

INTERNATIONALIZATION AND INTERDISCIPLINARITY OF ENGINEERING STUDIES: A EUROPEAN PERSPECTIVE

Carlos Rodríguez Monroy, PhD

*Professor of Business Administration, Universidad Politécnica de Madrid, Madrid, Spain,
crmonroy@etsii.upm.es*

Felipe Ruíz López, PhD

Professor of Business Administration, Universidad Politécnica de Madrid, Madrid, Spain, fruíz@etsii.upm.es

ABSTRACT

In today's globalized economy there is a growing need for adaptable and highly qualified engineers who can respond rapidly to unexpected changes in the companies' environment and provide the solutions or results that are required from them. It is generally accepted that engineers, besides having a sound technical knowledge and a certain degree of specialization, should be provided with a number of managerial skills which can be a very valuable asset in order to improve their professional performance.

A very ambitious initiative has been launched in the European Union which enables graduate engineering students from countries outside this geographic region to continue their technical education in top ranking European universities. Scholars from third country institutions are also invited to participate. Funds for scholarships provided by the European Commission are available through the *Erasmus Mundus* program. This program has been operating for a few years only, but some of the benefits for all the participants involved: students, scholars and institutions can already be perceived.

The value that derives from these multilateral exchanges is not limited to diffusion of technical knowledge but also includes other aspects of engineering education of fundamental importance in a global economy, such as exposure to different cultures, network building and cooperation issues, among others.

Key words: International Graduate Studies; Industrial Management; Globalization

1. INTRODUCTION

The International Master in Industrial Management (IMIM) aims at enhancing the quality of education of future engineers and managers in the domain of Industrial Management. Thanks to the cooperation of three leading universities in Europe, IMIM aims at increasing the level of internationalization of participating universities and make European education more competitive in a field that has been traditionally dominated by American universities.

The IMIM program was initially conceived as a proposal from UPM that after meeting with Stockholm's Royal Institute of Technology (KTH) and Politecnico de Milano (POLIMI) decided to design a Masters program which should have as one of its main objectives the preparation of students who already have a technical background

with business and managerial skills for an international career in industrial and service companies. Each of the three participating institutions would contribute to the program offering those courses in which it was considered that it had particular strengths. The main components of the IMIM program were designed and approved by the corresponding University Departments involved, and after agreement by the three Departments of the program as a whole was submitted to the universities' Rectors for approval.

In comparison with existing higher education programs, the proposed Master Program combines the teaching of social and economic sciences with managerial skills. It aims at offering education for engineers and managers who will be able to propose integrated approaches to industrial problems in Europe and third-countries, combining technological development and innovations together with the consideration of human, social and economic issues.

The Masters Course has been created from already existing courses. It is a relatively new degree but all three universities involved in the program have a wide experience in teaching those courses or similar ones. Even though IMIM is a young program, POLIMI, UPM and KTH have been exchanging students under the Socrates/Erasmus program for more than a decade. At graduate level the three institutions have also exchanged scholars.

The integration of management and engineering issues within the IMIM program actually addresses the new professional skills demanded by industry which now prefers enrolling engineers and managers who are able to design high level technological solutions while taking account of human related issues and socio-economic constraints. The objective is to contribute to European competitiveness with an improved dissemination throughout the world of new competencies and management techniques better designed for people and more acceptable to them and to society.

A broad foundation, comprising introductions to organizational behaviour, financial and managerial accounting, corporate finance and the function of capital markets, marketing, strategy and economics, are provided during the first semester. Building on this, the second semester further develops students' proficiency in operations, quality and supply-chain management techniques, and thus gradually strengthens the link between general managerial work and the challenges emerging in modern manufacturing and service operations. The third semester then comprises courses aimed at deepening some of the topics introduced during the first semester as well as developing a more integrated view of how various of these topics relate to one another. This includes advanced courses in management accounting, marketing and human resource management and application of previously taught topics in two integrative, thematic courses on project management and entrepreneurship. An introductory methodology course will also be given in preparation for the final semester thesis project.

