Knowledge-Based Model for Curricular Design in Ecuadorian Universities

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Abstract. The contemporary generation of students needs to acquire competences that help them to exercise judgment and solve problems aiming to face current economic and technological challenges. On the basis of this understanding, competence-based education with its teaching and learning approaches has received a good deal of attention and support in recent years. In this sense, the correct design of curriculums represents one of the main means for the gradual and systematic formation of these competences. Despite this fact, in Ecuador there is not a knowledge management model for competence-based curricular design at university education level. Hence, in this work, we propose a knowledge-based model for the design of competence-based curriculums that allow professionals to use teaching and learning strategies that facilitate the development and demonstration of competence, thus contributing to the academic formation of high-level professionals in Ecuadorian universities. All aforementioned will be possible thanks to the implementation of a Cloud-based platform that combines current technologies such as social networks, data mining, and ontologies in order to provide Ecuadorian professionals with the means for the design of competence-based curriculums.

Keywords: Knowledge management · Ontologies · Curricular design · Education · Competences

1 Introduction

The contemporary generation of students needs to acquire competences that help them to exercise judgment and solve problems aiming to face current economic and technological challenges. A competence refers to those characteristics – knowledge, skills, mindsets, thought patterns, and the like – that when used whether singularly or in various combinations, result in successful performance [1]. Competence-based education with its teaching and learning approaches has received a good deal of attention and support in recent years [2]. In this sense, higher education institutions have focused on the

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development of individual competences through the understanding of how people learn and how teachers can facilitate learning, and more importantly, how to apply that knowledge to the learning environment. In summary, competence-based education requires that teachers as experts define the necessary competences to become a fully qualified professional. With this in mind, correct curriculum design represents one of the main means for the gradual and systematic formation of these competences. Also, it is necessary to highlight that both the curriculum, as well as the knowledge generated from the curricular design process, should be disseminated among universities.

Nowadays, the Council of Accreditation, Assessment and Quality Assurance in Higher Education (CEAACES) is the responsible for evaluating the academic quality of higher education institutions in Ecuador. This council has awarded the highest category to universities that feature competence-based curriculum designs for each of the degrees that they offer. Despite this fact, at university education level there is no knowledge management model for competence-based curricular design. Hence, in this work, we propose a knowledge-based model for the design of competence-based curriculums that allows professionals to use teaching and learning strategies that facilitate the development and demonstration of competence [3], thus contributing to the academic formation of high-level professionals in Ecuadorian universities.

Our approach takes into account two main knowledge streams, the competence-based curricular design and the research lines acting as a transverse axis. On the one hand, our approach is focused on competences due to the fact that they are part of the integral education [4], and thereby it will be covering the fourth objective (Strengthen the capacities and potentialities of citizenship) of the National Plan for Good Living [5]. In addition, the research lines will allow the articulation of the curricular content, because all courses will be interrelated, which in turn allows the establishment of a permanent, purposive and proactive dialogue between teachers of the different courses [6]. All aforementioned will be possible thanks to the implementation of a Cloud-based platform that combines current technologies such as social networks, data mining, and ontologies in order to provide Ecuadorian professionals with the means for the design of competence-based curriculums.

In summary, the model proposed aims to facilitate the management of knowledge derived from the competence-based curriculum design process, thus allowing professionals to decide what the most appropriate content for a specific degree is, as well as to explain, evaluate, and share such content in order to plan future content.

The remainder of this paper is structured as follows. Section 2 presents a review of the literature concerning curricular design. Section 3 describes both the methodology followed for designing the model for curricular design and the model as such. The technological architecture that supports the knowledge-based model for curricular design, its components and interrelationships are described in Sect. 4. Finally, conclusions and future work are presented.

