Knowledge Management for Virtual Education Through Ontologies

Ana Muñoz[1,2(✉)], Victor Lopez[3], Katty Lagos[2], Mitchell Vásquez[2], Jorge Hidalgo[2], and Nestor Vera[2]

[1] CEMISID Los Andes University, Mérida, Venezuela
amunoz@uagraria.edu.ec
[2] Computer Science Department, Agrarian of Ecuador University, Guayaquil, Ecuador
{amunoz,klagos,mvasquez,jhidalgo,nvera}@uagraria.edu.ec
[3] GIISIC, Technological of Panamá University, Panama, Panama
victor.lopez@utp.ac.pa

Abstract. Current knowledge management focuses on knowledge acquisition, storage, retrieval and maintenance. E-Learning systems technology today is used primarily for training courses about carefully selected topics to be delivered to students registered for those courses. Knowledge management is used to rapidly capture, organize and deliver large amounts of corporate knowledge. The practice of adding value to information by capturing tacit knowledge and converting it into explicit knowledge is known as Knowledge Management. Ontologies can represent an existing knowledge from a domain, in this work; ontologies allow to model different aspects of knowledge management for virtual education in higher education. Universities, from the perspective of knowledge management, provide an updated concept of higher education where knowledge is considered a product, and the customers are students. This paper explains an ontological framework, used to model and integrate knowledge management processes and technological architecture for knowledge management in virtual education.

Keywords: Knowledge Management · Virtual Education · Ontology · Higher Education

1 Introduction

Knowledge management is the practice of adding value to information by converting tacit knowledge into explicit knowledge, through storage, retrieval, filtering and spreading of knowledge, and the creation and testing of new knowledge [2].

Currently, knowledge management is perhaps the most commonly used term in the literature of management and although it is widely used in the management area, in higher education it is rarely mentioned. However, it is in higher education where future knowledge workers are being prepared and also knowledge workers are already present as professors. Knowledge is an important resource in the knowledge society and knowledge workers play an important role in it; therefore knowledge management

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and best practice solutions in the business world can be extended and used for its application in modern higher education.

Ontology represents existing knowledge in a domain. In this case ontology represents a different model for higher education knowledge management. An ontology is ''A formal explicit specification of a shared conceptualization'' [10]. Ontologies are generally defined as a representation of a shared conceptualization of a particular domain. It is anticipated that Ontologies and Semantic Web technologies will influence the next generation of e-learning systems and applications. The role of ontology consists on facilitating the construction of a model domain. It provides a vocabulary of terms and relationships in a specific domain.

In this research we present a knowledge management for virtual education through ontology, focusing on academic processes carried out in universities. It is aimed to create a knowledge representation through ontology and engineering methodology to support both dimensions of knowledge. Ontology is used as the primary mechanism for representing information and knowledge. It defines the meaning of the terms, as well as the languages and relationships used in the knowledge management system.

2 Background

György Kende [12] show knowledge as a key asset for higher education and define knowledge management according to Davenport & Prusak [7]. They apply a business model as a plus point of the organization to achieve competitive advantage, as well as supporting tools to promote knowledge management and evaluation, utilization, creation, expansion, protection, division and intellectual equity of the organization. The model of Intellectual Capital and its structure as the INTELECT model [4]. This definition is related to the business world, but it is updated in association with higher education concepts, where knowledge is considered the product and students are the customers.

Knowledge creation refers to the activity that modifies organizational knowledge resources through socialization, internalization, externalization and combination of knowledge. The spiral of knowledge [18] shows how to extend individual knowledge, working groups into and across the organization. The authors explain the transformation of knowledge between individuals and between organizations and individual.

Paniagua et al. [20], describes how universities can develop these requirements under the vision of universities as knowledge bases. These new dimensions see universities as innovation centers to produce and distribute knowledge as a product. Every process of knowledge management for virtual education will be developed using this vision.