During the final semester the students work in a company or research institution, applying what they have learned during the previous terms. Through this Master Thesis the students have to show their ability to build on what they have been taught, getting results and giving value to the company or institution where they perform their final work. The objectives, content and program of the final project has to be approved by the IMIM Scientific Committee, and is supervised by the tutor in charge of the student. The IMIM program will be supervised by this Scientific Committee which is composed of two representatives from each institution of the Consortium (UPM, POLIMI, KTH).

2. EDUCATIONAL OBJECTIVES

The proposed master course will contribute to increase European competitiveness in several ways:

- European students, European universities and European professors will get in contact with different European and third-country cultures, thus increasing mutual knowledge and understanding.

- European students will integrate more among them, thus facilitating a stronger common European feeling and view.
- Third-country students will disseminate their European experience increasing the knowledge of Europe in third countries and will be integrated in a network of contacts that facilitates socio-cultural and business relations between Europe and non-European countries.
- As IMIM is a master in industrial management, many students will be employed in industrial companies with an international profile. It is expected that IMIM students will be assigned positions within companies with responsibility to manage commercial contacts with European countries.

Graduates are increasingly expected to assume broader tasks and responsibilities than most technical universities have traditionally prepared them for. The IMIM program prepares students to work for industry or academia, in internationally-oriented working environments, where a solid background in state-of-the art technology is required, together with the ability to deal with other cultural, management and working practices. Depending on their internship during the fourth semester, the IMIM students may also be exposed to some research work, therefore getting an adequate experience to embark on a PhD program, if they choose to do so.

The internationally oriented education which the IMIM program intends to provide implies: a) the ability to work in international settings, with colleagues from different cultures, sometimes working together although physically distant in different countries or regions making use of the wide range of possibilities that Information and Communication Technologies can offer and b) the ability to understand industrial management problems as international issues which can benefit from the experience and expertise of different countries/regions and which often require a multinational approach.

Students receive a degree from each of the partner universities in the Consortium where they spend one semester. The degrees issued are according to national legislations and therefore the degrees issued are the same for all students successfully completing this program.

3. TEACHING METHODOLOGY

The instructors in the IMIM program, are mostly full-time professors. They have ample experience in the subjects for which they are responsible. In many cases they have developed part of their professional life in industrial companies and are therefore capable of offering the participating students solid theoretical knowledge together with a practical approach of actual management situations. Their curricula demonstrate both their excellence in research and their relevant competencies in industrial practice, as well as their international dimension. The core of the teaching staff is composed of well known professors in various domains. Professors are either members of the faculty staff of each hosting institution or they come for one or two weeks to give their courses.

The IMIM Masters Course is supervised by a Scientific Committee composed of one representative of each institution of the Consortium, designated as the local pedagogic supervisor. It is the responsibility of the Scientific Committee to decide about the admission of every candidate, the possible evolution of the IMIM program content, the students' graduation, as well as about any issue concerning the academic life of the Master course. For these reasons, the Scientific Committee meets regularly in one of the institutions of the Consortium on a rotating basis or through video-conference or multi-conference. Academic matters are the responsibility of the Scientific Committee, which holds regular meetings during the duration of the Master's program.

The central office (headquarters) of the IMIM program is located at the Escuela Técnica Superior de Ingenieros Industriales (ETSII) of the UPM in Madrid, which is identified as the coordinating institution. This is the place where all the official documentation on the program content as well as on the students' applications is collected and registered.

In order to be admitted to the IMIM program, candidates must have a degree or equivalent of at least 3-year university level from a recognised university or engineering college. Applicants are requested to fill in the IMIM application form available from the IMIM web site and enclose a curriculum vitae accompanied by the following:

- Documented evidence of a high proficiency in English language (verified by TOEFL scores or equivalent certificate).
- A certificate showing that the applicant has completed a minimum of three years of full-time study in a scientific or technical discipline (B.Sc. degree or equivalent).
- Recent GMAT or GRE scores.
- Two letters of recommendation signed by academic referees.
- Relevant work experience (verified by appropriate documentation) is not a requirement, but is considered a merit in the selection process.

Students spend one semester in each of the universities participating in the Consortium in the sequence indicated (first UPM, then POLIMI and finally KTH). During the fourth semester students may complete the requirements for their degree doing project work in any European country.

