Semantic Enhancement of the Course Curriculum Design Process

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Abstract. In this paper we propose a methodology intended to improve Course Curriculum Design (CCD) tasks, using for this purpose Semantics and CBR techniques. In specific, our proposed methodology is focused on two points: (*i*) the re-use of available resources (courses, etc), and (*ii*) the application of the experience of different experts in the course creation. As a prove of concept, we present a case study where our methodology is applied for competence and course creation using the Spanish normative for vocational education domain (technical degree).

Keywords: Ontologies, Case-Based Reasoning, Course Design, Knowledge Based Systems.

1 Introduction

Education quality is related to the best use of the available resources, the proper design of the subjects and evaluations, and generally, to a good design of the courses and components which are part of the education process [1]. Typically, course design starts with the definitions of the competences or abilities that must be met at the end of the course. As pointed by Diamond [2], educators need to clearly identify goals prior to any kind of course assessment. Those goals are the same to what we understand as competence evaluation. Based on competences, the course designer builds the contents and the evaluations in a process known as Course Curriculum Design (CCD) [2]. We have found that CCD presents some interesting challenges. From the computational perspective, some of the most interesting are the following:

- Every country has its own design normative, and successful experiences in one country cannot be easily applied to another.
- Designers have different points of view, and the same course design differs from one designer to other. This situation leads to non-homogenized curriculum.
- The re-use of knowledge and prior user experiences coming from different experts is not included in the approach

In this paper, we propose a novel approach for the Course Curriculum Design that is enhanced by semantics, taking into account course designers' expertise and case based reasoning systems in order to produce a better course with the available resources. This

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paper is structured as follows: in section 2, we introduce a brief explanation about related concepts. In section 3, we present our proposed methodology. In section 4, we present a case study where proposed methodology is implemented. And finally, in section 5, we present our conclusions and future work.

2 Related Concepts

In this section, we introduce some concepts relevant to this paper. Our intention is to give a short overview of the involved technologies. An interested reader is invited to review [3], [4], [5] for a wider explanation on the concepts presented.

2.1 Case Based Reasoning (CBR)

CBR is a problem solving technique based on two tenets: (*i*) the world is regular, so many similar problems have similar solutions, and (*ii*) types of problems an agent encounters tend to recur [6]. CBR does not use generalized rules as a knowledge source, but a memory of stored cases recording specific prior episodes [6]. New solutions are generated by retrieving the most relevant cases from memory and adapting them to fit new situations. This is a powerful and frequently used way to resolve problems by humans. In its simplest form, CBR has four steps: (*i*) situation assessment, (*ii*) case retrieval, (*iii*) similarity evaluation and (*iv*) storage of the new case [6]. CBR as a tool is an important aid to analyze previous decisions by using statistical models. One of the keys success factors in using CBR based tool is the fact that every new choice made upon the available cases, feed back to the database and therefore enhancing the model. We believe that by mixing CBR and Semantic technologies the strong points of both techniques can be leveraged to the users advantage, while at the same time their weakness can be alleviated.

2.2 Semantic Technologies

Semantics is the area of the knowledge that studies the meaning of things [7]. Semantic technologies constitute one of the more interesting technologies derived from the World Wide Web revolution. In this work, we use ontology modelling for its inference capabilities and to support our architecture from a knowledge engineering point of view. Next section introduces brief descriptions regarding the semantic based technologies relevant to our work.

2.2.1 Ontologies

There are many possible definitions to describe what ontology is. In the Computer Science domain, the widely accepted definition states that "an ontology, is the explicit specification of a conceptualization" [8], or in other words an ontology is the description of the concepts and relationships in a domain of study. Some of the motivations to model a domain with ontologies are (*i*) to share common understanding of the structure of information among people or software agents, (*ii*) to enable reuse of domain knowledge, to make domain assumptions explicit, (*iii*) to separate domain knowledge from the operational knowledge, and (*iv*) to analyze the domain's modelled knowledge. Ontologies can be modelled using different languages, for instance, RDF, RDFS and OWL, the later is a new standard from the W3C consortium available in three flavours, OWL-Lite, OWL-DL and OWL-Full, depending on the desired level of semantic load [9]. The main characteristic of an ontology-based solution is its capacity to semantically infer newly derived information. Such information is not explicitly specified by the user and in order to obtain it modern inference engines and reasoners, like Racer or Pellet [10], are used.

