Industrielle Ingenieurwesen und Management in Österreich: Vergleich der Qualifikationsprofile und Berufswegen der Absolventen von Wirtschaftswissenschaftlichen Hochschulen

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Abstract

There are many different definitions of the term Industrial Engineering and Management (IEM) and due to changes in the higher education system in Europe, a wide range of IEM degree programs offered by Higher Education Institutions (HEI) in Austria has emerged. As a result, it is becoming increasingly difficult to distinguish between IEM degree programs and their qualification profile. Therefore, the alumni organizations of Austria, Germany and Switzerland have defined a job specification for IEM degree programs in a common declaration (so called “3-countries declaration”) to ensure a defined qualification profile and therefore a high employability of IEMs in industry. Both students and enterprises will then be able to rely on the acquisition of a certain qualification profile through the degree programs. Supporting the claims of the 3-countries declaration, the Austrian alumni Association of IEM called “WING” conducts periodical surveys in cooperation with the Institute of Business Economics and Industrial Sociology at Graz University of Technology to offer orientation and transparency for stakeholders in higher education and industry. The surveys are carried out as a secondary and a primary data-analysis.

To get an idea of the existing unclear term “IEM”, the first part of this paper aims to define the term IEM and present the range of qualification profiles of IEM degree programs offered at Austrian HEIs as well. The second part addresses alumni of IEM degree programs in an online survey and compiles their recommendation for an ideal qualification profile based on their professional experience. Furthermore, their career developments were reflected. The paper concludes with a summary of the recommendations deduced from the findings and a brief discussion and argumentation of IEMs’ employability.

Keywords
HEI, IEM, qualification profile, fields of operation

1 Introduction

There is an increasing number and dynamics of IEM degree programs provided by different HEIs throughout Austria that makes it difficult to get an overall view of the offered range of degree programs. The change in the educational system on European Union (EU) level starting from 1990, which was aimed at improving the transparency and diversification of degree programs and to foster the exchange of students in the EU, is also having a big effect on that.

Long-established universities such as Graz or Vienna University of Technology that have been offering IEM degree programs since 1950 and 1985 respectively still provide students with a multitude of IEM degree programs, but on the other hand, similar IEM degree programs are offered by various Universities of Applied Sciences that have
existing since 1999 [1] [2]. By adapting the subjects to the needs of industry and thus the degree programs of HEIs, especially at Universities of Applied Sciences but also at Universities of Technology, many new IEM degree programs offered today might not, or only in part, fit the defined or recommended qualification profile of the national IEM associations. In addition, national IEM associations in Europe, however, have continued to sustain the desire of a recommended qualification profile of IEM education on both Universities of Technology and Universities of Applied Sciences, thus maintaining the high employability of IEMs.

Based on that background information, this paper aims at both presenting a profound analysis of IEM degree programs in Austria and incorporating feedback from IEM professionals (are IEM graduates, now on the job) by drawing up their ideally proposed IEM qualification profile. To achieve this aim, the following research questions are to be addressed:

*Do IEM degree programs fulfill the minimum requirements in terms of a defined qualification profile? Which qualification profile for IEMs is recommended by IEM professionals and which are the fields of operation throughout average careers?*

To answer these research questions, (i) the higher education system in Austria is explained briefly and an appropriate definition of the term IEM is elaborated. (ii) A research framework consisting of both an analysis of IEM degree programs in Austria and a survey study is presented. (iii) Moreover, for students and graduates of IEM degree programs, an analysis and overview of IEM degree programs offered by Austrian Universities and Universities of Applied Sciences is shown and (iv) in addition, the recommended IEM qualification profile by IEM professionals is drawn up. Finally, (v) a contribution to literature, as well as some implications that might be used to position Universities and Universities of Applied Sciences in Austria among their stakeholders and to ensure the defined minimum qualification profile of IEM education, are given.

2 Higher education system of IEMs in Austria

The first objective of this paper is to compare degree programs that can be classified in German as so-called “Wirtschaftsingenieurwesen” degree programs of HEIs in Austria. Internationally, “Wirtschaftsingenieurwesen” (WI) is mostly translated as “Industrial Engineering and Management” but e.g. also as “Industrial Engineering”, “Industrial Engineering and Business Management” and “Engineering and Business Economics”. We will stick to the translation as IEM, but in order to understand the definition of the scientific content of IEM degree programs, the chosen subject categories for analyzing the IEM degree programs and the results displayed, firstly, the Austrian higher education system and secondly, the differences between the terms WI and IEM need to be illustrated.

