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Using graphs for exposing the underlying competence design of academic degrees

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Abstract

Academic degrees are usually presented with textual tables and lists, following a semester structure. This information is expected to help learners to create their own itineraries within a given degree, which may not be the case in a distance university, where learners may not take complete semesters. Furthermore, both tables and lists are useful to explain the contents of a specific degree, but they are limited for visualizing the relationships between the different subjects and the competences acquired and developed through them. In this paper we propose a new way to visualize an academic degree, equating subjects and competences as two complementary dimensions. We have applied this visualization to two degrees already offered by the Universitat Oberta de Catalunya and to another during its design phase, involving learners and degree managers, respectively.

Categories and Subject Descriptors (according to ACM CCS): K.3.1 [Computers and Education]: Computer Uses in Education—Distance Learning, H.5.2 [Information Interfaces and Presentation]: User Interfaces—Graphical user interfaces (GUI)

1. Introduction

Higher education (HE) is one of the pillars of our society, as it serves the purpose of creating and transferring knowledge through basic and applied research, empowering citizens with a common culture and standards and providing them with skills for increasing their employability. Traditionally, HE has been structured around knowledge domains, following the traditional division of academic disciplines. Curricula were organized in sequences of subjects arranged in semesters that introduce the learner from the most general concepts to the most specific ones. Subjects were created according to the content that determines the supposed knowledge to be taught. Since the adoption of the European Higher Education Area, new degrees are now designed following a completely different perspective, as learners are expected to acquire and develop competences, shifting from a content based scenario to a competence based one [GMGS09]. Nevertheless, such adoption was not completely disruptive [Soa12], as some of the basic procedures that constitute the way HE institutions work have not changed at all. For instance, students still need to enroll to individual subjects according to semesters, ignoring the underlying degree competence design. In the case of distance and open universities, with no enrolment requirements, learners need as much support as possible in order to have a clear picture of their positioning and orientation, beyond the current tables and lists of subjects and competences provided by the university. Currently now, learners do neither decide their enrolment nor perceive their progress within a degree in terms of competences, but only in terms of subjects enrolled and passed each semester. On the other hand, analyzing how learners advance through a degree is also necessary to provide managers with design and evaluation tools, identifying curriculum parts that are unclear or can be reorganized [GKL13, APH14]. Thus, the use of interactive visualizations as part of other institutional learning analytics strategies can be very helpful in this context [SRS13, Wil16], as proposed in this paper.

2. Development

The visualization described in this paper has a main goal, which is to represent a curriculum taking also into account competences, not only subjects and semesters. This visualization will serve two different purposes according to its end-user: for teachers and degree managers, it is a tool for designing and analyzing curricula from a global perspective [Wil16]. For learners, it is a tool for visualizing their position and progress within a degree, exposing both subjects and competences at the same level. In order to do so, we have chosen force-directed graphs [FR91], where nodes are subjects and edges are competences shared between subjects. Absolute positions of subjects within a graph are not important, while relative positions are expected to provide information about which subjects share more competences or none at all.

2.1. Data preparation

For a given degree, subjects and competences are related through a binary matrix where each row is a subject and each column is a competence. Each cell contains a binary indicator about whether a competence is developed in a subject or not. Therefore, subjects

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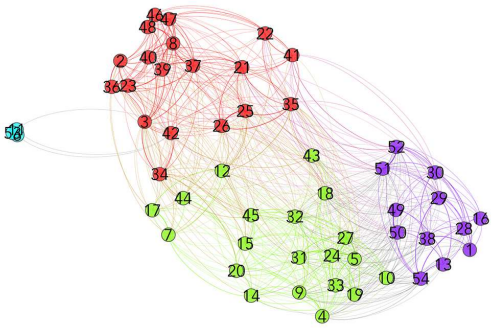

