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Sharpening the Industrial Engineering and Management Qualification Profile: Research Findings from Austria

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Abstract

Since the introduction of Industrial Engineering and Management (IEM) degree programs at Austrian Higher Education Institutions (HEIs) in the 1950's, the number of IEM degree programs has been rising continuously. Accelerated by changes in the educational system on the European Union level started in 1990, problems regarding the comparability of IEM qualification profiles have increased. To sharpen the IEM qualification profile, this paper presents (i) a recommendation of an IEM qualification profile approved by alumni associations of German-speaking countries, (ii) a structure to compare IEM degree programs and (iii) results from two online surveys among IEM professionals and IEM students, as well as human resource managers.

Key words: *Higher Education Institution, Industrial Engineering and Management, Qualification Profile, Degree Program.*

1. INTRODUCTION

The number of Industrial Engineering and Management (IEM) degree programs provided by different private and public HEIs (Higher Education Institutions) throughout Austria is still increasing. Hence, it becomes progressively more difficult for the involved stakeholder groups (IEM students and IEM graduates, industry partners as well as HEIs), to get and to keep an overview on the range of IEM degree programs and provided IEM qualification profiles. This situation is compounded by the change in the educational system on the European Union (EU) level starting in 1990, which was aimed at improving the transparency and diversification of degree programs and at fostering the exchange of students within the EU.

These current developments on an (English-speaking) EU level entail major challenges not only for German-speaking Universities of Technology offering IEM degree programs such as, for instance, Graz University of Technology (TUG) since 1950. Since 1985, also Vienna University of Technology (TUW) has provided a multitude of IEM degree programs. In addition to that, in 1999, various Universities of Applied Sciences (UAS) started to offer lots of similar IEM degree programs throughout Austria [1, 2]. As a result of this development, HEIs started to adapt their IEM degree programs to the needs of industry. Therefore, especially at UAS, but also at Universities of Technology (subsumed under HEIs), many new IEM degree programs offered today might not, or only in part, fit the recommended qualification profile of the national IEM associations in the German-speaking countries Germany, Austria and Switzerland. Several national IEM associations in Europe, however, have repeatedly expressed the desire for a recommended qualification profile of IEM education at both Universities of Technology and UAS in order to maintain the high employability of IEMs.

Based on this background information and the recommendation of the IEM associations in the German-speaking countries, this paper aims at presenting a pattern to structure IEM degree programs and a profound analysis of data derived from a survey among members of the Austrian IEM alumni and Austrian IEM student association (in German the so-called "WING" for the alumni and the "WINGnet" for the students' association) and human resource managers (HRMs) to incorporate feedback and, therefore, current needs of the job market.

To achieve these goals, this paper addresses the following three research questions:

> *(1) What stands behind the term "IEM" from a German-speaking countries' point of view and how should this notion be transformed into an "IEM education model" that helps HEIs to structure and design their IEM curricula?*

(2) Based on the "IEM education model": What could be a useful pattern for HEIs, HRMs, IEM alumni and IEM student associations to analyze the structure of IEM degree programs in order to get transparency and comparability of IEM qualification profiles on a national and cross-national level?

(3) What are the expectations of IEM professionals, IEM students and HRMs regarding the qualification profile of present and future IEM graduates? What recommendations can be given to HEIs to fulfill the job market's needs in order to maintain a high employability of IEM graduates?

To answer these research questions, first, we performed a desk research and then data were collected from the curricula of existing IEM degree programs in collaboration with deans of Austrian HEIs. In a next step, IEM professionals and students, as well as HRMs, were invited to participate in two online surveys. The hereby gained data were analyzed by deploying descriptive statistics.

