula-

tion, questionnaire etc.), the required educational level (high school, university etc.), language, interactivity level etc. The third level of generalization (*ontology*) is used for the specification of the *domain concepts* and the relations between these. A domain concept can be represented by one or more LOs having different attributes.
The main relationships between concepts are: *Has_part* and *Requires* dictating the hierarchical relationships between concepts as well as the constrains defining the mandatory learning order of the concepts; the relation *Suggested_Order* can be added optionally. The link between the concepts and the learning objects, depending on its type (expositive object or assessment), is stated by the relation *Explained_by* or *Assessed_by.*

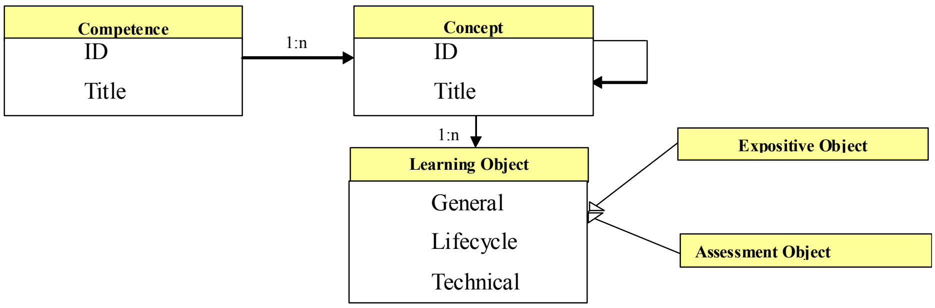

Fig.1. Educational content - Conceptual schema

The course ontology has been extended with the competences ontology, taking into consideration that a competence involves learning / proving knowledge referring 'n' basic concepts (*figure 2*)

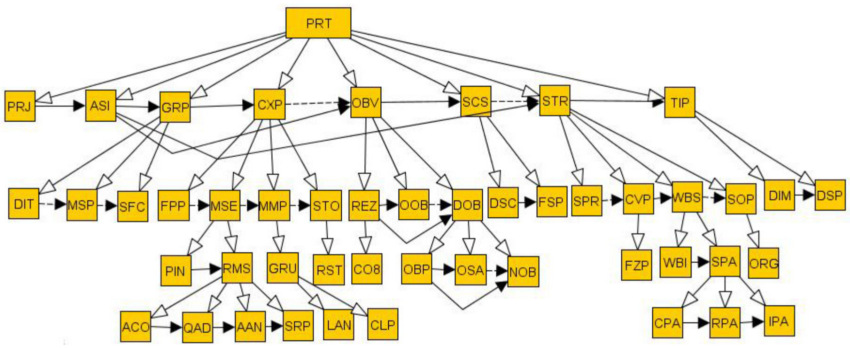

Fig.2. Fragment of domain ontology (Module 1 - Project)

In order to develop the ontology for "project management" an internationally recognized standard was needed, to provide foundation for the definition of the domain concept and project manager competences; the standard was ICB - International Competence Baseline of IPMA.
The ontology of the project management course developed by SinPers project contains 200 concepts, 46 competences**,** 366 learning objects**,** 61 tests and all types of relationships mentioned above [2].
The learner model consists of:

- the learner profile - containing the personal properties set (according to the IMS recommendations): *identification, goal, qualification-certification-license, competency, accessibility, affiliation, security key*
- the learner portfolio - containing the information set regarding the learner activities and results during the unit of learning, respectively recording and managing the learner's history of the training process, the scopes and achievements / obtained knowledge.

The *accessibility* holds the most important information needed to perform the personalization of the unit of learning, respectively learner preferences regarding: teaching *language*, educational objects *format*, the *technological support* used (operating system, browser), *difficulty level*, as well as the *learn-*

ing style (active/reflexive, sensorial/intuitive, visual/verbal, inductive/deductive) declared or established through testing.
The learner model is set up progressively, starting with the data entered at user's enrolment and continuing with the specification of the objectives and preferences, the assessment of the initial cognitive status, learning styles and results tracing.
Within a teaching-learning defined process, a personalized unit of learning (course, lesson, module) is composed by a learning path (the activity flow and learning objects tree) offered to the learner. These objects are selected from a digital content warehouse by comparing LO metadata with the characteristics and preferences of the learner and set up in a sequence according to the relations between concepts and the activity flow previously defined.