Figure 1: *Initial visualization of the Multimedia degree in Gephi.*

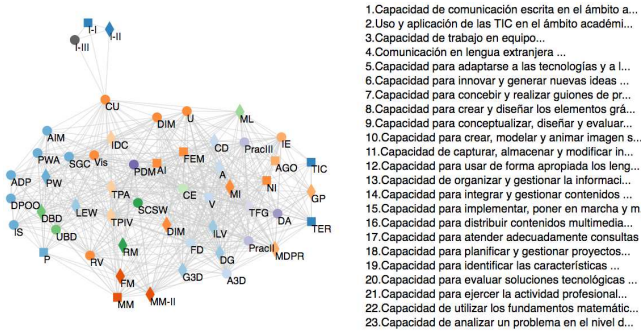

Figure 2: *Proposed visualization using* D^3.

can be seen as binary vectors sharing zero or more characteristics (i.e. competences), so a similarity measure can be established: the more competences share a pair of subjects, the closer they are (in a sense of competence development). Among all the possible similarity measures [CCT10] we have chosen Dice, which gives more importance to shared competences. Nevertheless, preliminary experiments showed that the importance of the used similarity measure is relative. The computed matrix of similarities between subjects defines an adjacency matrix that can be used to depict the intrinsic graph of relationships between them.

2.2. Preliminary experiments

Several static versions of the intented visualization were previously created using R (similarity matrix) and Gephi (graph layout), as shown in figure 1. We selected three different degrees (Computer Science, Multimedia and Design) to evaluate its potential as a new way to visualize a curriculum [BSMM14]. In this case, node color was automatically assigned according to a modularity-based clustering algorithm, detecting misplaced subjects. These static versions were presented to several focus groups involving different stakeholders, namely learners, teachers and managers [LBI*12]. We obtained positive feedback but some issues were raised. For instance, to use acronyms instead of numbers for identifying subjects and color for denoting its knowledge sub-domain.

3. Our proposal

As the visualization is intended to be used as an application, we used D^3 for implementing it, taking advantage of its interactivity capabilities [BOH11]. The visualization is a prototype of a future enrolment tool that will help both learners and their mentors to measure and determine learners' progress within a degree, including a subject recommender system [GB14, CTC*15]. On the other hand, the tool can be also used by degree managers in order to supervise the creation of new degrees, ensuring no subjects or competences are left isolated [SMVM07, KAF*08, SRS13, Wil16]. For each subject, we have its name, acronym, type (basic, mandatory or optional), expected semester when it should be taken and its knowledge sub-domain, which determine some of the parameters of the visualization, namely node shape and color, as shown in figure 2. The graph is accompanied by the list of competences.

3.1. Desired functionalities

Subjects are identifed by its acronym, and a tooltip appears when hover the cursor over it. When a subject is selected, all other subjects related through one or more competences are highlighted, while the rest are faded out. Competences related to that subject are also highlighted in the accompanying list. The same happens if a competence is selected from the list. Obviously, it is possible to select more than one subject or competence at the same time. For teachers and managers, subject position and color provides a clear idea of misplaced subjects according to their competences. Position also reveals "central" and "peripheral" subjects, as well as subjects that may behave as "hubs". On the other hand, learners can easily discover the competences developed in a subject or the subjects where a competence is developed, individually or in groups of subjects or competences, respectively. The proposed visualization serves as a skeleton for superposing other information layers. For instance, for each subject or group of subjects, enrolment and assessment data can be shown, helping learners to identify problematic combinations of subjects that should be avoided.

4. Conclusions and future work

Nowadays, universities are adopting learning analytics and visualizations as new ways to measure and optimize all the processes related to their activity. For instance, by helping learners to better understand their positioning within a degree and their available choices during enrolment, taking into account not only subjects and semesters but also competences. We have used D^3 to create an interactive protoype that helps both managers and learners to visualize a degree beyond the traditional textual information based on tables and lists. The visualization groups subjects according to the competences they share and makes navigation between subjects and competences easier, helping users to explore and interact with a curriculum combining both dimensions at the same time. The prototype can be found here: http://oer.uoc.edu/VIS/EUROVIS2017/.

Current and future research in this topic includes a formal evaluation [LBI*12] of the proposed visualization with its different stakeholders, before it is deployed as a new tool available to all the university's degrees. Then, we expect to add further functionalities in order to obtain an enrolment recommendation system for learners and a degree design and analysis system for managers.

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