Design of a methodology to update the curriculum contents in CIM technology in the Industrial Engineering degree of Spain

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Abstract

Nowadays the curriculum contents design in Spanish universities considers only the didactic vision of the faculty experts, and expects a successful output related with what they appreciate as the employer's needs. No assessment methodology has been performed to "listen" what employers expect from graduates in the design of the studies of technological degrees.

The quick technological development, integration and globalization are causing changes in industrial companies. Companies need changes in their systems of internal/external activities management, organization and architecture. These transformations are based on 3 axes: Technological, Quality improvement and Human Resources. CIM (Computer Integrated Manufacturing) has arisen to allow the needed technological transformations; the improvement of the planning processes, programming, production control and automation. CIM helps to achieve a more flexible and advanced management of enterprise resources.

Many manufacturing companies have implemented CIM as a way to improve their competitiveness. This implementation implies the human resources training and education. Graduated Spanish Industrial Engineers could be destined to develop their activity on CIM plants, and they should be able to demonstrate knowledge and abilities related with CIM. The staff qualification demand in CIM industry should be completed, mainly, in universities and professional training centres. The Curriculum design for engineers dealing with CIM should consider customers needs (employers and students) and university vision.

The methodology described here is expected to guarantee a curriculum design taking into account industry (employer) participation, besides university perception, so that the graduate has the professional qualification expected by CIM Industry. It is intended to be the translator of demands (industry, education) in curriculum contents suggested and prepared by faculty with didactic criteria. It uses methodologies like QFD (Quality Function Deployment) and Delphi, and use complementary tools like Surveys, Affinity Diagrams, AHP (Analytical Hierarchy Process), etc.

Some results are presented after the study of real case: Curriculum Design for CIM Education in Industrial Engineering Degree (Ramon Llull University –IQS, Barcelona), having considered Bologna Process.

Keywords: Assessment methods, Curriculum design, CIM, QFD, Delphi.

1 INTRODUCCIÓN

The complexity of the manufacturing industry nowadays requires setting about its management and organization around three main axes: technological development, quality improvement and the organization of the human resources.

To allow the integration of the three axes, in the 80's, CIM (Computer Integrated Manufacturing) arose. CIM allows not only a significant improvement of the planning, programming and control processes, but also the stock up, manufacturing and quality activities. When applied, CIM helps to obtain new manufacturing processes more advanced and flexible than traditional ones.

Every new technology requires training and education of human resources dealing with its implementation. Due to the characteristics of the CIM technology, engineering programs dealing with manufacturing are expected to perform this education and training activity. But not always universities design their engineering programs considering outer demands. Effective tools and methodologies are needed to help those who take the decision of matters and contents in an engineering curriculum. That is the main objective of the research work presented here: to design a methodology that considers students interests, employers' expectative and faculty vision of how to teach the matter.

The Curriculum design of a university degree is rather new in Spain. Often, this curriculum design is made only with didactic and pedagogic criteria; with no, or little, quantification of industry requirements. A methodology is proposed here to put up to date curriculum contents of what in Spain is called Industrial Engineering. It has to be mentioned that Industrial Engineering in Spain is a wide program of five years that is different from what is understood in other countries by this name. It is not only a management and organization degree, but also involves mechanics, electrical, chemical, energy, transportation, project management, and others. With the Spanish university undergoing the Bologna process, an opportunity to assess the adaptation of the industry requirements (as employer) to the academic requirements arises.

As a practical case, the proposed methodology is applied to the curriculum contents assessment dealing with CIM in the Industrial Engineering degree of the Higher Technical School IQS, University Ramon Llull, Barcelona, Spain. The inputs are taken from IQS students, faculty from Ramon Llull and other Spanish universities and CIM industry located in Spain.

1.1 CIM in the Spanish industry

Computer Integrated Manufacturing is a way of coordinating the elements participating in a manufacturing process: PLM (Product Life Management) tools, management and organization methods and technology applications (robots, flexible manufacturing cells). The objectives of CIM go further than partial application of automation technologies; is a long term project of great complexity that involves both technical and organizational structures. Its application produces proven benefits (qualitative and quantitative), and that is why competitive manufacturing industries apply it.

In the 90's, the Spanish government approved a group of incentive policies to improve the technological innovation in the industrial enterprises established in the country; CIM has been the most demanded improvement in manufacturing companies. The election of CIM responds to the benefits obtained after its application. The quantitative benefits: efficiency, productivity, inventory management, materials flow management, besides qualitative benefits: flexibility, better internal communications, better perception of the company, innovation management, better quality management, etc.

