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Research in Industrial Engineering and Management: An Explorative Survey among Seven European IEM Departments

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Abstract

The foundation of IEM departments in Europe has been accompanied by the rise of a new, complex research area, characterized by the interconnection among disciplines and the application of real life cases. This survey, based on discussions carried out at a European IEM symposium on this topic and on short interviews of the participants, illustrates the kaleidoscopic nature of IEM research and of the history of a set of seven IEM departments. IEM departments have shared research areas with closely linked academic disciplines as management, engineering and natural sciences. However, the symposium participants reported common issues and difficulties in conducting and developing IEM research, relative to the acceptation and recognition of IEM by colleagues from these traditional academic disciplines. The analysis of the survey data led to an insight in the possible causes of this phenomenon. IEM research represents a novel research approach with respect to that of classical academic disciplines, as far as its nature, methodology, and scope are concerned. This might cause a clear difficulty in aligning IEM research to the traditional academic research lines of the institutions where IEM is embedded.

Key words: industrial engineering & management research, interdisciplinarity, case studies and fundamental research

1. INTRODUCTION

Industrial Engineering and Management (IEM) concentrates on combining engineering science from classical disciplines such as mechanical, chemical, and industrial engineering with tools and insights from social, mainly management sciences. Education programmes are built accordingly. However, across Europe, the set-up of academic research is accomplished in many different ways, depending on the academic environment where IEM research is embedded and on the history of each specific IEM department. This survey among seven European universities explores the variety of topics in academic research in Industrial Engineering and Management.

A European network of IEM departments [1] provided the main data, during a symposium and on short interviews of the participants, subsequent to the symposium. The symposium concentrated on the integration of business and engineering in education and research. The generally shared view on education appeared to be that the industrial application of theoretical concepts must be a key element in the IEM curriculum, as it teaches students to incorporate the complexity of industrial context in their design

assignments. Although in general, the necessity of engineers and engineering type of research to work on innovation paths is widely recognised [2-3], the discussion on research revealed to be more intricate. This is mainly because there exists no clear-cut answer to the question: *what defines IEM research?*

Interestingly, the participants shared the same sort of issues and difficulties related to *conducting* IEM research. The core of the difficulties lies in how IEM department relate to their institutions of origin, institutions which are often endowed with a rich and long academic history, and therefore have a natural resistance to new approaches and methodologies.

Without pretending to be exhaustive, this paper aims at giving a voice to unspoken issues on founding and conducting IEM research and intends to serve as inspiration for those concerned with IEM education and research in Europe.

2. IEM FACTSHEETS

The departments contributing to the survey are shortly characterized below with factsheets on their main features and history.

2.1 Institute for Manufacturing (University of Cambridge, UK)

The Institute for Manufacturing (IfM) is responsible for IEM research and education at the University of Cambridge. IfM is part of the Department of Engineering, a completely integrated department covering all aspects of engineering. Management teaching had been included in the engineering department since the late 1960s. At that time manufacturing (defined as defined as the full cycle from understanding markets and technologies through product and process design to operations, distribution and related services) was also starting to exist, though not as an examinable subject. The program gained full recognition by 1990, followed by a steady growth of the research activity.

2.2 Industrial Engineering and Management (University of Novi Sad, Serbia)

The department of Industrial Engineering and Management of the University of Novi Sad belongs to the Faculty of Technical Sciences, an engineering faculty that encompasses a broad range of disciplines. The studies of the IEM department are articulated into Industrial Engineering, Engineering Management, and Mechatronics. The IEM department, rooted in 1990, evolved from the Department of Industrial Systems and is today the department attracting the largest number of students.

2.3 Industrial Engineering and Management (University of Bremen, Germany)

Industrial Engineering and Management (*Wirtschaftsingenieurwesen*) at the University of Bremen was founded in 1998 as a cooperation of the faculties of Production Engineering and Business Studies and Economics and it still stands as an example of successful interfaculty collaboration. IEM in Bremen is responsible for the *Bremer Institut für Produktion und Logistik* (BIBA). BIBA is a scientific engineering research institute dealing with the issues of production and logistics systems. It has two divisions: intelligent Production and Logistics Systems (IPS) and ICT applications for production (IKAP).

2.4 Industrial Management (Lappeenranta University of Technology, Finland)

The department of Industrial Management is part, together with the Department of Information, of the Faculty of Technology Management, together with the department of Information Technology. The former department of Technology Management, founded by the Faculty of Economics -though strongly connected to engineering and educating *MEng* students- grew into an independent faculty thanks to external funding. The Lappeenranta University of Technology encompasses six departments of classical engineering. In Finland there have been attempts of combining Industrial Management and business study at a national level, industry is on the other hand in favour of the separation of these academic disciplines.