3 State of the Art

Marla Corniel et al. [5] stand for an ontological model that provides support for decision making in the selection of educational opportunities for the Venezuelan higher education subsystem (SES). The model makes the standardization of the vocabulary

used in the domain. The prototype shows four elements: knowledge area, career, agency, region, and possible relationships established among them.

Aggarwal et al. [1] defines a knowledge management framework for curriculum development and research in universities. They define knowledge management factors that enhance the curriculum: curriculum design, faculty development and knowledge repositories, counseling techniques and lessons learned, relationships with companies and support of technologies to knowledge management.

Huang et al. [11] present an e-learning semantic framework that considers both technical and pedagogical aspects in an integrated environment. They present a generic model for semantic representation of context, both static and dynamic, considering the interoperability between XML / RDF and e-learning technologies on the WWW. The key feature of this framework is that it is sensitive to information management services supporting context-enabled learning model for knowledge representation and personality of the learner.

This research proposes a guiding model of quality standards for each one of the virtual education processes defined though ontologies. These different abstraction levels besides resembling the knowledge on the different processes of e-learning, will allow to deduce new knowledge through the business rules established on the knowledge management system. Knowledge processes are established at diverse levels of abstraction supported by a technological framework.

4 Ontological Model for Virtual Education

The Ontological Model Architecture for knowledge management is shown in Figure 1. It is formed by three layers: Model, Process and Technology. Those layers are all seen from the ontologies at different levels: general, domain and task. In the following figure the architecture of knowledge model shown consists of three layers: the knowledge management layer, the educational processes layer, and the technology layer. Acquisition of knowledge is done through ontologies, representing each of the layers of the model, from the general, domain and task view.

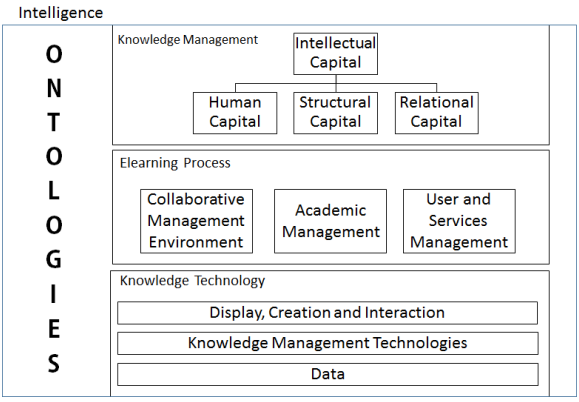

Fig. 1. Knowledge Management Model for Virtual Higher Education through Ontologies.

Knowledge Management Layer. The knowledge management layer describes the intellectual capital model consisting of 1) human capital, which is composed by the roles performed by students, professors, researchers and training personnel; 2) structural capital, made of policies and procedures to carry out the various academic processes existing in higher education, such as curriculum development, knowledge transfer service to community, technology development, and research and innovation; 3) relational capital is found, representing customer relationships. In this case we refer to students, professors, alliances and other institutions.

Educational Process Layer. The educational process layer consists of three modules: the collaborative environment module, the learning management module, and the user and services management module. These modules describe how processes are run in a virtual educational organization. The collaborative environment module describes the activities to be performed by professors, students and researcher in a virtual environment. We are using ontologies for collaborative learning management as described in this model (the first version was developed in Muñoz, et al., [15, 16, 17]). The learning management module is defined according to different instructional teaching models through the knowledge management. The users and service management module describe the different processes and activities undertaken to support users in an educational system, as well as the different types of users and services.

Technology Layer. Knowledge Technology Management involves the vision, mission, business models, and strategies which solve global managing of information and knowledge in virtual education. This platform has three layers: the creation, display and sharing of knowledge layer, the knowledge management layer and the data layer. The creation, display and sharing of knowledge layer would be shown to users through a Knowledge Portal and supported by elements such as the Semantic Web and technologies providing descriptions of the business model. All that has been shown above allows the conversion process of tacit to explicit knowledge and vice versa [19]. The technological elements that support the knowledge layer include: knowledge bases (as organizational memory and semantic repository of learning objects), information systems (like learning management systems, knowledge management content, knowledge-based systems, decision support systems, data mining, etc.). The information retrieval system, document management and workflow management support organizational memory.