Many of the companies that decided to implement CIM were asked to participate in this research work to consider their perception of what should be taught at the university.

2 Design of the proposed methodology

The proposed methodology combines several methods and tools in order to obtain the required information. Uses the following tools and methods:

Methods: Delphi, rotary Delphi, QFD (Quality Function Deployment), AHP (Analytic Hierarchy Process).

Tools: affinity diagrams, Blitz ®, surveys, hierarchy diagrams, tree diagrams and statistics.

The objective of the design of the methodology is to suggest curriculum contents for the industrial engineering degree to satisfy those requirements, referred to CIM and considered essential, that companies expect from graduates. Besides, it takes into account the requirements of experts in teaching matters related with topics dealing with CIM.

The proposed methodology "listen what the client has to say" interpreting the necessities of human resources education that companies expect from the qualified staff dealing with CIM. A real case study is presented to prove the convenience of the proposal.

Some outlined characteristics of the proposal are:

1. Objective of the research work: Design of a methodology to update curriculum contents.
2. Case of study: Updating of the curriculum contents, dealing with CIM, in the Industrial Engineering grade of IQS, University Ramon Llull.
3. Product or service to which is applied: Curriculum of the Industrial Engineer graduate.
4. Beneficiaries: Companies applying CIM (external clients) and students (internal clients).
5. Transformation agents: Academic sector, that is in charge of preparing curriculum contents.

Topics 3, 4 and 5 of the previous list make a system inspired in that proposed by Akao [1], defined as evaluators system, see figure 1

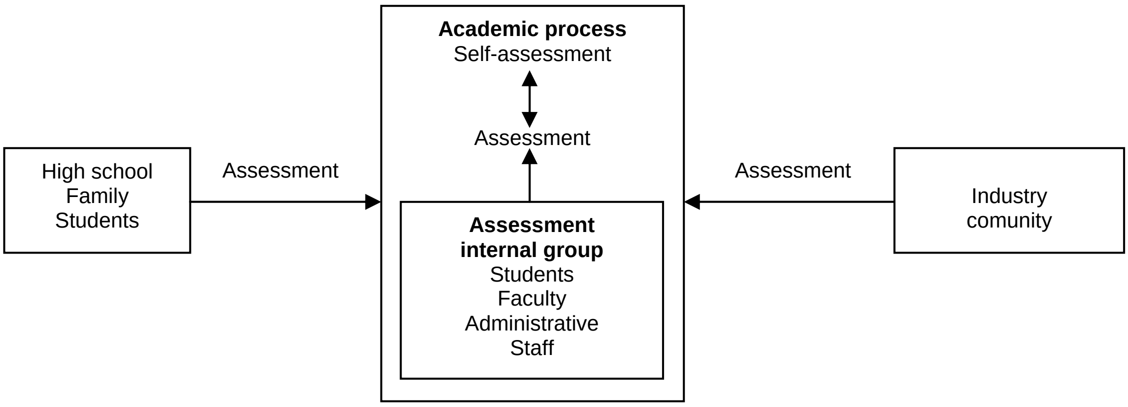

Fig. 1. Evaluators System (Akao, 2001)

According to the previous model, in this work a three stages development of the methodology is proposed according with figure 2:

1. Stage I: Obtaining of information about the profile requested from industry.
2. Stage II: Information of curriculum contents.
3. Stage III: Correlation between stages I and II and results analyzing.

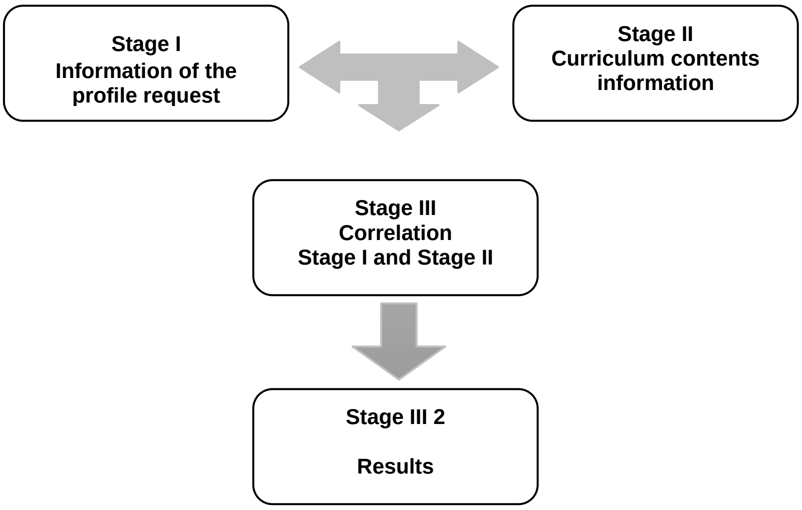

Fig. 2. Stages of the proposed methodology design

Stage I is intended to identify, define and characterize the requests of qualification that employers best value in engineers dealing with CIM in industry. In this stage should be defined the characteristics of the