2 Related Works

In the last years there have emerged several approaches that aim to improve the competences of university students. A clear example of these efforts is presented in [7], where the authors extensively report on the present-day curricular scope and sequence, genre-based pedagogies, and associated assessment practices that were developed and implemented in a four-year undergraduate German program. The authors emphasized the decisions that were made while also demonstrating the outcomes of these decisions in the form of practicable educational efforts and products. Another example is found in [8]. Here the authors presented a methodological guide for design and application of curricular strategies in Medical sciences. The researchers performed a review of curricular, methodological and normative documents of different degrees. Also, they conducted analysis and discussion sessions with groups of experts (curricular design consultants, methodological consultants, and teachers). In [9] the authors presented a framework focused on the alignment of interdisciplinary learning objectives. This framework will be useful for both curricular designers and education researchers to understand how integrated science curricula can be designed to support interdisciplinary learning objectives. Alternatively, in [10] the authors present an analysis of the methods to include competences in the professional profile. Furthermore, the authors concluded that it is very important to assume the competence based approach as well as the training of designers and the executors of the process. In [11] a project spine for software engineering curricular design is presented. This project addresses the technologically challenging, rapidly evolving discipline that represents the software engineering education, where engineers not only design but also construct the technology. Therefore, this project focuses on vertical integration of project experiences in undergraduate software engineering degree programs or course consequences. In [12] the authors discuss about a three-year experience implementing an evolving curricular design, which is focused on exploring how students valued different instructional methods. As conclusions, the authors establish that educational change is best viewed through a longer term lens, acknowledging the necessity for teachers to grow experience in implementing new methods in the context of their institution. Finally, in [13] the researchers present an engineering program whose main goal is to expand the engineering educational alternatives in the Maine Mid-Coast region, while at the same time implementing advances in engineering pedagogy with the aim of achieving a high level of curriculum integration. Furthermore, the authors expect that these measures enhance the learning experience.

The above-presented works have made a significant contribution to improving the competences of university students through the establishment of approaches focused on curriculum design and generation at different areas such as medicine and software engineering. Despite their contributions, these works do not address all issues that our approach aims to solve. More specifically, our approach puts the intellectual capital as the center stage of the model proposed. This decision is based on a detailed analysis of current state of the Ecuadorian university environment which is described in Sect. 3. Furthermore, our approach puts special attention on creating an environment that allows teachers, coordinators, and curricular design experts, among other professionals, to share knowledge and experiences that allow them to design the correct curriculum based on

the competences and needs of the students of the different degrees offered by the Ecuadorian universities. This environment will be based on an architecture that integrates current technologies such as social networks, data mining, and ontologies. This architecture is described in Sect. 4.

3 Knowledge-Based Model for Curricular Design

The design of the knowledge-based model for competence-based curricular design was performed following the model proposed in [14]. This model is composed by four phases:

1. Diagnosis. Aiming to develop a successful strategy, it was necessary to know what the current state of the organization is. Therefore, an analysis based on the strategic position of the organization was performed. This analysis aimed to determine the corporative resources that express the organization's knowledge and its use in the proposal of projects oriented to the organization's knowledge representation, its exploitation, as well as its use in the qualitative improvement of the organization.
2. Design. The main goal of this phase is the establishment of a logic and technique base on which the different projects will be developed. They are oriented to the knowledge management. Among the activities performed in this phase we find: the development of a knowledge strategy that allows the organization to change from its current state to the desired state; in order to carry out the aforementioned task, the Nonaka Takeuchi [15] model was used. This model enables managing the dynamic aspects of organizational knowledge. The central theme of this model is that organizational knowledge is created through a continuous dialogue between tacit and explicit knowledge.
3. Implementation. This phase aims to perform the implementation of the project as well as to establish the basic guidelines. This phase includes activities such as the implementation of the developed plans, and a periodic review of the strategies through the goals and plans associated with them.
4. Evaluation. The goal of this phase consists of the evaluation of the project implementation results, validating the knowledge strategy and providing feedback of the diagnosis process in order to generate a new knowledge management cycle.

As a result of this phase, we identified, selected and measured the tangible and intangible assets within universities' degrees. The accomplishment of this task was based on the Intelect model [16], which aims to provide relevant information that supports the decision-making process, as well as to provide information concerning the value of the company. This model groups intangible assets according to their nature: human capital, structural capital and relational capital. Each asset must be measured and managed through a dimension that integrates future and present as a dynamic and evolving perspective of the concept [17]. Additionally, it provides a general view of the organizational capacity for the generation of sustainable results, continuous improvement, and long-term growth. The Intelect model obtained for this work is shown in Table 1.