Scholars participating in the IMIM program can be hosted by any of the three institutions. During any specific semester at each of the participating universities, instructors from the other two universities will be asked to participate to give seminars or lectures in order to reinforce the students' perception that they are enrolled in a fully integrated program and not in three independent programs.

The IMIM program is built from the experience of already existing Master programs which have been designed to host an international population, bringing together students and scholars from Europe and from third countries as well. Most of the means which are to be used for IMIM to reach out to potentially interested third-country students and scholars are thus already in place. Actually, it is appropriate here to emphasize the strong international experience of all three hosting institutions.

For visiting scholars the admission criteria is based on qualifications and academic competence. The strengthening of links with the institutions from where the scholars come and the potentiality to disseminate the existence of the IMIM program among students are positive factors which are also taken into account. The selection process is to be competitive and managed by the Scientific Committee which takes overall responsibility for the evaluation and selection process. Decisions are to be made on the basis of the following criteria and data.

The CV of the candidate scholar is to be evaluated more specifically with regard to:

- The capability to carry out some teaching assignment within the IMIM Master course.
- The competencies in research, as demonstrated by his/her scientific publications and other realizations.
- The possibility to establish a partnership with the candidate's institution. Potentialities will be evaluated with regard to:
 - The capability of the candidate's institution to host European students, and the relevance of such co-operation.
 - The possibility to undertake joint research activities.
 - The possibility to jointly supervise the student during the project work in the fourth semester.

Scholars can participate in the program without being subject to any quota system. Their contribution is to be organised in location, time and duration so as to meet the student and academic requirements, as well as to maximise the potential for partnership, including common research projects.

The IMIM program has the following main learning objectives:

-the subjects taught

- the social, cultural and economic life in three European countries
- the living experience within an international, multi-racial, multi-cultural group

In particular, in order to fully exploit the first two, there will be a class coordinator in each institution. The class coordinator will be a staff member of the IMIM organisation, in charge of being the first interface between the students and the program. The class coordinator will be a clear reference point which will help and facilitate the students in profiting fully from their experience. Teaching staff will be available for answering specific questions after classes, in person, or via e-mail or using the virtual campus which provides a special “classroom” for each subject.

The international office in Madrid and those in the other campuses take responsibility of the operations when students actually enter the program and move from one campus to another. The IMIM central international office is and remains the main reference point of all students.

The Consortium provides all students with local language teaching courses and other related services to assist them getting basic communication skills with the language spoken in the country where they stay.

As all the 3 universities are running other international programs, opportunities for IMIM student to meet other International students are organized. The presence in IMIM classes of Italian, Spanish and Swedish students foster integration with local student population so that students can get the most from the IMIM experience. In order for the students to have the possibility to develop further connections and friendships with local population, opportunities to develop home-assignments and projects with local students of the same level are organized.

The language policy applied within the Consortium is clearly aimed at ensuring accessibility to an international top-level Masters program, at upgrading the visibility, attractiveness and competitiveness of European higher education world-wide, and at promoting dialogue and understanding between peoples and culture. Accordingly, the language of instruction is English which nowadays is the language of science and technology and the language of communication among industry managers who are active in a global economy.

Each student is given the opportunity to learn the language spoken on each campus where he/she spends a study period. Local language courses are offered at each location with schedules which are compatible with the core courses of the IMIM program. They also have the opportunity, but not the obligation, to take additional courses in matters related to the IMIM program in the local language of all three participating universities.

IMIM is a new and joint program, thus requiring itself a specific evaluation. Three mechanisms are planned. Two of them are short-term oriented. The third one is a periodic global evaluation, under the responsibility of the Scientific Committee, whereby every four years, the Scientific Committee will add four external persons to its standard composition: two representatives of industry, one academic and one IMIM graduate, with the mandate to proceed with a global examination of the IMIM program. This enlarged Scientific Committee will take into account the cumulative outcomes of the evaluation of courses, the percentage of students who graduate, the information available on their professional position after the Masters, the number of students enrolled in a PhD program, the number of papers written by the Masters students and accepted in conferences, etc.