expected professional profile that employers need in engineers who will work in companies applying CIM. The characterization is based upon future projection, development and relevance (economical, social, strategic, etc) of the demanding sector.
Stage II has the objective of identifying, defining and characterizing what information the Industrial Engineering degree should have, related with CIM. In this stage is studied the collected information of what is taught, when the contents arises, how knowledge is measured, what perception has a student of how much is learning and how does industry perceives the sufficiency of the knowledge of graduates.

Stage III makes a correlation between stages I and II to quantify how the qualification demand can be satisfied with the supply of curriculum contents that ensures qualification of human resources at the university. To make the mentioned correlation between stages I and II, QFD (7 matrices) and rotary Delphi with industry and university experts participants are used.

Figure 3. shows de use of QFD and the definition of each one of the seven matrices that gradually approximate the curriculum contents to what is expected. A brief description of the matrices follows here. Matrix 1: Is intended to correlate knowledge, abilities and characteristics (valued by employers) in respect with its education. Matrix 2 correlates the prioritized topics for learning contents and the goals of the degree in which they will be taught. Matrix 3 should correlate the goals of the degree with the matters related with the studied contents. Matrix 4 correlates matters with the way they should be taught. Matrix 5 correlates how to teach with when should be taught (in which year of the degree should be included the topic). Matrix 6 correlates the sequence of appearance of the studied contents with the contents themselves. Matrix 7 correlates contents and the deepness and concentration in which they should be taught.

The 10 rows and 10 columns of the matrices are defined with questionnaires. Both, industry and academy participants value the rows, but industry participants evaluate each one of the ten rows independently (0…100% of importance) and academic participants use the same scale for the same group of rows, but the sum of the 10 concepts should be 100%. Every questionnaire used to define concepts includes a field to accept commentaries or suggestions.

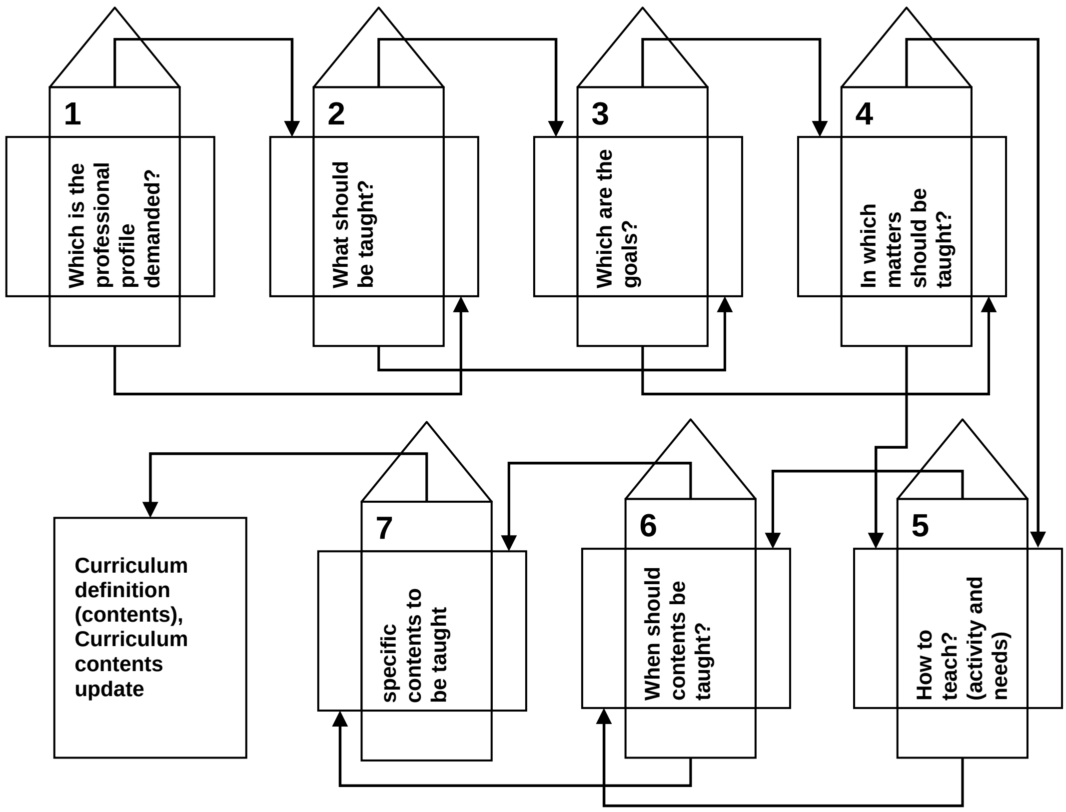

Fig. 3. QFD 7 matrices to define curriculum contents

Table 1 is a summary detailing the election of the tools selected to perform each activity of the present research and the identification of the stages and phases in which they appear.