Ontology Layer. In this transversal layer the concepts can be defined through the general, domain and task ontology as well as relationships and instances of the elements of different layer of Knowledge Management, Process and Technology Layers of academic processes in Virtual Education. This layer will allow showing the know-how of the processes of virtual higher education, establishing standards, from the view of knowledge management. From the perspective of the processes a model to be followed is the development of activities through existing and new knowledge, which can be provided by ontologies: also, viewing the ontologies on technology as agents of application and integration. The ontology model, in general, will guide the integration process among the layers that from the framework.

Some concepts used to describe the ontologies are: Intellectual Capital, Human Capital and Structural Capital and Technological Layer. Relationships can be: is a; part of; have. Axioms that construct the ontology are described in Table 1.

Table 1. Axioms that support the General Ontology Process Knowledge Management for Virtual Education.

Sentences	First-Order Logic (FOL)
Virtual Education Models have Knowledge Managemnt layer and Educational Process layer and Knowledge Management Technology Layer	∀ x VirtualEducationModel(x) → have (x, KnowledgeManagementLayer) ∧ have (x, EducationalProcess) ∧ have (x, TechnologyLayer)
The Knowledeg Management layer have Intellectual Capital	∀ x KnowledgeManagementLayer!(x) → have (x,IntellectualCapital)
Intellectual Capital has Human Capital, Structural Capital and Relational Capital	∀ x Intellectual Capital (x) → have (x, HumanCapital) ∧ have (x, StructuralCapital) ∧ have (x, RelationalCapital)
Human Capital has Roles, Work Capacity Leadership and Training	∀ x Human Capital (x) → have (x, Roles) ∧ have (x, WorkCapacity) ∧ have (x, Leadership) ∧ have (x, Training)
Roles are employees performing different organizational processes and they have salary	∀ x Role (x)→ is_a (x, Employees) ∧ have (x, Salary) ∧ performs (x, OrganizationalProcess)
Capacity Working assessments are performance Role	∀ x CapacityWorking (x) → is_a (x, Performance Evaluation)
Leadership has management skills	∀ x Leadership (x) → have (x, ManagementSkill)
The training phases have Training Needs Detection, Identify Training Resources, Training Plan Design, Implementation Training Program, Evaluation, Control and Monitoring	∀ x Training (x) → have (x, TrainingNeedsDetect) ∧ have (x, ResourcesTrainig(denfy) ∧ have (x, TrainigPlanDesign) ∧ have (x, TrainingProgram) ∧ have (x, TrainingProgramImplementation) ∧ have (x, TrainingProgramEvaluation) ∧ have (x, TrainingProgramControlMonitoring)
Structural capital has organizational structure, organizational culture, technological Systems, Research and Innovation	∀ x Structural Capital (x) → have (x, OrganizationalStructure) ∧ have (x, OrganizationalCulture) ∧ have (x, TechnologicalSystems) ∧ have(x, Research) ∧ have (x, Innovation)
The organizational structure has processes, Coordination and Control Areas, Rules and Procedures (degree of standardization of activities)	∀ x OrganizationalStructure (x) → have (x, Processes) ∧ have(x, CoordinationandControl) ∧ have (x, RulesandProcedures)
The organizational cultures have values, vision, standard, working language, systems, symbols, beliefs and habits.	∀ x OrganizationalCulture (x) → have (x, Values) ∧ have (x, Vision) ∧ have (x, Standards) ∧ have (x, WorkingLanguage) ∧ have (x, Systems) ∧ have (x, symbols) ∧ have (x , Beliefs) ∧ have (x, Habits)
Organizational Systems have structure, procedures and organizational processes.	∀ x OrganizationalSystem (x) → have (x, Structure) ∧ have (x, Procedures) ∧ have (x, OrganizationalProcess)
The Technological System has Communication Networks, Hardware and Software that support an organization	∀ x Technological System (x) → have (x, ComunicationNetworks) ∧ have (x, Hardware) ∧ have (x, Software)
Research and development activities are aimed to acquire more knowledge. These activities can be: Basic Science Research, Technological Development for Problem Solving, Product or Process Development	∀ x ResearchandDevelopment (x) → is_a(x, ResearchBasicScience) ∨ is_a (x, TechnologicalDevelopment) ∨ is_a (x, ProductDevelopment) ∨ is_a (x, ProcessDevelopment)
Innovation is a technological innovation or service innovation, or innovation in business models, or design innovation, or social innovation	∀ x Innovation(x) → is_a (x, TecnologicalInnovation) ∨ is_a (x, ServiceInnovation) ∨ is_a (x, BussinesModelInovation) ∨ is_a (x, DesignInnovation) ∨ is_a (x, SocialInnovation)
The Relational Capital has Users, Conventions and Alliances	∀ x Relational Capital (x) → have (x, Users) ∧ have (x, Conventions) ∧ have (x, Alliances)
The Educational Process layers has Management Learning, Collaborative Working and User and Services Management	∀ x ProcessEducationalLayer (x) → have (x, ManagementLearning) ∧ have (x, CollaborativeWorking) ∧ have (x, ManagementUserServices)
The Management Learning have Teaching Module and Learning Module	∀ x ManagementLearnig (x) → have (x, TeachingModule) ∧ have (x, LearningModule)
The Learning Module is a Visual or Auditory or Reading/Writing or Kinesthetic	∀ xLearningModule (x) → is_a (x, Visual) ∨ is_a (x, Auditory) ∨ is_a (x,ReadingWriting) ∨ is_a (x, Kinesthetic)
The Teaching Module is a direct instruction or inquiry-based learning or cooperative learning	∀ x TeachingModule (x) → ia_a (x,DirectInstruction) ∨ is_a (x, InquireBasedLearning) ∨ is_a (x, CooperativeLearning)
The technology layer has creation, presentation and sharing layer, knowledge management layer, and network and data layer	∀ xTechnologicalLayer (x) → have (x, CreationPresentationSharingLayer) ∧ have (x, ManagementKnowledgeLayer) ∧ have (x, NetworkandData)