2.5 Industrial economics and management (KTH Royal Institute of Technology, Sweden)

The Department of Industrial economics and management (INDEK) belongs to the school of Industrial Technology and Management at KTH, which also encompasses Mechanical engineering, Material Sciences and IEM. INDEK was founded as early as 1912 and graduated its first PhD in 1973. INDEK is connected with an excellent industrial network and its educational program is attracting talented students with a classical engineering background.

2.6 Production and Systems (University of Minho, Portugal)

The School of Engineering of the University of Minho offers an Industrial Engineering and Management Integrated Master at the department of Production and Systems. This is the oldest department of the School of Engineering, founded in 1975. The department of Production and Systems is associated with two research centres: the Industrial and Technology Management Research Centre (CGIT) and the Algorithm Research Centre. Interaction with society (and industry) is a trademark of engineering at Minho.

2.7 Industrial Engineering and Management (University of Groningen, The Netherlands)

Industrial Engineering and Management at the University of Groningen is embedded in the faculty of Mathematics and Natural Sciences, which for historical reasons also encompasses engineering programs. Founded in 2002, IEM is a relatively young department, fully embedded in the Faculty of Mathematics and Natural Sciences, in cooperation with the Faculty of Economics and Business. Currently IEM has strong connections with the departments of Chemical Engineering and Applied Mathematics, as well as with Operation Research at the faculty of Economics and Business.

3. THE SURVEY

Werequested the symposium participants to position research at their IEM department within the faculty or school areas of interest. The obtained information is reported in Table 1.

To give a first indication, research areas are roughly grouped under the designations *engineering-related* and *management-related*; though in practice such a sharp division is hard to find in the multidisciplinary realm of IEM research. Also, across Europe the name of certain research areas may have slightly different interpretations. Nevertheless, the authors chose for this layout in order to point out relevant differences in the business/engineering balance among the selected IEM departments.

According to the survey, see Table 1, the selected IEM departments show a higher degree of homogeneity among the management-related research topics than for the engineering-related. Technology management, strategy, innovation, and business development are

generally recurring areas of interest. Other relevant topics are investment, finance and accounting, human resources management, marketing and commerce, economics, and support systems for decision-making.

As far as engineering is concerned, the most recurring subjects are manufacturing, production systems / automation, maintenance and logistics engineering, and operation research. However, there seems to be a greater diversity among the IEM departments; a few include also information and communication technology, and sustainability, while others present unique research lines. Examples of the latter are Product and Process Technology in Groningen, Industrial Photonics in Cambridge, Applied Information and Communication Technology for production in Bremen.

As a follow-up, the symposium participants were further questioned on: "Is IEM research aligned to the main research lines of the faculty or school where the department is located?" The results summarized in the table, added with the information obtained from the interviews are discussed in the next section.

4. DISCUSSION

4.1 Rooted in engineering or management

Most of the selected European IEM departments are located at an Engineering School or Faculty. Interestingly, the affiliation to an Engineering faculty does not necessarily determine a strongly *engineering-related* research at the IEM department, as we can infer from the table data. In the case of the Industrial Economics and Management department (INDEK) at KTH, we observe a clear shift to the *management-related* research topics. Interestingly, the INDEK department belongs, together with Mechanical Engineering and Material Sciences, to a segment of the engineering disciplines that has grown into an independent faculty itself: the school of Industrial Technology and Management.

Another example of strongly *management-related* research is to be found at the department of Industrial Management (IM) at Lappeenranta. IM evolved from a department (educating engineers) at the faculty of Economics and Business into an independent program, which stands for up 70% of the faculty of Technology Management, thus representing the most "independent" IEM program of this overview. The University of Groningen represents another peculiar example of IEM department, being rooted in the Faculty of Mathematics and Natural Sciences. Born out of the cooperation between the science and the Economics and Business faculties, IEM has eventually been incorporated fully under the science faculty. Research at this IEM department is strongly *engineering-related*, in line with other engineering programs (or applied science-programs) at this faculty. Notably, in Groningen the IEM and Technology Management program and research are neatly separated, the latter being part of the faculty of Economics and Business and clearly located far from the engineering realm.

