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The Bologna Declaration and the Evolution of Telecommunications Engineering Education

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Nowadays, we are witnessing a joint effort of several European Union members that will possibly give rise to an important new pan-European change in higher education. Since its origins, the European Union has faced diverse integration initiatives. For the reader, the most evident ones will mostly be related to economics: the progressive integration of European economies and, of course, the adoption of the Euro currency. Other examples are the universal health care system (all Europeans are covered everywhere) or the (controversial but insistent) efforts to create a European army.

In order to harmonize some crucial Bologna goals (mobility and foreign student enrollment via highly similar programs everywhere) with industry needs, it is necessary to replace the old telecommunications engineering degree by a reasonable number of separate specialized degrees.

Soon the European Union will have 25 members, including many Central and Eastern European countries, and it is working hard toward the first European Constitution. Among these great achievements, we must cite that European citizens are free to move and get a job anywhere inside the European Union without the need of work permits. However, curricula interpretations are left to the employers: each country has its own higher education system, and the differences may be considerable.

In this context, the Education Ministers of the United Kingdom, France, Italy, and Germany launched the Sorbonne declaration in 1998. That declaration proposed the creation of a common higher education system. Next, the Bologna declaration (1999) had similar content, but it was signed by authorities from 29 European countries. It was the beginning of a new educational challenge. According to the document "The Bologna Declaration on the European Space for Higher Education: An Explanation," prepared by the Confederation of EU Rectors' Conferences and the Association of European Universities (CRE), the Bologna declaration is "a commitment freely taken by each signatory country to reform its own higher education system or systems in order to create overall convergence at the European level." The same document states that the Bologna Declaration is not a reform imposed on national governments or higher education institutions, and surprisingly declares that "Any pressure individual countries and higher education institutions may feel from the Bologna process could only result from their ignoring increasingly common features or staying outside the mainstream of change." We agree with this statement regarding countries, but the case of institutions is totally different. Indeed, institutions will have to face transience due to the abrupt change, and it is not fair to accuse them in advance!

In this article we often refer to a second relevant document, "Career Space Curriculum Development Guidelines," generated by the European Commission and a consortium of:

- Major European IT companies — the market view: Siemens AG (chair of the working group), ICEL (project management and coordination), British Telecom, Cisco Systems, IBM Europe, Microsoft Europe, Nokia, Philips Semiconductors, Telefonica SA, and Thales
- The European standardization body CEN/ISSS
- Representatives from 25 European universities (the only exception the University of Haifa, Israel, which was part of the consortium as a guest of IBM)

The Career Space document analyzes the needs of the IT (electronics, communications, informatics, telematics, etc.) industry and the skills expected as a result from IT degree holders. It proposes 13 curricula structures for IT profiles, composed by specific courses and their weights.

The influence of industry is obvious in the Bologna process. According to the aforementioned EU Rectors'/CRE document, the Bologna declaration is a consequence of "European higher education systems ... facing ... challenges related to the growth and diversification of higher education, the employability of graduates, the shortage of skills in key areas, the expansion of private and transnational education, etc." It is interesting to analyze this statement.

- The "growth and diversification of higher education" is likely related to the burden they impose on student mobility.
- Two reasons are related to industry needs (employability and shortage of skills).
- Regarding the expansion of private and transnational education, the authors consider that the former is not a good reason for deep changes. It is obvious that private education and public education systems have different motivations. Public education should not be inspired by the strategies of private education. Certainly, public education must analyze the context that generates the strategies of its private counterpart and make its own decisions accordingly. On the other hand, transnational education is a good reason for change. However, it is not that expanded in Europe. As in

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the case of the United States, students and employees have a continent-sized area to move around and a healthy underlying economic system. Nevertheless, Europe will need decades to create the same level of cultural homogeneity as the U.S. experiences. Not even mentioning language diversity! Therefore, transnational education must be promoted at the same time as other issues related to the Bologna declaration, to enhance better mutual understanding.