2.1 Higher education system in Austria

As already mentioned, IEM degree programs at Universities of Technology have existed since 1950 [2]. Later on in 1990, the Austrian federal government decided to adapt to other European countries and introduced by a resolution Universities of Applied Sciences with first courses starting in 1994 [1]. Universities of Applied Sciences educate students in specific industry related degree programs focused on Applied Sciences e.g. Industrial Management, Economics and Business, Advanced Nursing, Applied Electronics and Applied Image and Signal Processing. On the other hand Universities of Technology focus on scientific basic subjects and offer various degree programs e.g. Mechanical Engineering, Civil Engineering, Chemistry, Biotechnology, Architecture and Mathematics.

Subsequently, the so-called Bologna-Declaration with the main goal of establishing a European Higher Education Area until 2010 was signed in 1999 by the Secretaries of Education of 29 countries. Some of the important sub-goals of the Bologna-Declaration were [3]:

- Introduction of a system with easily readable and comparable degrees
- Introduction of a system pillowed by two main educational cycles (Bachelor and Master cycle)
- Introduction of a system of credits such as the European Credits Transfer System (ECTS)
- Promotion of mobility (students have access to study opportunities throughout Europe)

This Declaration started the now introduced structure of every degree program of HEIs in 48 European and Asian countries [4] with the following framework [5]:
The total credits for a HEI degree program is 300 ECTS  
The two main cycles are Bachelor (180-240 ECTS, undergraduate) and Master (90-120 ECTS, graduate)  
Every year has 2 semesters with 30 ECTS per semester  
1 ECTS is equivalent to 25-30 hours of work [6]

Having defined the basis of the higher education system in Europe, we would now like to elaborate a definition of the Austrian IEM.

2.2 Definition of the Austrian IEM

Basically, Industrial Engineering and Management (IEM) consists of two terms, namely “Industrial Engineering” (IE) and “Management” (M) which differentiate between the terms “Wirtschaft” (so called “Economics”) and “Ingenieurwesen” (so called “Engineering”). To illustrate the basic difference between these terms, we wish to explain them:

Engineering activities are defined as followed [7]: “An engineering activity is based on combined, interdisciplinary technological knowledge, mathematical-natural-scientific and normative basics as well as their interconnections, which establishes engineering activities in the end. Engineering activity serves the generic goal to improve the livelihood of humans through development and the adoption of technical means.”

This definition puts a focus on technological knowledge as the main driving force of engineering activity. Economics on the other hand can be defined as “the study of the way in which economies work, for example, the way in which they make money and produce and distribute goods and services” [8]. On the other hand the term “management” in terms of science is defined as [8]: “Management science is concerned with designing and developing new and better models of organizational excellence”.

According to the official definition by the Institute of Industrial Engineering (IIE) [9] the term Industrial Engineering “is concerned with the design, improvement and installation of integrated systems of people, materials, information, equipment and energy. It draws upon specialized knowledge and skills in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems.” In order to educate experts in this field of activity, HEIs all over Europe have introduced specific IE degree programs with many different focuses. The Industrial Engineering Standards in Europe (IESE) have analyzed IE degree programs in six European countries and, compared the countries’ average subjects of study distribution according to their proposed curriculum model. The proposed curriculum model as a reference IE syllabus by Industrial Engineering Standards in Europe consists of following 8 core subject categories [10]: Engineering Basics, IE Fundamentals, Operations Research, Management Systems, Innovation and Technology, Environment/Sustainability, Manufacturing Systems and Human Factors Engineering. According to IESE’s survey among HEIs offering IE degree programs in six European countries, IE degree programs are very different. Not only in terms of educational focus but also in terms of total ECTS. Furthermore the European Students of Industrial Engineering and Management (ESTIEM) define the combined term Industrial Engineering and Management [11] as “IEM integrates technological knowledge and management skills, helping students to cope with competitive business challenges while comprehending the underlying technology. The focus of IEM studies lies in providing students valuable engineering knowledge as well as practical management experience. Throughout Europe, IEM has many different names - and many different faces."