Phase	Phase Name	Stage	Stage Name	Activity	Code	Activity Name	Tool
I	Information of the request	1	Identification of the product or service	1	1.1.1	Selection of product or service	Affinity diagram
				2	1.1.2	Listen the client's opinion	Delphi (previous results)
				3	1.1.3	Detect necessities of client	Blitz
				4	1.1.4	Characterization of the kind of client (CIM industry, familiy, student)	Mapping of local industry
		2	Study of Needs	1	1.2.1	Identification of the specific studied needs (use and needs of CIM technology in industry)	Industry survey
				2	1.2.2	Organization of needs	AHP
				3	1.2.3	Demand of qualification (professional profile required by CIM industry)	Affinity diagram
		3	Validation of the diagnostic	1	1.3.1	Determination of the current qualification (knowledge, abilities, characteristics)	Industry survey
				2	1.3.2	Measurement of the contents oriented to qualification (valuation of CIM in learning)	Tree diagram
				3	1.3.3	Measurement of the contents oriented to teaching (valuation of CIM in teaching)	Students survey
				4	1.3.4	Priorization of contents (measured contents of CIM)	Students survey
				5	1.3.5	Comparison of theoretical needs (estimated) vs. Surveys	Faculty survey
II	Information of curriculum contents	1	Curriculum information	1	2.1.1	Profile of the curriculum contents related with needs demand (CIM contents taught in the current Industrial Engineer degree)	AHP
				2	2.1.2	Organization of the studied curriculum contents (CIM learning and teaching)	TSC
				3	2.1.3	Identification of convenience of appearance, oportunity and didactic of CIM teaching	QFD (7 matrices)
III	Correlation	1	Correlation	1	3.1.1	Correlation between qualification needs and the way to achieve them	Rotatory Delphi (university and industry)
			Results	2	3.1.2	Statistical treatment of the achieved results	Dispersion, central tendency markers
		2		1	3.2.1	Interpretation of the results	Graphics
				2	3.2.2	Conclusions	Resuming table

Table 1. Summary table of tools and methods proposed

The application of the presented methodology has allowed the articulation between the university point of view as the supplier of the professional profile of CIM curriculum contents and the industry point of view as the demander of human resources of industries applying CIM. In stages I and II, a characterization of the supply (current curriculum contents referred to CIM) and demand (characteristics of the qualification required by industry) has been done. The meeting point of both parts is the development of knowledge, abilities and characteristics of the personality expected in graduates. For university, this meeting point means contents of the curriculum, and for industry means qualification of the employed graduate. Figure 4 presents the idea of the previous sentences.