The Bologna declaration pursues a common European Higher Education Area (EHEA). It is well known that the European Union begins challenging lines of action or tendencies that are not enforced but difficult to ignore. Thus, in the Bologna model, each European country will ideally maintain its educational autonomy. Although Bologna declaration supporters claim that it is not a path to standardization and respects the fundamental principles of autonomy and diversity, it explicitly aims at convergence. As in the U.K. Euro case, the entrance in the common EHEA will be postponed by some, but decision makers will come back to the subject from time to time. And the EHEA will certainly ship, because several "large" EU countries already seem interested enough, Germany, Italy, and Spain among them. It is certainly worth mentioning that although France was a signatory of the Sorbonne declaration, it currently seems to dislike the picture emanating from the Bologna declaration. We will come back to this point later.

The key aspects of the Bologna declaration are:

- A comparable higher education degree system: No matter the institution that issues a degree, its scope and depth will be understandable everywhere.
- The adoption of European Credit Transfer System (ECTS)-compatible credit systems.
- The promotion of trainee (and trainer) mobility.
- A commitment to share future efforts to improve the quality of the system, and to maintain the integration philosophy as each country evolves within its implementation of the Bologna declaration.
- The system will be based on two consecutive degrees: a basic four-year degree, oriented toward satisfying average market needs, and a second two-year Master degree (the first degree will be compulsory to enroll in a Master program). The Master degree will offer higher specialization, possibly oriented toward highly demanding market needs and trends.

The expected European space for higher education should be ready in 2010.

The Master degree and doctorate will coexist. The Master degree will not be a requisite for the doctorate degree. Different rules will define how to access doctorate programs, depending on the previous one (basic or Master). Entering doctorate programs without a Master degree will possibly be the harder way.

Last but not least, the Bologna declaration contains a smart consideration of the competitiveness of European higher education. It wants to increase "the international competitiveness of the European system of higher education" and "ensure that the European higher education system acquires a worldwide degree of attractiveness." This is an implicit reference to the extraordinary success of the U.S. higher education system in attracting bright brains, boosted by the easy transition from academia to jobs from an administrative point of view (which was massive in the IT field in good times). The EU Rectors'/CRE document has a call for European institutions to compete more resolutely than in the past for students, influence, prestige, and money in the worldwide competition of universities.

Of course, the capacity of the Bologna philosophy to stimulate competence is a controversial issue. For bright students coming from third world countries, it is mainly the possibility of Western economies to offer creative jobs and a good standard of living that really counts. Competence will not necessarily be stimulated by being uniformity imposed by the Bologna declaration. Probably a well funded (and nonexistent) pan-European scholarship program would be more effective. If the good students are given the opportunity to move around, they always find their place in any system, regardless of the higher education system from which they come. The United States is, again, a good example.

Signatory countries are already facing legislative actions in their higher education systems. For, example, in the case of Spain, the Ministry of Education, Culture and Sports has recently submitted to the University Coordination Council (Consejo de Coordinación Universitaria) diverse regulations on the new degree structure (following the spirit of the Bologna declaration, and officially including the two-year Master degree and the degree supplement, a guide for any employer to understand it), and has publicly presented the conditions to simplify the recognition of foreign titles and expressed a commitment to fulfill the Bologna goals in 2010. Spanish regulations will favor collaborations between departments at national and European levels, to establish joint Master or doctorate degrees, or even a combination of them.

The new educational structure in the Spanish system can be a good example of Bologna-based higher education system implementation. It will be as follows:

1. A first four-year (in some cases three-year) degree. Engineering titles will belong to this category. Thus, it should be a sort of industry-oriented specialized degree, instead of the five- or six-year traditional engineering titles. (These were also specialized, but with a vast background; will an engineer without a vast generalist background succeed?) For a given degree, all programs will have 70 percent of courses in common, in order to stimulate student mobility (program contents will easily be recognized by other universities).

2. There will also exist a one- or two-year Master degree and a doctorate degree. The Master degree was previously present in some European countries, but it was not an official degree in Spain. (Some private institutions offered "master" degrees, usually in business, and some of them were very prestigious. It will be interesting to watch the competence between those unofficial "masters" and the official Masters in the public system, since they will probably coexist for a while!) The ministry describes specialization Masters and research Mas-

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(1) Computer science	(2) Integrated curriculum	(3) Information technology
Software architecture and design	Systems specialist	Radio frequency (RF) engineering
Software and applications development	Multimedia	Digital signal processing (DSP) applications design
IT business consultancy	Data communications engineering	
	Integration & test/ implementation & test	Digital design
	Product design	Technical support
	Communications network design	