2. The Assessment Design in SinPers System. Test Composition using semantic networks

Test is a distinctive class of learning objects designed to the learning evaluation in different stages of the teaching-learning process, in order to prove the achievement of the learning objective or to obtain a knowledge set specific for a given concept. For each concept from the ontology can be defined one ore more tests, having different characteristics (metadata).
According to the IMS recommendation [3], as each learning object, the assessment tests are composed from a content file and the attached metadata, regarding the following aspects:

- *General* - groups information describing learning object as a whole (e.g. *title, catalog entry, language, description, keyword, structure*),
- *Lifecycle* - history and current state of resource (e.g. *version, status, contributions*),
- *Technical* - technical features of the learning object (e.g. *format, size, location, technical requirements, installation remarks*),
- *Educational* - educational or pedagogic features of the learning object (e.g. *type of resource, language, description, interactivity type, interactivity level, semantic density, end-user role intended, age range of users, difficulty, context, learning time*),
- *Rights* - conditions of use of the resource (e.g. *cost, copyright and others restrictions, description*),
- *Relations* - features of the resource in relationship to other learning objects,
- *Annotations* - comments on the educational use of the learning object,
- *Classification* - description of a characteristic of the resource by entries in classifications.

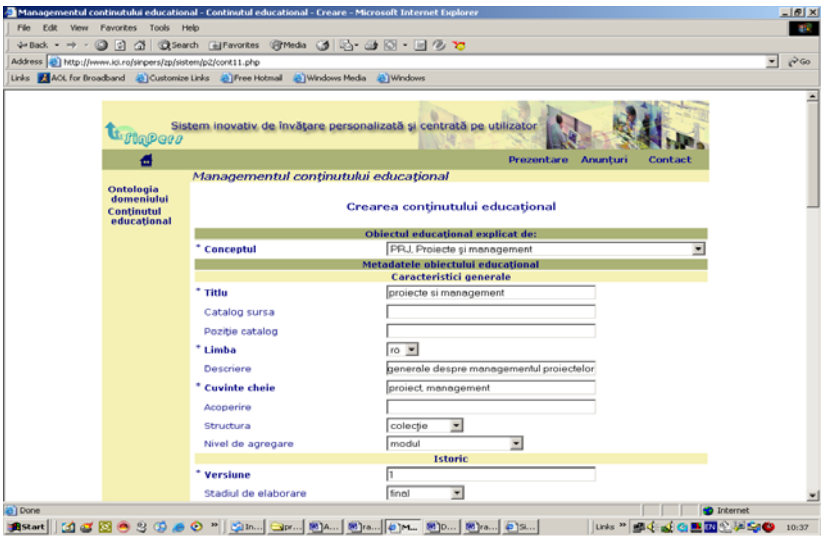

Fig.3. Example of assessment object: metadata

An assessment test contains all of the necessary instructions to enable the sequencing of the items and the calculation of the outcome values (e.g. the final test score). So the assessment objects' metadata contain also:

- *Grading*
  - o Qualification level
  - o The necessary credit for the qualification
- The *weight* of the elementary test grade from a composed test

In Sinpers system, the tests are created and edited in the same time with the expositive learning objects and are stored in content files; the metadata are described as represented in the figure 3 and are connected to the content by the selection of the file from its location.

Figure 4 presents the semantic network for CXP concept (derived from the ontology shown in figure 2) and the corresponding concept space graph (the projection of the semantic net).

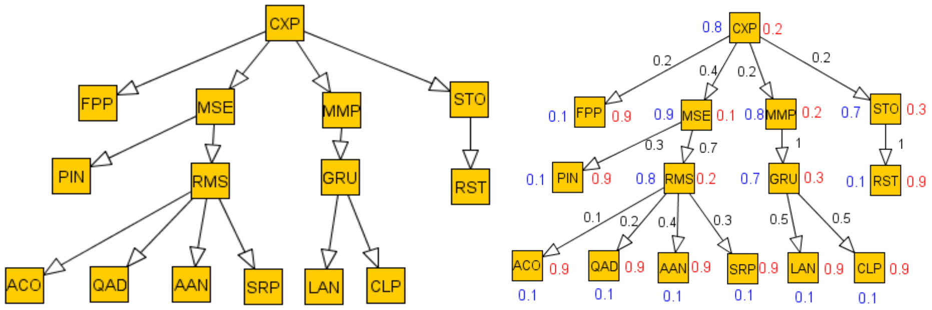

Fig.4. The semantic network and the concept space graph for CXP

In a semantic network [4], nodes c_i are concepts and links l(i,j) represent the semantics that c_j is a prerequisite for learning c_i. For example, FPP, and MSE, and MMP, and STO are all prerequisites for learning CXP.