Because of the above-mentioned wide scientific spread of the terms IE and M, in October 2010 the WING (Austrian alumni Association of IEM) formulated together with its two sister associations from Germany and Switzerland a common declaration (“3-countries declaration”) and job specification in order to secure defined IEM’s qualification profiles across borders. This declaration represents the common will to ensure high quality and the distinctive profile of IEM graduates, which means a certain relation between subject categories. The goal is to foster high employability of IEMs through the establishment of a common brand [7]. The core of the common brand is the following job specification: “IEMs are economically educated engineers with an academic degree which holistically connect their technical and economical competences in their working activity”.

In contrast to the IESE model, the figurative face of IEM degree programs in Austria has been shaped by WING’s model [12] (see Figure 1).
The WING’s model differs a lot compared to the IE model of IESE. The main reason for classifying the compulsory subjects in four main categories and three sub-categories (see below) built upon the complementary thesis and internships, is the facilitation of subject attribution. Unlike in the IESE model, which categorized the subjects into small subject categories and therefore had a huge variance in their results [10], the WING’s model categorizes subjects into four main categories and three sub-categories according to the two composing definitions of IEM in Austria (Engineering and Economics), which are defined as followed:

**Natural science and technology subjects (main category)** are bindingly defined by the “Engineering and Technology” and “Natural Sciences” specialization according to the revised field of science (see OECD [13]) of the analyzed degree program. E.g. Simulation, designing, chemistry, software engineering, mechanical technology, fluid dynamics, CAX, machine elements, building, mechanics of materials.

**Technology-related subjects (main category)** are subjects where the technological basis predominates. E.g. Recycling, industrial engineering, infrastructure management, methods of engineering, production management, quality management, technical project management, sustainability in engineering, traffic planning.

**Economics (main category)** are subjects with economics core contents. E.g. business studies, business intelligence, change management, information management, investment and financing, supply chain management, marketing, personnel management, management accounting, general management and organization, macroeconomics.

**Integration subjects (main category)** are subjects with interdisciplinary questions which have to be analyzed and solved with scientific and methodic approaches through the combination of different mindsets from different disciplines, e.g. ethics, social- and employment law, civil- and corporate law, ergonomics and job design, communication, creativity techniques, team building and training, knowledge and time management.

“Attributable” subjects (sub-categories) (see Figure 1) have to be seen as restricted elective subjects of the respective subject main categories.

**Mixed restricted-elective and free-elective subjects (sub category)** are subjects, which either can be chosen out of a catalogue with subjects attributable to more main categories (e.g. 5 subjects out of 10 are attributable to economics and the other 5 subjects are attributable to technical subjects) or are free-elective and therefore can not be attributed to one subject category because no general statement is possible.
Internships, Bachelor thesis and Master thesis (complementary) can be seen as a neutral category because for the subject analysis only the subjects need to be attributed to their respective category and therefore the sum of subjects is seen as the main unit. But to gain an overview of the degree program they still have to be considered in the analysis of the degree programs.

Our defined minimum qualification profile for an IEM degree program of a HEI is a minimum of 50 % and maximum of 80 % technical subjects. These 50 % to 80 % technical subjects have to be attributable to a revised field of science classified under “Engineering and Technology” or “Natural Sciences” by the OECD [13], e.g. civil, mechanical-, Electrical, and materials engineering, bearing in mind that this research is based on the understanding that technical subjects are considered as “natural science and technology subjects” and “technology-related subjects”. The remaining minimum of 20 % to 50 % of subjects has to be attributable to Economics and Integration.

In addition to this defined minimum qualification profile of IEM degree programs, the WING recommends a minimum of 50 % technical subjects, 20 % economics and 10 % integration subjects [14]

3 Methodology and sample

Since the undertaken empirical study consists of both an analysis of IEM degree programs and the recommended ideal qualification profile by IEM graduates, as well as the fields of operation and employability of IEMs in Austria, the applied methodology and sample has to be separated for both parts of research.