These three layers are modeled using ontologies to represent knowledge, processes and technology layers. The Ontologies will be developed in three levels: General, Domain and Tasks. The general Ontology is shown in Figure 2.

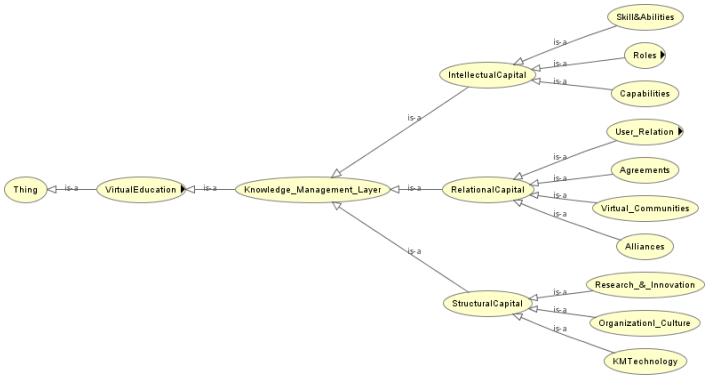

Fig. 2. General Ontology for Virtual Education.

The Ontology for Collaborative Module describes the activities to be performed in a collaborative environment for the learning management for both student-to-student

and student-to-teacher interaction. To describe this model we are using ontologies for collaborative learning in management, which first version was developed in Muñoz et al., [17] it is shown in figure 3.