2.3 The Set of Experience Knowledge Structure (SOEKS)

The Set of Experience Knowledge Structure is an experience tool able to collect and manage explicit knowledge of different forms of formal decision events [5]. The SOEKS has been developed as part of a platform for transforming information into knowledge named Knowledge Supply Chain System. In this methodology, there are four basic components: variables, functions, constraints and rules associated and stored in a combined dynamic structure. The combination of the four components of the SOEKS offers distinctiveness due to the elements of the structure that are connected among themselves, imitating part of a long strand of DNA. A SOEKS produces a value of decision, called efficiency. Besides, it is possible to group sets of experience by category, that is, by objectives. These groups could be store a “strategy” for such category of decisions. By using this methodology and its underlying ability to model user experience, we have a proven method for modelling the Expert who is designing the Course. The benefits of using such expert model is not only restricted to the fact that the actual system becomes more stable in terms of repeatability (the same set of needs will produce similar courses) but in terms of confidence and trust as the Case based systems produce only statistical results on the set of variables, while by using expert models, such systems would be filtered to enhance in fact the CCD.

3 Proposed Methodology

In this section, we propose our methodology for the enhancement of the CCD process. The goal of our methodology is to solve two common reported problems: (*i*) CCD uses many different sources of information (in many cases, in non-digitalized forms), and (*ii*) At present time, a CCD expert is not able to use the prior experiences from other CCD experts in the design of new similar courses. In Fig. 1, our methodology is depicted. As can be seen, we divided it in four stages that will be explained next:

3.1 Data Categorization

On a normal scenario, initial information for the CCD is found dispersed in different media types (e.g. electronic, books, similar courses and their components, etc). The aforementioned data needs to be categorized in usable differentiated types of elements for posterior analysis. In the first stage of our methodology, a human practised sorts out the information using their knowledge of the domain; possible categorizations are made using domain restrictions and such domain depends on the specific educational normative used. The need for an expert in this stage obeys to the necessity of comprehension on the characteristics of the courses that is a direct consequence of the

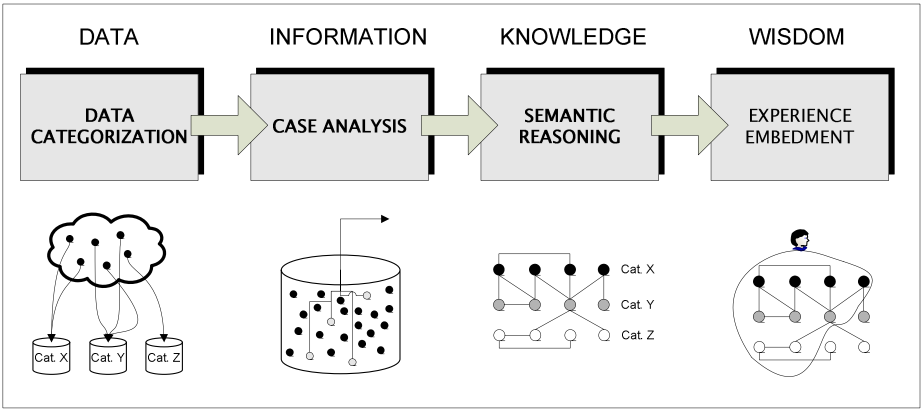

Fig. 1. The four stages of our proposed methodology

knowledge about the domain. Usually, in this stage some computational techniques could be used, e.g. Data Mining, taxonomies, however the most common approach is a manual sort. At the time being, this part of our methodology is the only one that needs direct human interaction, although we are currently pursuing some lines of research that could lead us to automate it. Typical data categorization for an educational domain could be for example: courses, competences, objectives, evaluations, etc.