A red number (showed in the right side of the node) is the node's self-weight and a blue number is the prerequisite of the node. A black number is a link weight. The self-weight $W_s(i)$ represents the relative semantic importance of the root topic c_i with respect to all other prerequisites. The prerequisite weight $W_p(i)$ represents relative semantic importance among the prerequisite topics. A link weight, for example the weight of l(CXP, MSE) represents the relative importance of learning MSE for learning CXP.

For any node in the concept space graph, the sum of self-weight and prerequisite weights and the sum of the prerequisite link weights to its child node set are both always 1.

$$W_s + W_p = 1$$

$$\sum_{j=1}^{n} l(c_0, c_j) = 1$$

Given a root concept x_0 and a projection threshold coefficient λ, a projection graph is defined as a sub-graph with root x_0 and all nodes x_t, where there is at least one path from x_0 to x_t such that node path weight $\eta(x_0, x_t)$ satisfies the condition: $\eta(x_0, x_t) >= \lambda$, where node path weight between x_0 and x_t for the path $[x_0, x_1, \ldots, x_t]$ is:

$$\eta(x_0, x_t) = W_s(x_t)\prod_{m=n}^{1} l(x_{m-1}, x_m) * W_p(x_{m-1})$$

3. Learning Assessment Strategies

In SinPers the learning assessment has two main objectives and also two test composing methods:

- prerequisites assessment necessary to learn a given unit of learning (module, sub domain, competence) - pre-assessment tests;
- assessment of the acquired knowledge after the completion of a unit of learning - intermediary tests and final test.

In SinPers the learning flexibility consists in the fact that the learner must not learn the whole course (the whole concepts' hierarchy and the associated learning objects) if he is interested only in a module, a competence or a specific aspect. In these situations, the learner must complete successfully a pre-assessment test in order to establish if he has the necessary knowledge in order to under-

stand the desired module / competence / aspect or if some prerequisites are necessary.
The testing strategy in this case is established based on the ontology of the domain and on the hierarchical (*Has_part*) and precedence (*Requires)* relations between concepts.
Thus the learning of a given concept *Cn Requires* the knowledge of another concept *Cm* the pre-assessment test will be composed by all the tests associated to *Cm* concept (the tests of the concepts which compose the *Cm* concept).
Example: The project management course has three main modules: *M1* "Project (general notions)", *M2* "Project Management", *M3* "Project Oriented Organizations", which according to the relations defined in the ontology *M2* and *M3 Requires M1*. Thus if a learner want to learn *M3* he must pass the pre-assessment test composed by the tests for *M1*. If he complete successfully this test his learning path will be composed only by the concepts of *M3*; if not, his learning path will be composed from the concepts of *M1* and *M3* (*figure 5*).

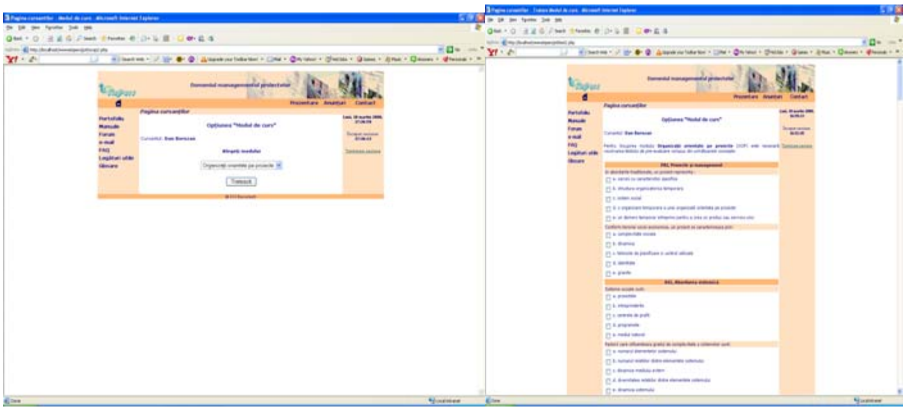

Fig.5. Example of pre-assessment test

The intermediary and final tests are achieved by composing the test for the completed unit of learning (module, sub domain, competence) using the domain ontology and the *Has_part* relations, by joining all the tests of the concepts that covers the given unit of learning.