3.1 Methodology and sample applied for analysis of IEM degree programs in Austria

To analyze the different degree programs of Universities and Universities of Applied Sciences in Austria, a 4-step analyzing approach was used that follows the “top-down”-approach of system engineering [14]. These 4-steps are described in chronological order (see also Figure 2)

![Figure 2: Methodology applied for analyzing IEM degree programs](image)

**Step 1 - Collection of Universities and Universities of Applied Sciences in Austria:** To identify possible IEM degree programs in a first step, all accredited public and private Universities and Universities of Applied Sciences (in sum called: HEIs) in Austria were collected. Provided that these HEIs are registered in Austria, we presume that foreign Universities, which are registered in Austria, should be taken into account in their home country studies. Moreover theological, religious and military colleges were not taken into consideration. This first analysis of 53 HEIs, where it was tried to identify possible IEM degree programs because of the appellation or description of the HEI, resulted in a list of 32 HEIs that had to be further analyzed in step 2.

**Step 2 - First analysis of Universities and Universities of Applied Sciences:** Based on step 1, an in-depth analysis was conducted into whether the identified 32 HEIs theoretically offer an IEM degree program, either provided by them, or supported by another University or University of Applied Sciences. After checking the offered degree programs of all remaining HEIs, this step resulted in a list of 23 HEIs that offer at least one potential IEM degree program.

**Step 3 - Rough analysis of degree programs of Universities and Universities of Applied Sciences:** In order to gain an insight into all potential IEM degree programs offered by the HEIs detected in step 2, all compulsory subjects and restricted-elective subjects of 154 potential IEM degree programs (57 Bachelor-, 63 Master- degree programs and 34 combinations) were categorized in technical subjects and “Economical + Integration” subjects. The limits adopted for passing to step 4 were set at a minimum of 50 % and maximum of 80 % plus/minus 4 % technical subjects. These limits were chosen because of the rough pre-analysis and the sometimes possible attribution of subjects to more than one subject category in order to obtain all potential IEM degree programs.
Step 4 – Detailed analysis of and feedback on degree programs, accreditation: After rechecking their accordance with the relevant OECD revised field of science of potential IEM degree programs, and asking the respective deans if they were commit to the IEM job specification and the “3-countries declaration” for their degree program, all new potential IEM degree programs of HEIs and those, which had already been accredited by WING, were precisely investigated. This involved sending a pre-filled Excel spread sheet (all ECTS of the subjects of the related degree program had already been allocated to the eight subject categories of the WING model displayed in Figure 1, and the percentages calculated) to the dean of each degree program. If there were still any misunderstandings after the Excel spread sheet had been corrected by the dean and checked by us for its plausibility, the dean was requested to correct the Excel spread sheet again. Deans were given feedback on their degree programs and the degree programs were proposed to become accredited in the future by the WING as IEM degree programs, or not. For an accreditation of any kind of IEM degree program, following options and prerequisites are given:

Accreditation of a Bachelor IEM degree program: Minimum 50 % technical subjects, Minimum 20 % Economics + Integration subjects.

Accreditation of a Master IEM degree program: A clear definition of the required Bachelor education as a prerequisite for the Master degree program is obligatory (Bachelor has to have a technical focus in order to obtain a minimum of 50 % technical qualification profile). The relative sum of the required Bachelor qualification profile and the Master qualification profile has to fulfill a minimum of 50 % technical subjects and 20 % Economics + Integration subjects as a prerequisite.

Accreditation of a combined (Bachelor + Master) IEM degree program: The sum of both degree programs has to include a minimum of 50 % technical subjects and 20 % Economics + Integration subjects. The prerequisites for the Master degree program have to be the same as the qualification profile provided by the connected Bachelor degree program.

All options of IEM degree programs have to be attributable to the “OECD revised field of science and technology” to “Engineering and Technology” and “Natural Sciences” [13].

3.2 Survey study on the qualification profile of IEMs in Austria

A quantitative study based on the results of the analysis of IEM degree programs was conducted in order to perform a detailed analysis of the recommended ideal qualification profile by IEM professionals, the fields of operation and the employability of IEMs in Austria. Because of the size and complexity of the target group in which all WING members, alumni and students of IEM degree programs of Graz and Vienna University of Technology, it was decided to use an online survey designed with the Lime Survey tool, which consisted of the following five question categories: 1. Education, 2. Career entry and career path, 3. Further education, 4. Competences needed for the job/adjustment requirements of education, 5. Benefits of the WING (Internal survey for WING members only).