4.2 A problem of acceptance

Interestingly, irrespective of the faculty in which they are rooted and irrespective of their research policies, the majority of the selected IEM departments share -to different extents- difficulties in their relationship with other departments of the same institution, as reported in a series of interviews following the last EPIEM symposium. Even those IEM teams having a strong engineering component in their research, report the overlap with existing research areas at the other departments within the same engineering faculty to be relatively small or at least unsatisfactory.

Several IEM departments report having (or having previously had) evident difficulties in initiating collaborations with the colleagues from the classical engineering disciplines. More or less evidently, these issues seem to stem from a lack of recognition of the academic value of IEM. In a few cases, the participants even report that throughout the years the credibility as well as the "legitimacy" of the IEM department had been questioned. The existence of these issues is in a way related to the length of the history of the IEM department (being obviously stronger in the case of young IEM departments), though these problems still slightly persists even at departments with tenths of years of experience in the field and a flourishing research activity. This can be pointed at as a general acceptance problem of a (relatively) new education and research area.

4.3 Interdisciplinary approach

However, the novelty of IEM, discussed in the previous paragraph, is not likely to be the main reason why the classical disciplines would adopt such a cautious approach. IEM does not simply add up to the existing engineering research, but introduces a new dimension to it. There are evidently a number of elements in IEM research which represent a rupture with the tradition of classical engineering research. One of those is its clear interdisciplinary character. We deliberately use the term interdisciplinary instead of multidisciplinary [4-6] in order to stress that the different disciplines in IEM research aim at being profoundly interconnected, such as they are in real life cases (see paragraph 4.4). In other words, the contents of a typical IEM research project aim at being more than a sum of research data that can be analysed independently. This sort of interdisciplinarity is experienced as a *disturbing* element also in fields different than IEM. Buanes and Jentoft [4] report that any interdisciplinary approach not only requires agreement on a cognitive dimension, but also on the regulative and normative dimensions of established disciplines. Especially with respect to the latter two, this should be interpreted as follows: crossing disciplinary boundaries involves questioning paradigms and norms (in this case especially the rules according to which research is carried out), which is often considered to be inappropriate. The representatives of the monothematic disciplines can be conservative to the point of applying some form of *sanction* if one is breaking the rules.

Table 1. Main research areas at a selection of European IEM departments (and at the Faculty or School to which the Department is affiliated).

IEM department	University	Management -related research	Engineering-related research	Faculty/School	Related research areas at the Faculty/School (other than IEM)
Institute of Manufacturing	Cambridge	Design Management Industry and Government Strategy and Performance Measurement Technology Management	Distributed information and automation Industrial Photonics International Manufacturing Production Processes Industrial sustainability	Department of Engineering	Engineering Design Sustainability Advanced Photonics and electronics
Department of Industrial Engineering and Management	University of Novi Sad	Engineering Management Investment, Finance and Accounting Media Engineering and Management Marketing and Commerce Entrepreneurship and Innovation Organization and Human Resources Management	Production Systems Automation, Robotics and Mechatronics Information and Communication Systems Quality, Maintenance and Logistics	Faculty of Technical Sciences	Mechanical Engineering Production Engineering
Department of Industrial Management	Lappeenranta University of Technology	Innovation and technology management Technology Entrepreneurship Supply chain and operations management Industrial Marketing and International Business Cost and information Management Support systems for decision-making	Logistics	Faculty of Technology Management	Knowledge management and Information systems
Department of Industrial Engineering and Management	University of Bremen		Intelligent Production and Logistics Systems Applied Information and Communication Technology for Production Controlling	Faculty of Production Engineering, Faculty of Business Studies and Economics	Production Engineering Systems Engineering
Department of Industrial economics and management (INDEK)	KTH Royal University of Technology	Industrial management Industrial dynamics Industrial work science Economics Business development and entrepreneurship Management and change Management accounting and finance Industrial marketing		School of Industrial Technology and Management	Integrated product development (Machine Design) Banking and finance Industrial ergonomics

Department of Production and Systems	University of Minho	Industrial Management and Systems Systems Economic Analysis	Human Engineering (includes ergonomics) Nonlinear Systems Optimization and Statistics Distributed and Virtual Manufacturing Systems and Enterprises Systems Engineering, Optimization and Operations Research	School of Engineering	Science and Textile Technology Biological Engineering Territory, Environment and Construction Sustainability and Innovation in Structural Engineering Mechanical and Materials Science and Technology Information Technology
Department of Industrial Engineering and Management	University of Groningen	Operations Research Supply Chain Management	Process and Product Technology Production Automation Smart Manufacturing Systems Control Engineering Information Engineering Biotechnology Logistics Engineering	Faculty of Mathematics and Natural Sciences	Product Technology Biotechnology Systems, Control and Applied Analysis

In some cases, we could think of the lack of acceptance we described above as an informal sanction.