In addition to the periodic global evaluation the Consortium commitment to quality is to be assured, on a continuous basis, thanks to two mechanisms. The first one is the assessment and evaluation of all IMIM courses and instructors by the students. Students are asked to fill in periodically a form to evaluate the lectures. They have to judge the quality of lectures as concerns: validity of lesson content and information given, contribution of the professor to the learning process and usefulness of course material. Furthermore they will be asked to self-evaluate previous knowledge of the subject studied. This frequency of the evaluation process has two main advantages. First of all, students remember well the topics of the lectures and secondly it gives the chance of taking quick suitable countermeasures if problems arise. Every subject and the instructor responsible for it will also be evaluated when it has been completed. Particular attention is paid to the informal contacts between the

students and the class coordinator. This informal communication, which is supposed to be of a continuous nature, may be particularly effective in the early detection of incidents or problems that can be solved at an early stage without putting to risk the quality of the overall program.

Three levels of formal evaluation by the students are considered:

- a) Individual subjects and instructors
- b) Semester evaluation in each of the universities of the consortium
- c) The whole program including practical experience

The second mechanism will consist on the meetings that local coordinators are going to organize at the end of each semester in each hosting institution, whereby they will collect "immediate" comments and recommendations about the teaching and the life of the program. A synthesis report will be addressed to the Scientific Committee. Students are asked to evaluate the period as a whole as concerns services provided by the universities (international office, housing facilities, coaching and counselling, welfare services, language courses, activities aimed at social integration, other support measures). Third-country students and scholars take part in this common approach but the Consortium pays specific attention to matters related to their condition such as assistance in obtaining visas, financial aid, accommodation and cultural integration.

Particular attention will be paid to the implementation in the quality assessment mechanisms described above of the best practices which exist in each of the universities participating in the Consortium with the aim of consolidating a philosophy of continuous improvement.

Regular coordination meetings among the members of the Consortium are held in each of the universities, rotating the venue in the same fashion as the meetings that have taken place since the year 2000 when the IMIM program was first designed. The frequency of these meetings has been determined in the past by the needs of the program and is now three meetings per year (one at each participating university each year). Together with these meetings other communication mechanisms such as video conferences or conference calls have been used extensively. Scholars are invited to participate in the coordination meetings. One of the results of coordination is a common evaluation system.

Also data about students performances and difficulties are exchanged among the members of the Scientific Committee, so that the second and third institution hosting the master already know the previous difficulties and troubles faced by students and therefore can take suitable countermeasures to have the students give their best. One further way to strengthen the cooperation among the universities in the Consortium is the exchange of instructors so that in any given semester in one university instructors from the other two can do some of the teaching in the way of seminars, lectures or specific classes.

4. RESEARCH ACTIVITIES

All IMIM courses are taught by professors who are active in research, fundamental or applied to industry problems, in several fields of Management. The scientific excellence of all the Consortium members is supported by the number of first-class publications resulting from their research.

The scientific and research experience of the instructors from the three universities in the Consortium is applied to the contents of the Master program. In many cases the Master thesis can be linked to research. Scholars participating in the IMIM program could also make their contribution in their area of research, being this one of the elements that will be considered in the selection process.

A large part of the material that is taught in this Masters Course is linked to research activities within the Consortium and in other research teams/organisations. This is obviously necessary due to the rapid development

and innovation of management methods. All that requires a regularly updated teaching material which will be developed by professors through their research activities. These activities are not only fundamental or basic research. They also include applied research which is carried out in the frame of commercial contracts which already exist between different departments of the universities integrated in the IMIM Consortium and a wide range of companies in the industry sector.

One mechanism which has been designed to expose IMIM students to research activities is having mid-semester presentations by instructors and scholars about the research projects in which they are involved. Students can detect this way areas of interest which they can pursue during the fourth semester or upon completion of the IMIM program if they decide to devote their efforts to a career in research. In some cases IMIM students will be allowed to participate in research-related tasks whenever this possibility is considered acceptable by the Scientific Committee. The IMIM studies grant access to Doctoral studies

5. RESULTS

Students will have the chance to experience the richness and cultures of single countries; on the other side, moving from two universities in Southern Europe to a university in Scandinavia to attend closely linked parts of the same course will foster the perception of Europe as a single region. Furthermore, during the Masters course, examples and case studies will be given to illustrate the social, cultural and economic characteristics of Europe.