Table 1. Intelect model for the establishment of a knowledge-based model for curricular design

Present	Future
Human capital	
Staff: teachers, coordinators, secretaries, curricular design experts, researchers. *Human competences*: own degree, Information and communications technology (ICT), pedagogy, research, educational quality, teamwork. *Leadership*: degree coordinator, planning coordinator. *Teamwork*: Interdisciplinary working groups.	*Improved skills*: Updating of knowledge associated with the curriculum design process, updating of communication tools, new ways of knowledge acquisition
Structural capital	
Organizational culture: Regulations and internal and external policies of higher education institutions. *Business philosophy*: Vision and mission of the degree. *Organizational structure*: Organization chart of higher education institutions. *Design processes*: training processes, curricular organization, learning planning. *Knowledge capture processes*: Information management. *Dissemination and communication mechanisms*: Organizational communication, Collaborative Social Network. *Information Technology*. Technological architecture that supports the model.	*Innovation processes*: Educational innovation of the curricular design.
Relational capital	
Strategic alliances: University networks, Inter-Institutional Agreements	*Capacity improvement*: Providing the bases for higher education institutions, teacher's training on pedagogical innovation, adaptive curriculum.

As we can see in Table 1, human capital assets refer to the different knowledge and skills that university staff has. These assets represent the basis for the generation of intellectual capital. Also, they will allow the development of a model for competence-based curricular design. Concerning structural capital assets, we have identified the knowledge that the organization, in this case the university, is able to systematize and internalize and that at the beginning can be latent in the staff. It is worth noting that a solid structural capital improves the knowledge flow across organization thus improving its effectiveness. Finally, relational capital refers to the value perceived by the university concerning the relations that it has with different social agents. These assets are directly linked to the university's ability to integrate into its socioeconomic environment and develop collaborative networks.

Once the current state of the universities has been analyzed, in addition to establishing a general view of its capacity for the generation of sustainable results, continuous improvement, and long-term growth, we establish the knowledge-based model for competence-based curricular design. For this purpose, we took into account the curricular-design process proposed by Tobón [4], as well as the Tuning project [18]. According to the Tobón's process, the competences are complex performance processes that allow addressing problems through suitability and ethical commitment. This fact demands curricular transformation processes as well as a learning plan based on problem-solving activities and workshops. With regards to the Tuning project, it is an independent project, promoted and coordinated by universities in many different countries in both Latin America and Europe. This project puts the competences at the central stage in the process of curriculum reform and modernization. It is worth noting that competences established by the Tuning project are taken into account by the CEAACES in order to evaluate the different degrees offered by higher education institutions in Ecuador. Therefore, the present model focuses on the courses of action of the Tuning project. Figure 1 presents a general view of the proposed model for competence-based curricular design.

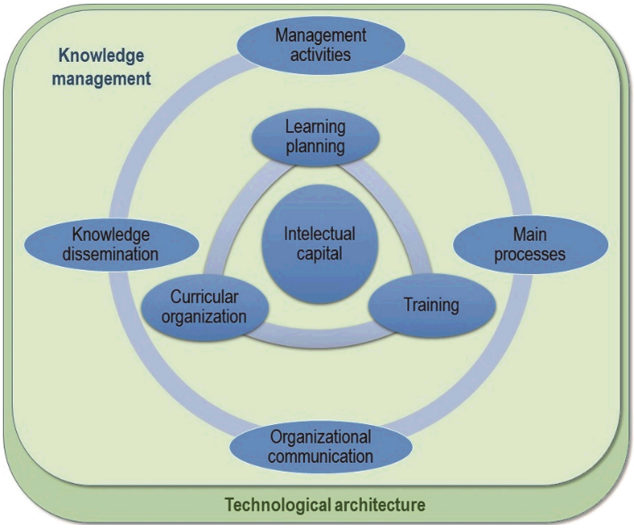

Fig. 1. Model for competence-based curricular design.