3.2 Case Analysis

Once the data is organized, the contained elements are ready to be queried in order to solve the question of which ones better answer the set of requirements for the course. In order to perform the aforementioned information query, relational databases and Case Based Reasoning are two techniques that can be used (this last technique was our choice for implementation due to easiness on implementation). A typical query for a Case analysis could be: "*retrieve the available courses of less than 200 hours with algebra pre-requisites*". The goal of this stage is to obtain full advantage of the stored data.

3.3 Semantic Reasoning

Until this point, the elements belonging to the different categories can be recovered in order to compose an answer to a complex question. For such query retrieval, it is necessary to know how these elements are related. As the domain defines relationships, so there exists the need of a model of such specific domain. This model can be obtained using different Domain Modelling techniques, and stored in several ways, like relational databases or ontologies. When ontologies are the election, there is possible to infer semantically new information not stored explicitly, using semantic reasoners. A typical question could be: *"Retrieve the competences that have the needing of an advanced algebra course"*.

3.4 Experience Embedment

Lastly, the expert experience has to be used in order to refine the obtained answer. As mentioned before, experts have different perspectives of how the same course has to be assembled, for example, an expert in CCD with an engineering background, would design a physics course oriented to engineering better than a physicist would do. In this last stage of our methodology, the goal is to apply the experience of experts with the correct point of view for the specific situation. For this purpose, a model that allows storing and handling of such experience is needed. SOEKS is an experience modelling and storing structure that we used in several knowledge systems previously [11], obtaining good results.

4 Case Study

In this section, we present our case study; we intend to model a new course using our methodology with compliance to the Spanish normative for vocational education domain (technical degree). With the help of an expert in this domain, we identified five different categories to distribute the data: (*i*) competences, i.e. the abilities to be acquired, (*ii*) objectives, i.e. the necessary goals to achieve the target competence, (*iii*) courses, i.e. individual and self-contained pieces of knowledge that fulfills an objective, (*iv*) units and (*v*) projects, being both of them the smallest elements belonging to courses. For each one of the five categories, we created a repository to store the elements belonging using for such purpose a MySQL database. We have found that separated repositories improve the extensibility, modularity and efficiency of the system. Upon the repositories, we implemented CBR modules for the Case Analysis

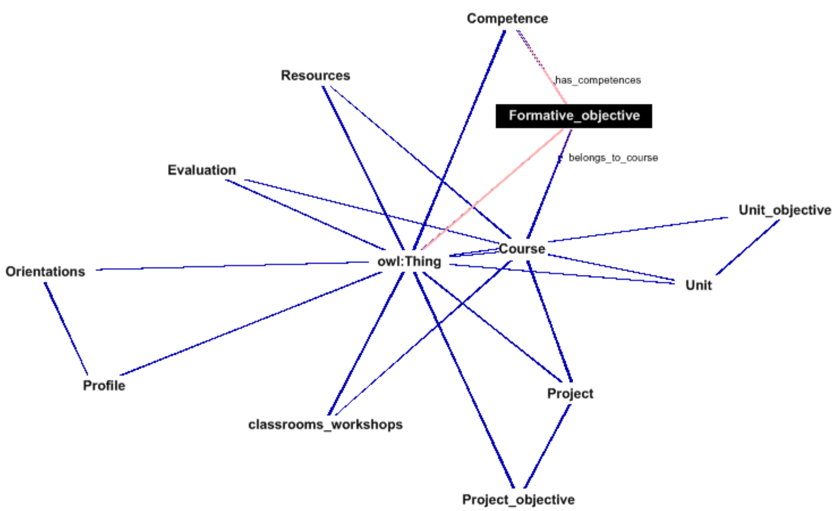

Fig. 2. Graphical representation of part of the set of ontologies

stage. Each category (except objectives) has its own independent CBR module, in order to maintain the modularity. These CBR modules have been developed with jColibri2 [12], a Java API for the development of CBR systems created by the GAIA group at the Complutense University of Madrid. For the implementation of the Semantic Reasoning stage, we modelled the domain in a set of ontologies in OWL-DL [9]. The use of OWL-DL was decisive when reasoning the Knowledge Base from the open world assumption as it simplified the rule system used (not shown here for confidentiality reasons with the contractor of the underlying project which generated this approach). The modelling process was performed in the Protégé ontology editor, in part because of the possibility of use of its API for the automatic instantiation. A section of the resultant ontology is depicted in Fig. 2.