Fig. 3. Ontology for collaborative learning, Muñoz et al., [17]

The learning Management Model describes the instructional model of students and teachers through knowledge management as shown in Figure 4.

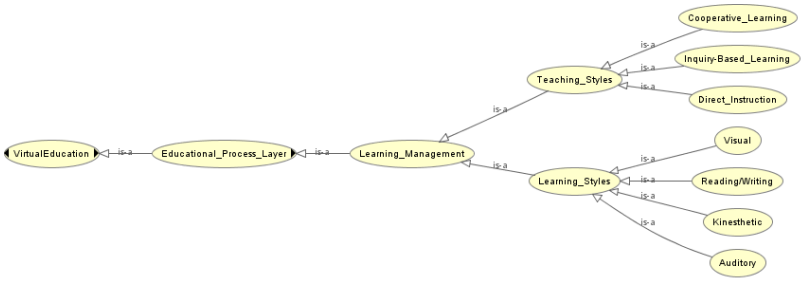

Fig. 4. Learning Management Ontology.

The learning management ontology shows the concepts that govern the process of teaching and learning in a virtual education, based on different instructional theories. The Learning Module contains different learning styles. One of the most accepted understandings of learning styles is that student learning styles fall into three "categories:" Visual Learners, Auditory Learners and Kinesthetic Learners. These learning styles are found within educational theorist Neil Fleming's VARK [9] model of Student Learning. VARK is an acronym that refers to the four types of learning styles: Visual, Auditory, Reading/Writing Preference, and Kinesthetic.

The Teaching module refers to the general principles, pedagogy and management strategies used for classroom instruction. There are three main teaching styles in educational pedagogy: direct instruction, inquiry-based learning and cooperative learning.

Direct instruction is the general term that refers to the traditional teaching strategy that relies on explicit teaching through lectures and teacher-led demonstrations. Direct instruction is the primary teaching strategy under the teacher-centered approach, in that teachers and professors are the sole supplier of knowledge and information. Direct instruction is effective in teaching basic and fundamental skills across all content areas.

Inquiry-based learning is a teaching method that focuses on student investigation and hands-on learning. In this method, the teacher's primary role is that of a facilitator, providing guidance and support for students through the learning process. Inquiry-based learning falls under the student-centered approach, in that students play an active and participatory role in their own learning process.

Cooperative Learning refers to a method of teaching and classroom management that emphasizes group work and a strong sense of community. This model fosters students' academic and social growth and includes teaching techniques such as "Think-Pair-Share" and reciprocal teaching. Cooperative learning falls under the student-centered approach because learners are placed in responsibility of their learning and development. This method focuses on the belief that students learn best when working with and learning from their peers.

The users and services management module is just being developed and should describe the different processes and activities to support users in the learning management model, as well as the different types of users and services. Knowledge Management Technology is the vision, mission, business models, and strategies which solve globally managing information and knowledge in higher education.

The Technology Management layer is an adaptation of the architecture proposed by Paniagua et al. [20], and describes the technological elements that must support the model, as shown in figure 5.