In addition, interdisciplinarity is generally experienced as a lack of depth, because, as Buanes and Jentoft [4] state, the idea exists that one must necessarily choose between professional depth and breadth, and that the disciplines represent the former and the interdisciplinary approach the latter. In this respect, interdisciplinarity is therefore regarded as superficial, and encroaching upon other disciplines.

As a matter of fact, the modern interpretations of engineering or applied science research are rarely monodisciplinary. We often encounter collaborations that cross the boundaries of classical disciplines, generating stable teams of researchers with a constant output of joint publications. Clearly, it is not for a researcher to have unlimited knowledge ranging over many disciplines, but it is overall accepted to be competent in more than one. However, the IEM interdisciplinary approach is different as it encompasses disciplines from profoundly dissimilar fields, such as business and technology; fields with different methodologies, cultures and histories. This is likely to cause a greater resistance to the integration into the realm of the classic disciplines.

4.4 Real life cases

Another important element that could explain the difficulty of integration of IEM in academic research is its focus on real life scenarios, as this is experienced as a lack of scientific rigor by classical researchers.

Incidentally, also this critic to IEM research seems to be irrespective of the nature of the discipline of origin, i.e. whether the IEM department belongs to a school of engineering or business.

In the interviews and at the symposium we could sense a concern among IEM researchers on the best way of combining academic research with real life (business) cases. There is plenty of literature on how and why academia and business should cooperate on engineering research, see e.g. [8-9] and references therein. However, the best recipe for IEM still needs to be found. In particular, further investigation on IEM research methodology and how it relates to classical (engineering) research methodologies seems to be recommendable.

4.5 Performance indicators

Despite critics (see e.g. [7]), in an academic world dominated by performance indicators, focussing on real-life and industry-related subjects is obviously a handicap. Clearly, in a few cases an additional disturbing element of IEM research appears to be the low publication rate or the low performance indicators of IEM research staff. We do not mean to state here that IEM researchers are by definition not performing according to academic standards. What the interviews illustrate is that setting up an IEM research line with a certain publication output objectively requires a longer “start-up time” than for the classical disciplines and therefore generate an initially low output of publications. The actual reasons for this slow start-up probably stem

from the history of the IEM department and the research topics in question. Besides, the embedding of IEM in real life cases and secrecy considerations on the part of the industrial partners can in some cases hamper academic exploitation of IEM research projects.

The generally accepted focus on publications and performance indicators also results personally detrimental for IEM researchers. For example, if their performance as academic employees is evaluated with the same criteria as those used for researchers of the classical disciplines, they might feel obliged to partly redirect their research topics to more fundamental research, in order to align them to the leading research fields at their faculty or institution.

4.6 The ideal environment

Fortunately, not all of the interviews reported the existence of problems. The IEM departments which did not report issues on credibility or difficulty in establishing cross collaborations are those whose main goals coincide with the faculty's research policy. We could then state that a crucial factor for the recognition of the value of IEM research is the culture and the environment shaped by the faculty (or by the institution as a whole).

Also those IEM departments possessing a sufficient degree of independence from the faculty of origin reported these issues to be present only to a minor extent. In this case, one refers to independence mainly as financial autonomy, accomplished by a relevant amount of external (industry) funding.

5. CONCLUSIONS AND RECOMMENDATIONS

Representatives of seven European IEM departments have been asked to evaluate the embedding of their research in the academic environment where they are located. This revealed to be an opportunity for discussing existing issues relative to the integration of IEM research into classical academic research, either management or engineering-related. The majority of IEM departments reported that the lack of recognition of the academic value of IEM and the lack of acceptance by the colleagues is (or has ever been) an issue. Based on the available data on research lines at the IEM departments, we tried to analyse and rationalize this phenomenon. We could indicate the novelty and the singularity of IEM research and the resistance to change of the classical disciplines as possible causes. IEM introduces a new, complex research area, requiring new research methods and different performance evaluation methods than monothematic academic disciplines.

Despite the limited scope of this explorative survey, the striking similarities of the issues reported by the survey participants lead us to a series of possible recommendations.

We could observe from the positive examples of the survey that it is essential to shape a research environment that gives room and time for the

development of an IEM research vocabulary. This development can be expected to counterbalance the pressure of cooperating classical disciplines on the IEM researchers' performance to fully adapt to their standards.