In order to send out a high-quality questionnaire, 14 previously described people from the target group were asked to participate in a pilot test and to give feedback on the questionnaire. This feedback was then incorporated into the final questionnaire. In a next step, 1234 WING members (both graduates and students of IEM degree programs) were invited via email to participate in the study. In a further step, the same questionnaire invitation was sent by email to 827 alumni and 2548 students of Graz University of Technology (TUG). To avoid redundancies, only TUG alumni and students who are not WING members were taken into account. In a final step, the questionnaire invitation was sent again by email to 140 alumni and 900 students (higher than 3rd semester students) of Vienna University of Technology (TUW), but once more, WING members were not part of that sample.

To sum up, the total sample size of the quantitative survey amounted to 5649 IEM alumni and students. From this sample 947 questionnaires were filled out (805 fully and 142 partially filled out questionnaires), thus representing an overall response rate of 16.76 %.

4 Results

As already explained in the methodology, the results will also be separated into two parts. Firstly, the results of the Austrian IEM degree program analysis will be shown, secondly, the results of the conducted survey will be displayed, finally brought together and discussed in the conclusion part.
4.1 Results of the comparison of IEM degree programs in Austria

The analysis in Step 1 resulted in a list of 20 Universities of Applied Sciences, 22 Public Universities and 11 Private Universities. After looking through all degree programs offered by the HEIs that remained after step 1, in step 2 four Universities of Applied Sciences out of 19, one Public University out of nine and four of four Private Universities were not included in step 3.

After step 3, 21 combined IEM degree programs (Bachelor + Master), five Bachelor IEM degree programs and one Master IEM degree program from two Public Universities, three Public Universities of Technology and eleven Universities of Applied Sciences were analyzed. The analysis resulted in a subdivision of percentages of all subject categories shown in the WING model in Figure 1. In order to provide an overview and to be able to compare the different IEM degree programs, the seven subject categories (ECTS for Internships, Bachelor and Master thesis were not considered) were synthesized into two categories as followed:

Percentage “Technical subjects” = % of “Natural Science and Technology subjects” + % of “Technology-related subjects” + % of “Attributable Technology and Technology-related restricted elective subjects” + half of the % of “mixed restricted elective and free-elective subjects”.

Percentage “Economic and Integration subjects” = % of “Integration subjects” + % of “Economic subjects” + % of “Attributable economic restricted elective subjects” + half of the % of “Mixed restricted elective and free-elective subjects”.

Figure 3 shows the results of the analyzed IEM degree programs of HEIs in Austria. As highlighted in Figure 3, the IEM degree program’s qualification profile of Universities of Technology has a focus between 65% and 80% of technical subjects though one University of Technology offers one combined degree program with 51% technical subjects, whereas Universities of Applied Sciences are dispersed throughout the whole range between 50% and 78% of technical subjects. The index table lists the analyzed HEIs, the corresponding “OECD revised field of science and technology” attributable to the respective IEM degree program and the kind of degree program (Bachelor (BA), Master (MA) or combined (BA + MA)).

Figure 3: Comparison of Qualification Profiles of IEM degree programs in Austria
As Figure 3 shows the range of qualification profiles of all IEM degree programs of HEIs in Austria and in order to check if the offered IEM degree programs provide the qualification profiles requested by the stakeholders and if the WING recommended qualification profile is still corresponding to markets needs, IEM professionals have been asked about their ideal recommended IEM qualification profile.

### 4.2 Results of empirical study – Qualification profile of IEMs in Austria

**Qualification Profile:**

468 IEM professionals answered the question as to which ratio of technical- and economics- subjects would have been ideal for their IEM degree program from their professional perspective. 77.56% said that their ideal IEM degree program should have offered between 50% and 70% technical subjects and the rest should have included economics and integration subjects. The average qualification profile resulted in 61.5% technical subjects and 38.5% economics and integration subjects, and can be interpreted as the ideal qualification profile recommended by IEM professionals based on their professional experience.