This paper is structured as follows. Section 2 provides a brief literature background of the higher education system in Europe and continues with an argumentation of the translation of the German word "Wirtschaftsingenieurwesen" (WI) into the English term "IEM". Furthermore, a recommendation of an IEM qualification profile accompanied by the alumni organizations in Germany, Austria and Switzerland, the so-called "3-countries declaration" and ends with an Austrian job specification of IEMs. Section 3 outlines the research process of this project to (i) analyze the currently offered IEM degree programs in Austria and to (ii) identify the expectations of IEM professionals, IEM students and HRMs regarding the requested qualification profile of IEMs. Section 4 focuses on the design of the Austrian "IEM education model" and presents the so-called "3 Pillars of IEM Education". This model is used to analyze current IEM degree programs in Austria. Section 5 reports the core findings of two online-surveys, one among IEM professionals and students and one targeting at HRMs. In addition to the "internal" view of IEM associations on the IEM qualification profile, this allows the incorporation of "external" needs of the job market. The findings lead to the conclusions section 6, which contains implications that might help HEIs to ensure transparency of IEM degree programs keeping in mind a minimum requirement of the IEM qualification profile in order to maintain a high employability of IEM graduates on the long-track. Finally, limitations and prospects of further work are outlined in section 7.

2. LITERATURE BACKGROUND

IEM degree programs of HEIs in German-speaking countries are known as "Wirtschaftsingenieurwesen" degree programs. For international use, "Wirtschaftsingenieurwesen" is mostly translated as "Industrial Engineering and Management" but, for example, also as "Industrial Engineering", "Industrial Engineering and Business Management" and "Engineering and Business Economics".

As there are many (of course possible) different definitions of the term "IEM" and due to changes in the higher education system in Europe (Section 2.1), a wide range of IEM degree programs offered by HEIs in Austria has emerged. As a result, it is becoming increasingly difficult to distinguish between IEM degree programs. Therefore, the alumni organization of Austria decided to translate the German WI into IEM, knowing that there are several differences in scientific and teaching content of IEM degree programs.

Based on that, the alumni organizations of Austria, Germany and Switzerland have defined a job specification for IEM degree programs in a common declaration (the so-called "3-countries declaration") to ensure a comparable qualification profile and, therefore, a high name recognition of IEMs in industry. Both students and firms will then be able to rely on the acquirement of a certain qualification profile through the degree programs offered by the educational system on a European Union level, as well as in German-speaking countries, respectively.

2.1 **The higher education system in europe in a nutshell**

Aiming at establishing a European Higher Education Area by 2010, the so-called Bologna Declaration was signed in 1999 by the Secretaries of Education of 29 countries [17].

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 (BA) and master (MA) 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 with the following framework [4, 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 consists of 2 semesters with 30 ECTS each.
- 1 ECTS is equivalent to 25-30 hours of work [6].

On the basis of the introduced higher education system in Europe, at the beginning of the following section, a definition of the term (Austrian) "IEM" is discussed.

2.2 **"IEM": terminology, "3-countries declaration", austrian job specification**

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") in an "industrial context".

On the one hand, "economics" 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] "[… being] concerned with designing and developing new and better models of organizational excellence". "Engineering" activities [16] 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.

To put these two words into an industrial context and 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." 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 Austrian "WING" and its two sister associations from Germany and Switzerland formulated a common declaration ("3-countries declaration") and a 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 in German-speaking countries [7, 14]. The core of the common brand is the following IEM job specification: "IEMs are economically educated engineers with an academic degree which (sic!) holistically connect their technical and economic competences in their working activity".

3. RESEARCH PROCESS

The reported research project consists of two parts: (1) a secondary data analysis of IEM degree programs in Austria to identify a framework to categorize and to compare current IEM degree programs and (2) two online surveys with a subsequent descriptive data analysis among (i) IEM professionals / IEM students and (ii) HRMs with the goal to carve out a recommended IEM qualification profile incorporating feedback from the job market.

3.1 **Method and sample applied for the secondary data analysis of iem degree programs in Austria**

To analyze the different degree programs of HEIs in Austria, a 4-step procedure applying a desk research was used that follows the "top-down"-approach of systems engineering [15]. These 4-steps are described in chronological order:

- Step 1: To identify possible IEM degree programs in a first step, all accredited public and private Universities and Universities of Applied Sciences in Austria were listed. 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 analysis resulted in a list of 53 HEIs (20 Universities of Applied Sciences, 22 Public Universities and 11 Private Universities). On the basis of these HEIs' appellations or descriptions, possible IEM degree programs were identified. This resulted again in a list of 32 HEIs that had to be further analyzed in step 2.
- Step 2: 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 HEI. After checking the offered degree programs of all remaining HEIs, 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. This procedure resulted in a list of 23 HEIs that offer at least one potential IEM degree program (analyzed in step 3).
- Step 3: 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 degree programs, 63 master degree programs and 34 combinations of bachelor and master programs) were categorized into technical subjects and "Economics + Integration" subjects. The limits adopted for passing to step 4 were set at a minimum of 50% and maximum of 80% plus/minus 4% of 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. Out of step 3, 21 combined IEM degree programs (bachelor and 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 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 follows (with reference to Figure 2):
  - Calculation of the percentage "Technical subjects" (see Figure 1) = % 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".
  - Calculation of the percentage "Economic and Integration subjects" (see Figure 1) = % of "Integration subjects" + % of "Economic subjects" + % of "Attributable economic restricted elective subjects" + half of the % of "Mixed restricted elective and free-elective subjects".
- Step 4: After rechecking the accordance of potential IEM degree programs with the relevant Organisation for Economic Co-operation and Development (OECD)-revised field of science (see also Figure 2), and asking the respective deans if they were committed 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 accepted by the Austrian IEM alumni association, were precisely investigated. This involved sending a pre-filled MS Excel® spread sheet (all ECTS of the subjects of the related degree program had already been allocated to the eight subject categories of the model called "3 Pillars of IEM Education" in Austria displayed in Figure 1) to the dean of each degree program. If there were still any misunderstandings after the MS Excel® spread sheet had been corrected by the dean and checked by us for its plausibility, the dean was requested to correct the MS Excel® spread sheet again. Deans were given feedback on their degree programs and the degree programs were proposed to become recognized in the future by the "WING" as IEM degree programs, or not. Additionally, all options of IEM degree programs had to be attributable to the "OECD-revised field of science and technology" [13]. Finally, for a recognition of any kind of IEM degree program, the following options and prerequisites are given:
  - Precondition for the recognition of a bachelor IEM degree program: Minimum 50% technical subjects, minimum 20% Economics + Integration subjects.
  - Precondition for the recognition 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.
  - Precondition for the recognition of a combined (bachelor and 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.

3.2 **Method and sample applied for the survey study among iem professionals and iem students on the qualification profile of iems in Austria**

A survey study based on the results of the secondary data analysis of IEM degree programs was conducted in order to perform a detailed analysis, first, of the "IEM qualification profile" recommended by IEM professionals and IEM students, and, second, of the fields of operation (Figure 6) of IEMs in Austria. Because of the size and complexity of the target group in which all members of the Austrian IEM alumni and IEM student association – "WING" and "WINGnet" (i.e. the target group consists of alumni and students of IEM degree programs of TUG and TUW) – are included, it was decided to use an online survey designed with LimeSurvey™. 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 version of the questionnaire. In a next step, 1234 "WING" and "WINGnet" members were invited via e-mail to participate in the study. In a further step, the same questionnaire invitation was sent by e-mail to 827 alumni and 2548 students of TUG. To avoid redundancies, only TUG alumni and students who are not "WING" or "WINGnet" members were taken into account. In a final step, the questionnaire invitation was sent again by e-mail to 140 IEM alumni and 900 IEM students (who were already in their third semester or higher) of TUW. This procedure resulted in a total sample size of 5649 IEM alumni and IEM students. From this sample 947 people responded (805 fully and

142 partially filled out questionnaires), thus representing an overall response rate of 16.76%.

3.3 **Method and sample applied for the survey study among hrms on the qualification profile of iems in Austria**