History tells us that, even if a number of European IEM departments encountered acceptance problems of the kind described above, they nevertheless managed to grow into highly productive research teams and source of innovation. IEM research departments and educational programs are highly popular among students and IEM applied research is welcomed by industry. They have demonstrated to be added value to their institutions.

However, IEM research in general still requires to be set on solid pillars. Best practices must be shared and new rules, aimed at defining what is permissible and successful research methodology and practice, should be established. The symposium discussion and the interviews clearly indicate that a generally accepted definition of IEM research –at least at European level– must still be formulated. This is confirmed by the variety of interpretations of IEM research, as illustrated in the reported table. How can indeed an integration and acceptance problem be tackled when one is not able to answer the question "what defines IEM research?"

6. ACKNOWLEDGMENTS

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7. REFERENCES

- [1] European Professors of IEM (EPIEM). Symposium held at the University of Groningen, November 18-19, 2011, the Netherlands. More information can be obtained at the authors.
- [2] Adams, R., Evangelou, D., English, L., De Figueiredo, A.D., Mousoulides, N., Pawley, A.L., Schiffelitte, C., Stevens, R., Svinicki, M., Trenor, J.M., Wilson, D.M. (2011), "Multiple perspectives on engaging future engineers". *Journal of Engineering Education*. vol 100, No. 1, pp. 48-88.
- [3] Hockfield, S., (2009), "The next innovation revolution." *Science*. Vol 323, No. 5918, p. 1147.
- [4] Buanes, A., Jentoft, S. (2009). "Building bridges: Institutional perspectives on interdisciplinarity". *Futures*. Vol. 41, No. 7, pp. 446-454.
- [5] Pautasso, M., Pautasso, C. (2010), "Peer reviewing interdisciplinary papers". *European Review*. Vol 18, No. 2, pp. 227-237.
- [6] Porter, A.L., Rafols, I. (2009), "Is science becoming more interdisciplinary? Measuring and mapping six research fields over time". *Scientometrics*. Vol. 81, No. 3, pp. 719-745.
- [7] Mansfield, E. (1991), "Academic research and industrial innovation". *Research Policy*. Vol. 20, No. 1, pp. 1-12.
- [8] Perkmann, M., Walsh, K. (2009), "The two faces of collaboration: Impacts of university-industry relations on public research". *Industrial and Corporate Change*. Vol 18, No. 6, pp. 1033-1065.
- [9] Çağlar G. (2010), "Systems Thinking Curriculum as "Strategy"", *International Journal of Industrial Engineering and Management*, Vol.1 No 2, pp. 53-61.
- [10] Lawrence, P.A. (2003). "The politics of publication". *Nature*. Vol 422, No. 6929, pp. 259-261.

Istraživanje u oblasti industrijskog inženjerstva i menadžmenta: istraživačka studija sedam evropskih departmana za IIM

Fiorella Brustolin i Gerald H. Jonker

Rezime

Osnivanje departmana za IIM u Evropi praćeno je porastom nove složene istraživačke oblasti koju karakteriše povezanost među disciplinama i primena slučajeva iz stvarnog života. Ovaj pregled, koji se zasniva na diskusijama vođenim na evropskim IIM simpozijumima na ovu temu i na kratkim intervjuima sa učesnicima, ilustruje kaleidoskopsku prirodu istraživanja u oblasti IIM kao i istoriju niza od sedam departmana za IIM. Departmani za IIM dele istraživačke oblasti sa usko povezanim akademskim disciplinama kao što su menadžment, inženjerstvo i prirodne nauke. Međutim, učesnici simpozijuma izložili su zajedničke teme i poteškoće u sprovođenju i razvijanju istraživanja iz oblasti IIM, važne za prihvatanje i prepoznavanje IIM od strane kolega iz ovih tradicionalnih akademskih disciplina. Analiza podataka istraživanja dovela je do pogleda na moguće uzroke ovog fenomena. Istraživanja vezana za IIM predstavljaju nov istraživački pristup s obzirom na onaj vezan za klasične akademske discipline u pogledu prirode, metodologije i raspona istraživanja. To može da izazove problem u izjednačavanju IIM istraživanja sa tradicionalnim akademskim istraživačkim pravcima u institucijama gde je IIM utemeljeno.

Ključne reči: *istraživanja industrijskog inženjerstva i menadžmenta, interdisciplinarnost, studije slučaja i fundamentalna istraživanja*