As we can see in Fig. 1, our approach puts the intellectual capital at the central stage of the model proposed. The intellectual capital refers to the collective knowledge (whether or not documented) of the individuals in an organization, in this case, of the different kind of people involved in the curricular design process such as teachers, coordinators, secretaries, curricular design experts, researchers. At first instance, structural capital assets such as processes of learning planning, training, and curricular organization, work around the intellectual capital. These assets will allow identifying and planning learning activities that help students achieve the course goals and objectives of each degree's curriculum. Furthermore, they will allow selecting curriculum elements from

the subject, the current social life and the student's experience, then designing the selected curriculum elements appropriately so that they can form the curriculum structure and type. At second instance, the intellectual capital is surrounded by knowledge management processes such as management activities, knowledge dissemination and organizational communication. These processes will allow communicating results to potential users as well as to gauge their effectiveness on outcomes such as knowledge acquisition, changes in attitudes and changes in practice [19]. Finally, the model described above will be supported by an architecture that combines current technologies such as social networks, data mining, cloud computing and ontologies in order to provide professionals with the means for generating competence-based curriculums. This architecture is described in the next section.

4 Technological Architecture

As it was mentioned in the previous section, the knowledge-based model for curricular design presented in this work needs a technological architecture that allows it to accomplish the established goals. One of the most outstanding goals is the establishment of a collaborative environment that allows professionals (curricular design consultants, methodological consultants, researchers, and teachers, among others) to pay special attention to the students' learning needs and patterns, and to identify the expected competences (knowledge, skills, professional's behaviors), creating a supportive environment for learning. With this in mind, we propose a cloud-based architecture that supports the model presented in this work. Figure 2 presents a general view of such architecture.

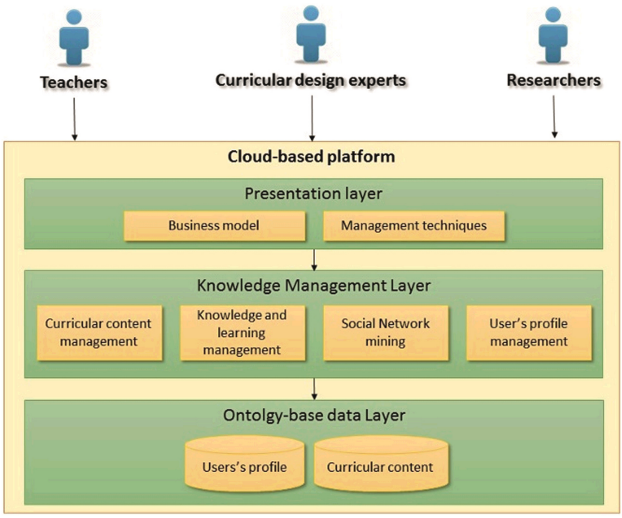

Fig. 2. Technological architecture that supports the model for curricular design

The architecture proposed in this work is based on a cloud computing approach which offers advantages such as simplified software installation and maintenance and centralized control over versioning. Moreover, end-users can access the service "anytime, anywhere", share data and collaborate more easily, keeping the data safely in the infrastructure [20]. Also, this approach has been successfully applied in works such as [21, 22, 23]. As we can see in Fig. 2, the architecture is composed of three layers namely: presentation layer, knowledge management layer and data layer. These layers are described in detail in the next sections.

4.1 Presentation Layer

This layer is composed of the business model and management techniques modules. On the one hand, the business model module refers to the activities related to knowledge generation, curricular design and content searching. Therefore, these processes aim to follow the plan implemented by our model to generate knowledge concerning curricular design, and make profit from the knowledge generated i.e., designing the correct curriculum based on the competences that the students must have according to their degree. On the other hand, the management techniques module deals with internal communication processes as well as shared online services. The main goal of this module is to deliver an internal communication framework that supports the internal communication plans, as well as to ensure the correct communication among all professionals, thus allowing them to manage and share knowledge that promote competence-based learning in higher education.

4.2 Knowledge Management Layer

This platform focuses on the management of knowledge in curricular design along with examples of a curriculum plan and sample modules. It is necessary to have clear evidence of the curricular design process in order to demonstrate the correct performance of the model. Therefore, the present module aims to consciously and comprehensively gather, organize, share, and analyze the knowledge generated in terms of resources, documents, and people skills. In this sense, this layer is composed of four modules: curricular content management, knowledge and learning management, social network mining, and user profiles management. These modules are described below.

Curricular Content Management. Curricular content represents a main level of education quality. Therefore, this module deals with the management of all information that describes the activities concerning the knowledge, skills, and attitudes imparted in learning subjects, cross-cutting approaches, and extracurricular activities. The correct management of this knowledge plays a key role on the general performance of the model proposed due to the role of every professional involved in the curricular design process. These professionals will be able to see what is intended and required in terms of curriculum provisions and learning results.