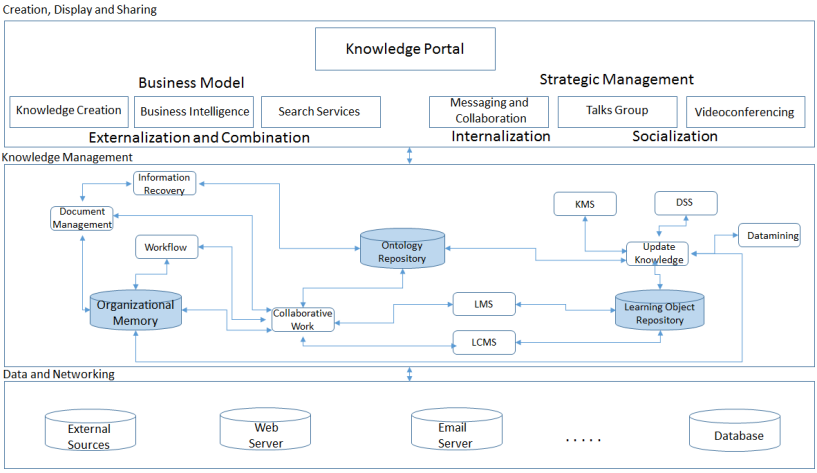

Fig. 5. Technology Platform Knowledge Management Virtual Higher Education

Ontology describing these three layers as shown in figure 6. The presentation layer shows the business model and strategic management to the users through a Knowledge Portal and supported by elements such as the Semantic Web. All these activities allow the conversion process of tacit to explicit knowledge, according to Nonaka &Takeuchi [19], for example the transformation of tacit knowledge to explicit knowledge occurs while recording knowledge in the repositories, and new knowledge can be deduced from ontologies. The presentation layer shows the business model and strategic management to the users through a Knowledge Portal and supported by elements such as the Semantic Web. All these activities allow the conversion process of tacit to explicit knowledge, according to Nonaka &Takeuchi [19].

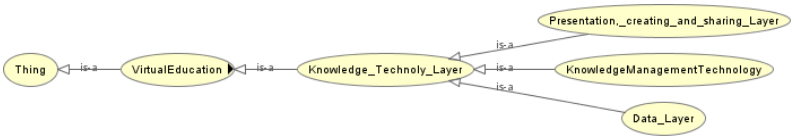

Fig. 6. Technology Knowledge Ontology for Virtual Education.

The knowledge management layer describes the technological elements that support the presentation layer such as: the creation and management of knowledge bases like organizational memory and semantic sources of learning objects, these are supported by ontologies that allow integration of learning management systems and knowledge management objects. Knowledge-based systems, decision support systems and data mining allow updating of knowledge. The information systems, document management and workflow management support organizational memory. Ontologies for integration process to both systems and ontologies. The data and networking layer is formed by the external data sources, Web servers, email and domain repositories, among others.

5 Conclusions

Universities are generators of knowledge, and thus there are new knowledge workers being formed in them by professors, who in turn are knowledge workers as well. On the other hand, it is really important that knowledge completes its permanent vital cycle (tacit-to-explicit-to-tacit) so that added value can be provided to processes performed by universities. The latter allows universities to be real organizations that learn by preserving their experiences, reusing them properly and evolving them into best practices. Using business models and best practices should (with proper respect to academics as repository of formalized knowledge obtained from the theory-practice-theory cycle) allow universities to be more dynamic and to better serve their clients with mature and reusable “knowledge products”.

A first version of a formal model for virtual education is presented in this research, using first-order logic (FOL). It is modeled through ontologies, which describe the semantic architecture of a knowledge management system. We have been able to establish rules and meaning of behaviors through the different ontologies of the

processes that comprises it. The ontologies describe the intelligent behavior of the model. General ontologies describe the superior level of processes, while domain ontologies describe the different processes in the education domain such as collaborative learning, teaching, etc. Finally, task ontologies will describe different tasks of the model, for example creation of learning objects.

General Ontology is the element that represents the management of knowledge which guides the model; this ontology is formed by concepts that allow to integrate the diverse layers that form the model, as well as the rules and axioms that domain the framework from a general view. This is apparent when we describe the structural capital, containing the learning management processes and collaborative work, such as found on the processes and technologies on the third layer. General ontology (shown in figure 2) integrates different layers of the model done through axioms of behavior described on table 1. For instance a rule states that "integrations include the human capital, which includes professors, students and researchers."

Each one of the ontologies describes the processes of integration and re-use of knowledge given on the different processes; this is a work in development using Neon methodology.

Future research will be conducted on the development of intelligent agents that support recommended activities to establish processes standards. Agents whom would allow to consult on the activities of measurement of quality which will be communicated to users, as well as other Agents who will allow the creation of users' profiles.

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