4. Applicability of the SinPers System to the Certification

The following table presents all concepts of the course ontology, in connection with the ICB competence elements [2]:

ICB competence elements	SinPers concepts	ICB competence elements	SinPers concepts
Project management success	INT, PRJ, SCS, DSC, FSP, SUC	Assertiveness	CO4
Interested parties	MSP, MSE, PIN, RMS, ACO, QAD, AAN, SRP	Relaxation	CO5
Project requirements and objectives	ENT, ASI, STO, RST, OBV, OOB, DOB, OBP, OSA, NOB	Openness	CO6
Risk & opportunities	MRO, IER, ACA, MOC, PMM	Creativity	CO7
Quality	MCP, PCP, PPR, PCR, PCM, ASC, ADP, CON, COA	Results orientation	CO8
Project organizations	SOP, ORG, OPR, RPR, PRP, MGP, CMP, STP, ASO, CER, FDP, CAM, MEP, COL, EPR	Efficiency	CO9
Teamwork	FEP, CEP	Consultation	C10
Problem resolution	MPR, CRD, PSO	Negotiation	C11
Project structures	GRP, CXP, STR, SPR	Conflict & crisis	C12
Scope & delive-	SFC, REZ, WBS, WBI, SPA, CPA, RPA, IPA	Reliability	C13

rables			
Time & project phases	DIT, FPP, CVP, FZP, MTP, PLC, PJA, JAL, DGT, ADC, DRA, DEP, RDD, DRC, ALG	Value appreciation	C14
Resources	RES, NOR, ESR, ALR, MLR, OAR	Ethics	C15
Cost & finance	MCF, COS, TCO, CEN, PCO, ECO, BPR, MFP, SFP, PFN	Project orientation	OPP
Procurements & contract	ACC, NAP, SFR, NCO, DCA	Programme orientation	MPG, PGR, OPG
Changes	MSH, MSC, MSR, MSF	Portfolio orientation	MMP, GRU, LAN, CLP, MPP, POP, SPP, OPO, GPP, TPP
Control & reports	CCT, RPT, ACP, CRE, RCR, DUR, CCO, RPC, AEV, CFN, RAF, TMC, CTR	Project, programme & portfolio implementation (PPP implementation)	TIP, DIM, DSP
Information & documentation	IDP, SMD, SMP, SIP, BDP	Permenent organisation	ICO, DMP, MOP, COO, MMO, EMP
Communication	COP, STC, TIC, SWP	Business	IPR, INV, IDE, CRV, SFZ, ACB, AEC, ASZ, ARC, SWO
Start-up	DDI, DIP, PRO, CPR, DDP, EEP, ATP	Systems, products & technology	PTH
Close-out	TPR, DOF, APR, LIN	Personnel management	MGF, MGE, MGR
Leadership	CO1	Health, security, safety & environment	SSS
Engagement	CO2	Finance	AFC
Self-control	CO3	Legal	AJD

We consider as an example the concept related to the competence element **C1.02: Interested parties**. The semantic network and the corresponding concept space graph for this competence element are shown in figure 6.