Knowledge and Learning Management. This module deals with the fact that just as human beings are unable to draw on the full potential of their brains, organizations are generally not able to fully utilize the knowledge that they possess [24]. Therefore, this module aims to allow professionals to acquire and create potentially useful knowledge and make it available to all users of the platform, thus allowing to achieve the maximum effective usage in order to positively influence the design of competence-based curriculums.

Social Network Mining. There is a constant increase in the number of people who consider the Internet as a powerful means of communication. In this sense, the social media mining approach has emerged as the process of representing, analyzing, and extracting actionable patterns from social media data [25]. Nowadays, there are lots of tools that allow to obtain and combine information from multiple sources such as social networks [26, 27]. On the basis of this understanding, this module will allow professionals to obtain information from academic groups established on social networks such as Facebook. These groups will be analyzed by means of data mining techniques in order to identify and obtain the information concerning competence-based learning in higher education.

User's Profile Management. As mentioned throughout this document, the competence-based curricular design demands the support of a multi-disciplinary team of professionals such as teachers, a curriculum design committee, and curriculum design experts, among others. Therefore, this architecture provides a module focused on the management of the profiles of all kind of users involved in the curricular design process. Hence, this module is directed, at a first instance, to teachers who are now teaching or who have not had experience in competence-based teaching and learning strategies; learners which must be engaged and active in all aspects of acquiring the knowledge, skills and professional behaviors needed to demonstrate practice in a specific discipline; as well as to a curriculum design committee composed of representatives of various university stakeholders responsible for the design process, thus providing experience to the other professionals involved.

4.3 Ontology-Based Data Layer

The amount of information available on the Web, intranets or databases has been steadily increased. This fact is present in this work because the curricular design process generates a lot of information from internal sources as well as social networks. Most of this information contained in this kind of sources is designed to be read by humans, and not to be meaningfully manipulated by machines. In this sense, the semantic Web has emerged as an extension of the current web, where information has well-defined meaning which is understandable not only by humans, but also by computers [28]. One of the most important components of the Semantic Web are the ontologies which are viewed as a formal and explicit specification of a shared conceptualization [29]. Also, it should be mentioned that ontology-based knowledge bases has significantly grown and are being applied to different domains

such as information retrieval [30] and opinion mining [31]. On the basis of this understanding, we find the present uses of the ontology proposed in [32] in order to represent the concepts, relationships and instances of the presentation and knowledge management layer. This layer will allow integrating semantic mechanisms that support the decision-making process performed by professionals during the selection of educational content and the design of the appropriate curriculum according to the needs of the Ecuadorian university students. In summary, the ontology model used in this layer will guide the integration and dissemination of all knowledge generated from the model for curricular design proposed in this work.

5 Conclusions and Future Research

Nowadays, the Ecuadorian higher education institutions are being evaluated by an academic and government organization known as CEAACES. This council has awarded the highest category to universities that feature competence-based curriculum designs for each of the degrees that they offer. Therefore, in this work, we presented our research effort to provide a model for curricular design that allows professionals from different universities to select the content needed for students to acquire the knowledge, skills and professional behavior so that they can demonstrate practice in a specific discipline. Also, this model is based on the learning through competences approach, on the seventeen competences of the Tuning project oriented to measure the learning results, as well as on the ones stipulated by the CEAACES in its guide for the creation and accreditation of professional degrees.

As future work, we plan to implement the model for curricular design as well as the architecture presented in this work at the Agrarian University of Ecuador. Furthermore, we need to define measures for impact, and determine how this model fits with the established pattern for curricular design in engineering programs of Ecuadorian universities. Therefore, we plan to use quantitative and qualitative data. On the one hand, quantitative data refer to program size, institution type, college and student background. On the other hand, qualitative data can be collected through surveys and interviews of all professionals involved in the curricular design process. All aforementioned information can be collected via the technological architecture proposed in this work.

Concerning the implementation process, it must be emphasized that teaching and learning processes in whatever type of curriculum require common goals, shared responsibility and accountability between teachers and students, and supportive environments to maximize success. Therefore, the success of this work will require the provision of a sense of shared purpose and concrete support of change in addition to the development of policies that support the use of this model among the Ecuadorian higher education institutions.

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