Table 1. *Traditional Career Space clustering.*

(A) Computer science (software)	(B) IT systems	(C) IT networks	(D) Electrical engineering (information technology)
Software architecture and design Software and applications development Multimedia	Systems specialist IT business consultancy Integration and test/ implementation and test	Communications network design Data communications engineering Technical support	Radio frequency (RF) engineering Digital signal processing (DSP) applications design Digital design Product design

Table 2. *Career Space area clustering.*

ters. The latter will replace current doctorate courses. This is an interesting Spanish interpretation of the Bologna tools, seeking to stimulate the doctoral option. Nowadays, in EU countries without a strong IT industry, the doctorate is only profitable for people seeking an academic job, since industry does not demand doctorates. Unfortunately, the demand for research Masters may also be low in those countries, and therefore, the advantages of people holding them may be relative.

Spanish universities will not be allowed to start programs following the old model after September 30, 2003. A new catalog of official programs will be prepared starting October 1, 2003 and finishing by the end of 2006. Universities will start teaching those programs in fall 2004, and the entire educational system will follow the Bologna model in 2010.

The Impact on Telecommunications Education

As previously mentioned, the Career Space document defines 13 IT profiles, or Generic Skill Profiles, which we list here:

- Radio Frequency (RF) Engineering
- Digital Design
- Data Communications Engineering
- Digital Signal Processing Applications Design
- Communications Network Design
- Software and Applications Development
- Software architecture and Design
- Multimedia Design
- IT Business Consultancy
- Technical Support
- Product Design
- Integration and Test/Implementation and Test Engineering
- System Specialist

Some of these clearly belong in the scope of telecommunications: RF engineering, data communications engineering, digital signal processing applications design, and communications network design; and others are closely related: digital design and technical support, for example.

Of course, there is no official relation between the Career Space document and the Bologna declaration. In preparing the new programs there will be all types of interests involved, including group interests, inertia (minimum adaptation of existing staff and programs), and the like. It could be argued that those institutions not doing their homework will have fewer students (e.g., nobody will pay for their Master courses). However, note that for the sake of mobility, programs will have many courses in common! Therefore, programs (or at least their "national" or "European" part) must necessarily be prepared by open consortia representing all tendencies, or at least by open-minded independent professors and professionals.

Here we are mainly interested in telecommunications profiles. Some Career Space profiles belong to three "traditional" telecommunications categories in Spanish higher education: electronics (digital design), communications (RF engineering and digital signal processing applications design), and telematics (data communications engineering and communications network design).

It is interesting to compare this "traditional" Spanish clustering with those provided by the Career Space consortium.

1. "Traditional" Career Space clustering (i.e., clustering according to traditional curricula) (Table 1):

The Career Space consortium considers that "Clustering in this way, group (1) and group (3) represent the wide area of existing ICT (Information and Communication Technologies) curricula whereas group (2) would include the innovative area of new ICT curricula which tend not to exist at present, but which are urgently needed to meet a high demand from industry for graduates with particular specialized qualifications."

2. Career Space "area clustering": Computer science (software), IT systems, IT networks, and electrical engineering (information technology) (Table 2):

In this clustering, we observe that technical support has been wisely added to IT networks. Remember that these profiles are demanded by industry, and it is evident that technical support is a key complement to the other two "traditional" telematics profiles (e.g., for system managers).

It is interesting to point that the Career Space document has frequent references to "institutions" preparing their curricula following their recommendations. In a "Bologna-ed" Spain, as possible in other European countries, there will be little margin left for that, since there will be little independence left to institutions when preparing their programs. Thus, there is an interesting contradiction in the Bologna declaration: it stresses national independence, but requires strongly centralized regulations in each country to start the machine, affecting local independence!

We can extract two conclusions from Career Space clusterings:

- First, clusters 1-2 and 1-3 are similar to 2-C and 2-D, respectively, and would correspond to Spanish telematics (especially 2-C) and communications (especially 2-D), as defined above.
- Second, it is necessary to create several programs in telecommunications to cover industry needs (perhaps three?). Due to the constraint that specifies a high number of shared courses to promote mobility, a single program would either i) be too generalist and perhaps not useful in the sense that it would force students to take the Master degree to achieve specialization, which is clearly against the Bologna philosophy (first degree adapted to market needs) or ii) favor one of the clusters above and either discard the others or include a minimum amount of their contents in the favored one, which is simply absurd.