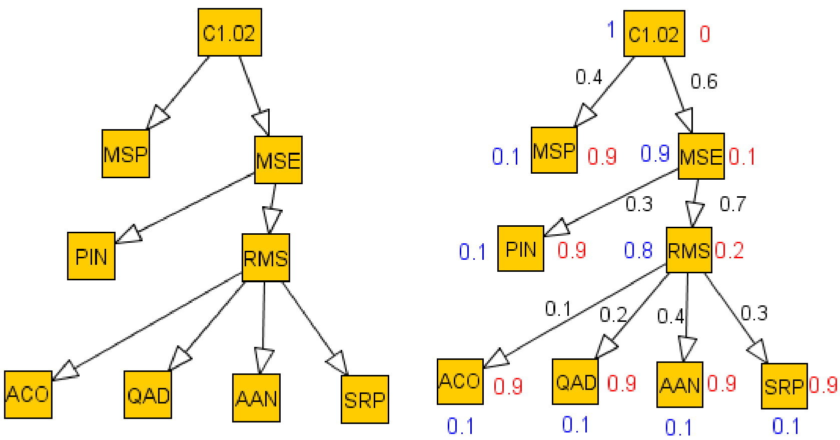

Fig.6. The semantic network and the concept space graph for **C1.02: Interested parties**

R (Root)	N (Node)	η(R,N)	η(R,N) >= (λ=0.001)	η(R,N) >= (λ=0.03)	η(R,N) >= (λ=0.08)	η(R,N) >= (λ=0.01)
C1.02	MSP	0.36000	√	√	√	√
	MSE	0.06000	√	√	√	X
	PIN	0.14580	√	√	√	√
	RMS	0.07560	√	√	X	X
	ACO	0.02722	√	X	X	X
	QAD	0.05443	√	√	X	X
	AAN	0.10886	√	√	√	√
	SRP	0.08165	√	√	√	X

When we want to design the certification test for this competence element we should differentiate between different certification levels. In order to that we use the λ parameter, to assure different coverage for the assessment. A small value for λ parameter has as result large assessment coverage and high difficulty. A big value for λ parameter has as result small assessment coverage and less difficulty, as shown in the following table

The figure 7 presents the projects graphs corresponding to **C1.02: Interested parties,** for different value of the λ parameter. The gray nodes are not included in the projection graph for **C1.02: Interested parties.** The projection graphs are the certification tests, for different certification levels.

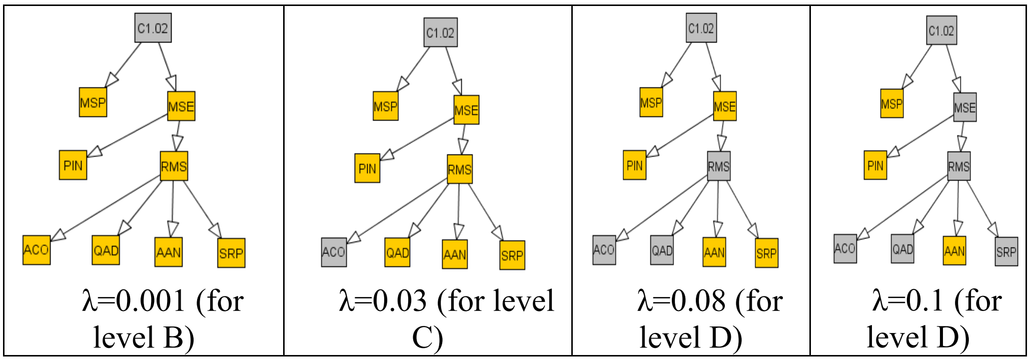

Fig.7. Certification tests for **C1.02: Interested parties,** for different certification levels

Conclusions

It is possible to use an ontology based learning system for knowledge assessment at different acquired level. In order of doing that, the educational ontology should be mapped into a semantic network. Further, the semantic network should be projected into a concept space graph, with different values for projection parameters. The paper presents how to use the coverage parameter. These results are relevant in designing certification exam, at different certification levels. The semantic computability should be used for differentiating between different certification levels.

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References

• Trandafir, I., Borozan, A-M. (2007) *eLearning Design based on Personalization Requirements* in Proceedings of International Technology, Education and Development Conference (INTED 2007), held in Valencia, Proceedings CD

• Bodea, C., (2007), *SinPers-An Innovative Learning System in Project Management*, in Proceedings of 21st IPMA World Congress, held in Cracow, ISBN 978-83-89541-93-2

• *IMS Global Learning Consortium (1999-2007).* Available from: http://www.imsglobal.org/ [Accessed 2005-2007]

• Khan J., Hardas M., Ma Y. (2005) *Analyzing Question Difficulty using Course Ontology BAsed Semantic Knowledge Maps for Test-ware Standardization*, Available from: www.cs.kent.edu/~mhardas/papers/ [Accessed 2006-2008]