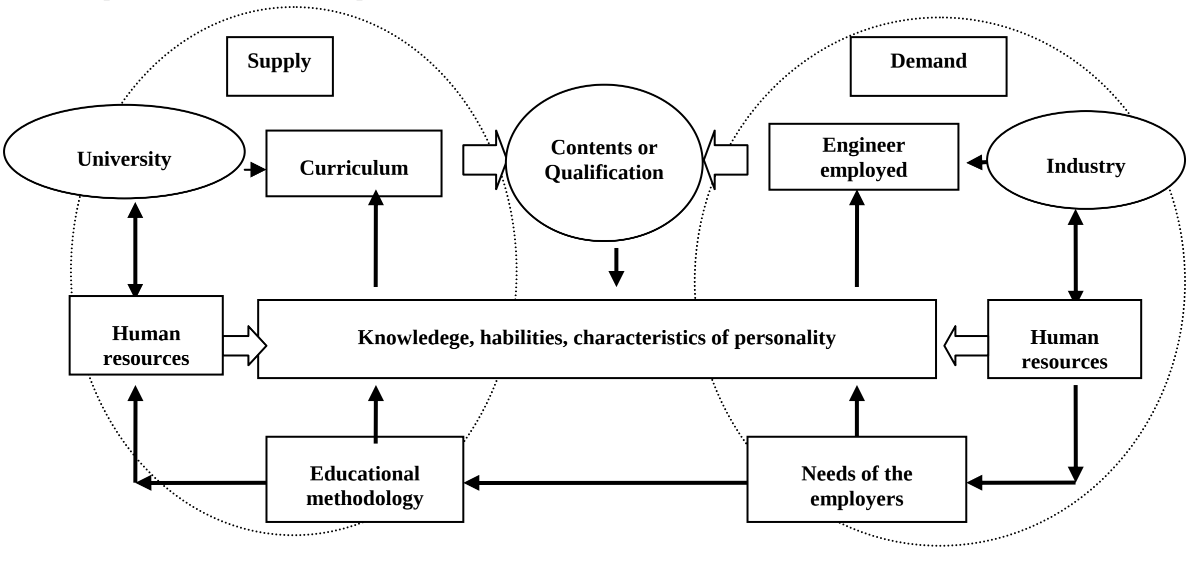

Fig. 4. Articulation between the university and industry points of view.

2.1 Results of the application of the methodology

The following results can be listed:

1. The polled companies have agreed that the proper way to maintain leadership is increasing efficiency, as they are technological companies related with CIM.
2. Companies recognize the importance of human resources, and its training and education, in achieving efficiency.
3. The polled Spanish CIM companies demand a graduate with a profile having the following knowledge, abilities and personality characteristics:

   a Knowledge: of computer assisted technologies (CAx), tools for decision making, integration technologies (Flexible Manufacturing Systems, Enterprise Resource Planning, CIM).

   b Abilities with: computer software applied in CIM, research methodologies, analysis methods (quantitative and qualitative), communication techniques, problem solving methods.

   c Personality characteristics: empathy and leadership, team integration, entrepreneurship, development under stress conditions, critical analysis and creativity.

4. The topics that academics and employer consider most important in the education of the future graduates in relation with CIM are:

   - Manufacturing processes, resources management (human resources, materials, waste, economics, etc),
   - Manufacturing technologies.
   - Infrastructure and resources organization,
   - Machine tools management and control,
   - Process planning and programming, etc (MRP, MRP II, 6Sigma, CAx, etc.)
   - Engineering information, management and control.
   - Industrial security.
   - Maintenance management.
   - Quality assessment, management and maintenance.
   - Vertical and horizontal integration of Computer Assisted process in the company
   - Manufacturing management.
   - Management of the industrial organization.

5. The main goals that academics must manage to let the graduates obtain the professional profile characteristics expected from CIM companies are:

   a Knowledge: ensure general knowledge of science and engineering, knowledge of engineering standards, problem assessment with systematic and interdisciplinary approach.

   b Abilities to: reduce and compile information, analyze, reformulate and solve wrong formulated problems, communicate and divulge technical information, solve problems integrated in a team.

   c Personality characteristics: creativity, self learning, professional ethics.

6 Matters, of the Industrial Engineering grade studied at IQS, that are most related with the goals of CIM technology learning are: Manufacturing Technologies, Industrial Organization and Companies Management, Projects, Applied Mechanics, Electronics, Advanced Manufacturing Process, Regulation and Automation, Operations Management and Company Management and Computer Aided Design. Both, academic and industry experts, agree with the selected matters.

7 According to industrial and academic experts related with CIM, matters mentioned above should be taught through the use, combined or alone, of the following teaching methodologies: lecture, conducted study, public presentation (made by the student), seminars, practices, case study,

project implementation, electronic learning, use of the new technologies of information and communication, blended learning.

8 Topics distribution with their corresponding learning goals, according to academic and industrial experts, should appear in the 3rd, 4th and 5th course. Thematic matters referred to CIM should go further when studied in the minors of Manufacturing and Machines and Management of Industrial Companies.

9 Finally, specific topics, suggested by academic and industry experts, to accomplish the required education and training of CIM specialists are: theoretical knowledge of new manufacturing processes, automation and integrated manufacturing, CAx, industrial communications, programming and planning of manufacturing facilities and resources, robotics, control systems, integrated systems of industrial management, quality management, infrastructure and software and equipping for industrial automation.

3 Conclusions

1. CIM is one of the best valued technologies, by modern manufacturing companies in Spain, to maximize their efficiency and competitiveness
2. The study carried out and presented here considers both: industry and academic points of view to define curriculum contents of graduates related with CIM technology.
3. The most valued knowledge, abilities and characteristics of personality, dealing with CIM, that industry expects from graduates, have been identified and presented in the results of this research work.
4. The contents of the curriculum, the way of teaching them, and the sequence of their appearance during the 5 years of the present Industrial Engineering grade in Spain have been studied. Academics have a series of recommendations, with quantitative meaning and the point of view of employers considered.

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