Now we can take a look at traditional "long" telecommunications degrees to see how far they are from the Bologna model. In Spain and France, engineering degrees used to offer a vast background and a medium level of specialization.

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In fact, the Spanish model was inspired by the French one (Grandes Ecoles). Specialization took place in the last two years or so, and all engineers had a reasonable amount of knowledge of everything: they could change fields if required. The effort to do so was reasonable, and industry benefited from it (is the Bologna model too oriented to "high" economic cycles? Note it was launched in 1999!). On the other hand, three-year degrees had a high level of specialization. Completing a five-year degree starting from a three year-one was possible, but not immediate (in some cases it required a whole additional year).

Therefore, the engineering degree in Spain was totally opposed to the Bologna model: a generalist education was considered important, and industry or anybody else should wait as long as necessary. The three-year degree (termed technical engineering, just for the sake of calling degree holders engineers and reluctance to call them simply engineers) was closer, as far as specialization and market needs are concerned, but everybody agreed that it was not enough: unlike in the United States, in Spain there are as many engineers as "technical" engineers (in the United States, most people with a higher education degree have Bachelor degree).

However, existing engineering degrees have worked well for a long time and enjoy job mobility worldwide due to their generalist curricula, hard work training, and reasonable facility to adapt to specialization in a limited time. Substituting them with Bologna-like ones abruptly has some unpleasant implications that should not be ignored:

- First, a change of mind in students. They will be called telecommunications engineers once they get the four-year degree and will find a job shortly afterward. Inevitably, Master students will be a highly motivated minority, competing for a limited number of job offerings in major IT industries.
- As a result, many telecommunications schools will be unable to maintain a Master degree. This means that many university researchers (young researchers) that have a temporal contract will be fired, since staff boards will be overpopulated by tenured people. Thus, there will be a contradiction between the EU higher education system and the EU research system, where a lack of researchers is evident.
- Most well established professors will be responsible for the incoming challenges, but there will inevitably exist some degree of educational inertia: regardless of official program contents, some professors will try to perpetuate the same lectures they gave in the old system.
- On average, the industry may tend to reduce reference salaries (an important component of many European social systems) in an scenario in which most engineers have the "low" degree and few have the "high" one (especially in countries without a strong IT industry).

For these or similar reasons France is not clearly supporting the implementation of the Bologna declaration. Some Spanish engineering communities (e.g., civil engineering) are also skeptical. There is plenty of room for controversy. It is always instructive to compare Europe and the United States. Take, for example, the following words, quoted from J. M. Tien, IEEE Vice President Educational Activities, "Time to Think about a Master's of Engineering," *The Institute*, June 2003:

"I propose restructuring the U.S. undergraduate and graduate degrees into a professionally oriented program..." (so far, Bologna-friendly) "...based on a five-year European model such as the Diplomingeniur program in Germany, which includes writing a master thesis similar to that required by the current U.S. master's of business administration degree."

This is the closest description of the current five-year Spanish telecommunications engineering program!

Conclusions

The Bologna declaration will have immediate impact on a large portion of European higher education systems. In order to harmonize some crucial Bologna goals (mobility and foreign student enrollment via highly similar programs everywhere) with industry needs, it is necessary to replace the old telecommunications engineering degree by a reasonable number of separate specialized degrees. Inevitably, this will mean higher educational costs (different programs can share resources only to some extent). European educational authorities should not enter the Bologna declaration way if they are not willing to pay the price. Regarding this issue, it is worrying to notice that instead of taking direct responsibility for the degree catalog, the Spanish Ministry of Education has outsourced the problem by funding some university consortia to study the possible titles of degrees (with degree unification and cost cutting directives in mind). The Agencia Nacional de Evaluación de la Calidad y Acreditación (ANECA) of the Spanish government initially decided to fund only 17 program committees out of 63 proposals. A single telecommunications proposal was approved, with the flavor of unifying the current existing electronics, telematics, and communications skills in a single degree. This seems against the logical specialization of science as human knowledge expands. Indeed, it is clearly against the Bologna spirit, and is not coherent with industry specialization requirements and new topics emerging in the IT field, as stated in the Career Space document.

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