Queries are made to the ontology using the Protégé OWL API [13] and reasoned using Pellet [10] in order to infer new knowledge. The last stage of the methodology comprises the experience filtering by using the model of the expert with a SOEKS compliant methodology [14]. Fig. 3 depicts the scenario described before.

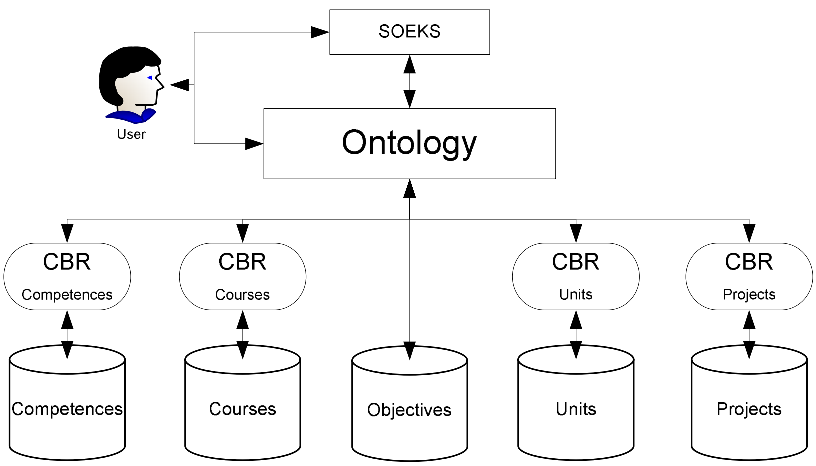

Fig. 3. Implementation for our case study

Fig. 4 depicts a user case for competence and course creation, divided in three different tasks: competence creation, course creation, and objective assignment.

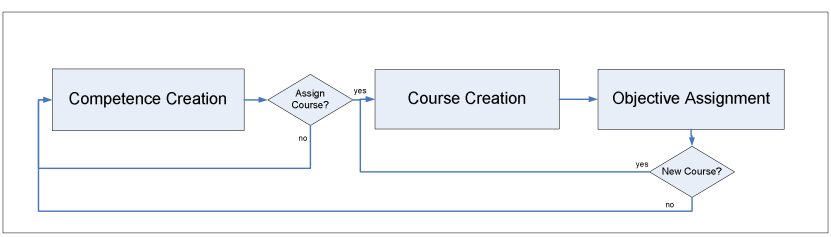

Fig. 4. Create courses for a non-existing competence user case

For the competence creation, the user defines the master guides that their new competence has to fulfil. With these guides, the CBR module implemented over the competences repository is launched, and returns a set of competences that are near to the desired new competence. With the help of these returned competences, the user is able to complete their new competence. CBR can be launched more times if necessary, changing the master guides in order to obtain new suggested competences. Once is completed, the new competence is stored and becomes part of the stored cases of the CBR for future questions. Once the new competence creation is done, the new task is the creation of courses for such competence. Using the relations between elements stored in the ontology, the system offers to the user the courses (and the units and the projects that form them) related to the competences used for the new competence creation. Moreover, user can decide to launch CBR processes over courses, units or projects, in order to obtain more suggestions for their design of the course. When a course is completed, user has to assign a common objective to the competence and to the course. As we said before, in our domain objectives are quite simple elements, so we decide not implement the option to launch any CBR process over the repository of objectives but show all them in a list. If desired objective is in the list, the user chooses it. If the objective is not in the list, the user creates it directly. When this task ends, the course is stored in its repository and the user can create another course for the competence or end the user case.

5 Conclusions and Future Work

In this work, we presented a new methodology to solve some of the problems encountered in CCD tasks, specifically those focused on the re-use of available information and the use of many different experts' experience. We presented a case study that follows our proposal in the Spanish normative for mid-level vocational education domain, implementing a competences and courses creation tool. As future work, we are focused in two different points: (i) to apply our methodology in several education domains and (*ii*) to enhance the Semantic Reasoning stage with Reflexive Ontologies [15] in order to enhance our domain ontology with quicker answers for the queries [16].

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