**Fields of operation of IEM professionals:**

In the survey, IEM professionals were asked to indicate how many workplaces they had had until now with a maximum of 10 workplaces. On the left side of Figure 4, the fields of operation (FOO) are listed, always indicating two bars per FOO. The first bar corresponding to the FOO shows how many people worked in that FOO (displayed in percentage). The second bar attached below, which always corresponds to the same FOO without any percentage indicated, illustrates how many people working in this FOO had a leading position. In total 510 professional IEMs answered this question.

510 IEM professionals had 703 FOO in their first job. This means that every third IEM had 2 FOOs. This number stays the same in the second, third and fourth job. In their first job, most IEM professionals start in Engineering, R&D, Process- Product- and Quality Management, with only a few people starting directly in an executive or strategic management position. In their first job, 18.3% of the 510 IEMs had a leading position.

Figure 4: Fields of operation per workplace of professional IEMs in Austria
This number rises dramatically in the second job where 46.5 % of the 420 IEM professionals had a leading position. It is noticeable that in their second job, the number of IEMs working as an executive or strategic manager, as book keeper and PR or product manager increases, with a decreasing number of FOO in R&D, Engineering and Process. In their third job, 70 % of the 320 IEM professionals already hold a leading position and FOO in executive and strategic management rise to almost 17 %. In their fourth job, 74 % of the 212 IEM professionals have a leading position and along with the increase of jobs in the executive and strategic management, an increase in the entrepreneurship and in consulting can also be seen.

5 Discussion and conclusion

Although the WING recommends a minimum qualification profile of 50 % technical, 20 % economic and 10 % integration subjects, the qualification standard in this study was set to a minimum of 50 % up to 80 % technical subjects, with the remaining percentage of subjects of a degree program as a mix of economics and integration subjects. The analysis results of IEM degree programs are a complex topic because as opposed to Universities of Applied Sciences, Universities often offer mixed restricted elective subject catalogues which led to the decision to split those percentages 50/50 and to attribute them in the same scale to “technical subjects” and “economics + integration subjects”. This was justified by arguing that deans had experienced students mostly choosing economic, integration and technical subjects in equal parts from these catalogues, and that the BA and MA thesis always implied technical, economic and integration aspects. In order to gain more transparency when revising future degree programs, it is recommended to offer clearly defined restricted elective catalogues attributable to one specific subject category.

Many degree programs defined as an IEM degree program by deans who are committed to the job specification and the “3 countries declaration” differ slightly from the recommendation made by the WING. This should not be seen as a reason for excluding the IEM definition and community in Austria if the degree program offers a qualification profile between 50 % and 80 % of technical subjects, because the commitment to the IEM community, the “3-countries declaration” and to the job specification is definitely more important. The qualification profile recommendations made by the WING have to be seen as a framework and as a direction to follow if degree program structures are going to be revised in the future.

Furthermore, the variety of qualification profiles of IEM degree programs of HEIs in Austria can be used as a statement for positioning and profile formation for stakeholders and students alike, enabling industry to choose which qualification profile they want and need. The clear profile of Universities of Technology was displayed in Figure 3, which leads to the conclusion that Universities of Technology put their focus on a profound technical and engineering education, which on the other hand is recognized by the industry. In any case, transparency is important for HEIs, students, industry and all other stakeholders. Beyond that, all HEIs have to emphasize their focus in leadership and management education and also extend their educational offers in the field of entrepreneurship for IEM graduates, because 46.5 % of IEM graduates already take over leadership positions in their second job (see Figure 4).

The results of the ideal qualification profile recommended by IEM professionals aptly reflects the recommended qualification profile by the WING and hence it is proven that it is still up to date and should be maintained as a reference.

For future research, the sample size of IEM graduates could be defined more precisely as there are no statistics that could indicate any numbers. It was therefore relied upon WING members, IEM students and registered alumni IEM. The focus of the survey was on Austrian IEM professionals, but in future, this survey could also be conducted across borders to make comparisons possible. Having appraised current IEM degree programs in Austria, defined the WING model as an analysis tool, set rules and limits within a still dynamic “degree program market”, conducting a future study in other countries could result in a map of “many different names – and many different faces” [11] of IEM degree programs to help gain transparency throughout Europe. Besides that, also a survey comparing the subjects’ recommendations of IEM professionals and the subjects being taught at Universities and Universities of Applied Sciences in Austria could be considered.
References