Offering a study program at the Masters-level that implements such an integrated approach is only feasible in the context of an international collaboration with an appropriate financial support, i.e. an environment which provides the opportunity to bring together -from different countries- a significant number of highly qualified graduates and some of the best professors/researchers in the field concerned.

The IMIM Consortium has definitely also the potential for contributing to the development of European research competitiveness. It is designed to induce a cross-fertilisation of analysis, methods and solutions in the field of Industrial Management, that is to boost co-operation in research between the institutions within the Consortium, as well as between the Consortium and third-country institutions, all that in a crucial field for academia and industry.

Due to the international profile of the students involved in the program, IMIM will give the chance of creating an international alumni network with strong connections among people that will hold managerial positions in internationally oriented companies. This connection will strengthen the economic relations among European companies and between European companies and foreign ones.

One of the aims in the design of the IMIM program has been the adequate integration of the contents taught in each of the participating universities. IMIM has been designed as a joint program paying special attention to the full integration of the matters taught and to avoiding overlaps among the three institutions. Furthermore, apart from the courses of the core program, students will have several opportunities to experience the life of three different European countries and the fact that students have to spend one semester in each country guarantees that there will be plenty of these opportunities.

The blend of theory and practice achieved through the use of the case methodology and also through the practical experience in an international company during the fourth semester is another example of good practice.

6. IMIM AS A EUROPEAN MASTER: THE ERASMUS MUNDUS INITIATIVE

In spite of its short life, the International Master in Industrial Management (IMIM) is experiencing a very strong demand from students seeking to be accepted into the program. It offers an exceptional opportunity to study in a

truly multinational, multiethnic environment and trains students in the managerial skills which are so necessary for companies that are active internationally.

In 2005 IMIM was selected by the European Commission as a European Master within the *Erasmus Mundus* program. *Erasmus Mundus* is a cooperation and mobility program in post-graduate higher education financed and managed by the European Commission in which more than 200 European universities are participating. It aims to promote the European Union as a centre of excellence in learning around the world, by attracting high quality students from countries outside the European Union to register for Joint Masters Degrees.

Except for the geographical balance required by the *Erasmus Mundus* program itself no special conditions apply to third-country students and the common admission criteria are applied. The Consortium considers that specific assistance should be given to third-country nationals based on cultural differences and in areas such as obtaining visas, counselling on professional perspectives, search for accommodation, etc.

The criteria applied by the European Commission for selecting IMIM as an *Erasmus Mundus* program were the following:

- 1) The objectives of the master course are clear and convincing, the academic quality of the program, including the quality of teaching staff, meets the required standards for European Master programs. The program shows a high degree of integration, which is reflected through well designed study paths at three universities and joint activities in program development and management, through a Scientific Committee and its sub-groups. The existence of a central office at a coordinating institution and a central information and application point is a good example of a well thought out organization of Consortium.
- 2) Very positive, strong links with business life are also demonstrated through the management structure (representatives from private and public sectors join the Scientific Committee). Very good cooperation between the university and the business world.
- 3) Innovative management in cooperation with business and student representatives.
- 4) The added value of the Master has been also increased through links with research in a real business world (project work in a company).

For the academic year 2006/2008, which is the first edition with Erasmus Mundus qualifications, 170 applications from third country students were considered, out of which 26 applicants have been selected to participate in the program as shown in table 1.

Table 1: Erasmus Mundus accepted students

Asia	N.º	Latin America	N.º	Africa	N.º	Europe	N.º
India	7	Brazil	3	Kenya	1	Russia	1
China	4	Argentina	1				
Pakistan	1	Mexico	1				
Nepal	2	Ecuador	1				
Thailand	1	Peru	1				
Malaysia	1						
Uzbekistan	1						

For the forthcoming edition a large proportion of third country students will join the program. However, as can be observed from figures 1 and 2, there is a large majority of Asian students responding to the European Union's policy of fostering European higher education among specific Asian nations. Two aspects need to be corrected in

the future: the lack of candidates from continents other than Asia and Europe and the decreasing percentage of female candidates.

The possibilities to multiply these exchanges and share methodologies and learning experiences is further enhanced with a new initiative that allows a significant number of European engineering students and scholars to broaden their academic and professional horizons in third country partner institutions with which agreements have been signed. The third country institutions host the European students and scholars for specific courses which complement or add value to courses already taken in the home institution and very often provide the means to perform research in specific projects.

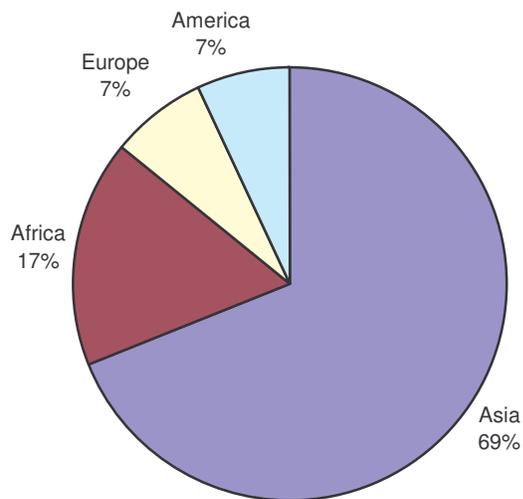


Figure 1: Erasmus Mundus applicants for IMIM 2006/2008 by continent

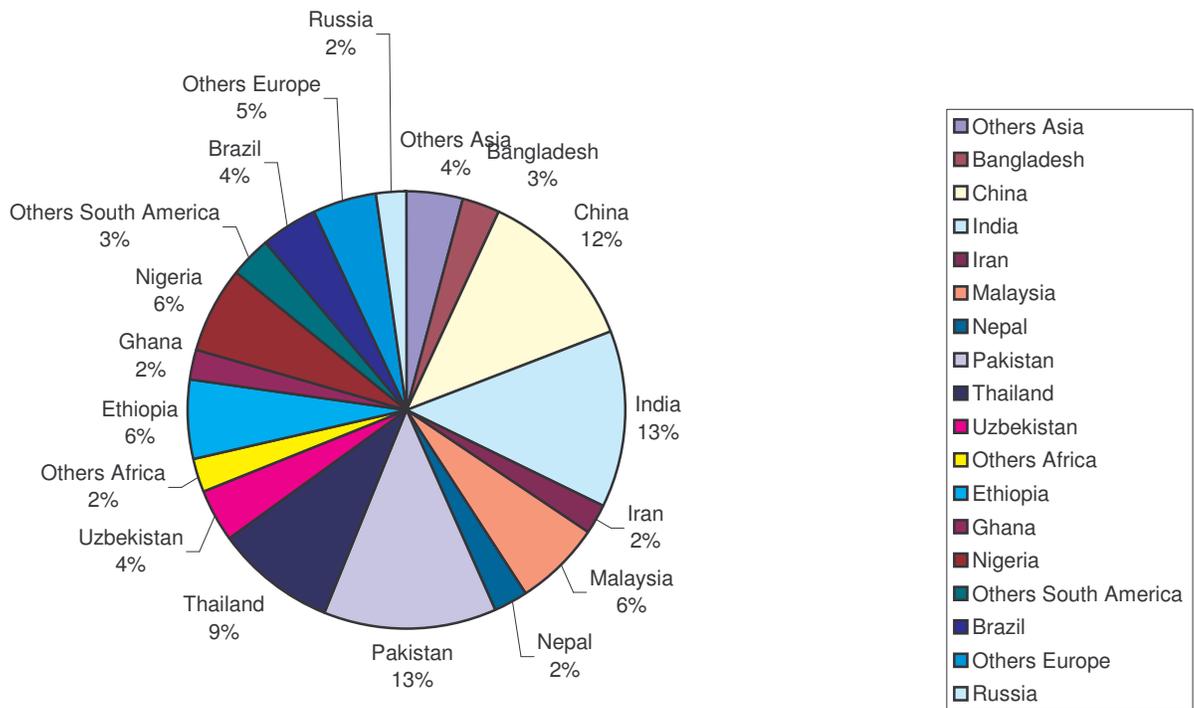


Figure 2: Nationalities of Erasmus Mundus applicants (2006/2008)

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