In addition to the online survey described in section 3.2, a survey was performed among HRMs to incorporate the view of the job market in the IEM qualification profile. The target group was selected out of members of the Austrian HRM association called "Personalist.at". The survey was performed applying LimeSurvey™. After the online survey design, the questionnaire for HRM comprised 44 questions. In order to send out a high-quality questionnaire, seven HRMs were asked to participate in a pre-test and to give feedback on the questionnaire. This feedback was then incorporated in the final version of the questionnaire. In the next step, an e-mail including the hyperlink to the questionnaire and the invitation to participate in the study was sent to 1294 members of "Personalist.at" by the "Personalist.at" office in a newsletter. Because of the low response rate on the first try, the following HRMs were invited to participate in the study: 85 HRM who participated in the job fair called "Teconomy" of TUG in April 2013, 187 HRMs who are members of the "HR-lounge.at", 7874 HRMs out of the organization database "HEROLD.at" and, in addition to that, 965 IEM professionals were asked to forward the invitation to participate in this online survey via e-mail to their firm's HRMs.
To prevent multiple compiling by the same respondents, the feature of LimeSurvey™, which implements cookies on the respondents' computer, was activated. Finally, the total sample size of the online survey mounted up to 9111 HRMs. From this sample, 311 HRMs responded (289 fully and 22 partially filled out questionnaires). This represents an overall response rate of 3.41%.

4. THE "3 PILLARS OF IEM EDUCATION" IN AUSTRIA

In order to educate experts in this field of activity, HEIs all over Europe have introduced specific IEM degree programs with many different focuses. These make it very difficult to compare the different programs, which implies the need to design and use a generalizable analysis framework.
The Industrial Engineering Standards in Europe (IESE) have, therefore, 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 the following eight core subject categories [10]: "Engineering Basics", "Operations Research", "Management Systems", "Innovation and Technology", "Environment/Sustainability", "IE Fundamentals", "Manufacturing Systems" and "Human Factors Engineering". According to IESE's survey among HEIs offering IE degree programs in six European countries, the IE degree programs differ substantially. Not only in terms of educational focus but also in terms of total ECTS. In contrast to the IESE model, the figurative face of IEM degree programs in Austria has been shaped by the "IEM education model" [12]. Its "3 Pillars of IEM Education" in Austria (Figure 1) and its eight subject categories can be used as a framework to analyze different IEM degree programs.

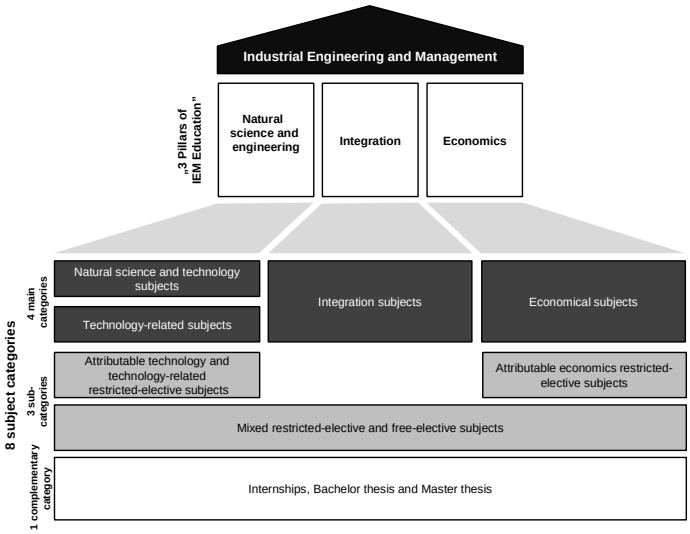


Figure 1. Analysis Framework: The Austrian "3 Pillars of IEM Education" [20].

4.1 **IEM subject categories of the "3 pillars of iem education" in austria in detail**

The "IEM education model" (see Figue 1) differs substantially compared to the IE model of IESE. The main reason for classifying the compulsory subjects into four main categories and three sub-categories 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 model shown in Figure 1 categorizes subjects into four main categories and three sub-categories according to the two composing definitions of IEM in Austria (see also section 2 of this paper):

- Natural science and technology subjects (1st main category) are bindingly defined by the "Engineering and Technology" and "Natural Sciences" specialization according to the OECD-revised field of science [13] of the analyzed degree programs (e.g. "simulation", "designing", "chemistry", "software engineering", "mechanical technology", "fluid dynamics", "CAX", "mechanics of materials").
- Technology-related subjects (2nd main category) are subjects where the technological basis predominates (e.g. "production management", "recycling", "industrial engineering", "methods of engineering", "infrastructure management", "quality management", "technical project management", "sustainability in engineering", "traffic planning").
- Economics (3rd main category) are subjects with economics teaching content (e.g. "business studies", "business intelligence", "information

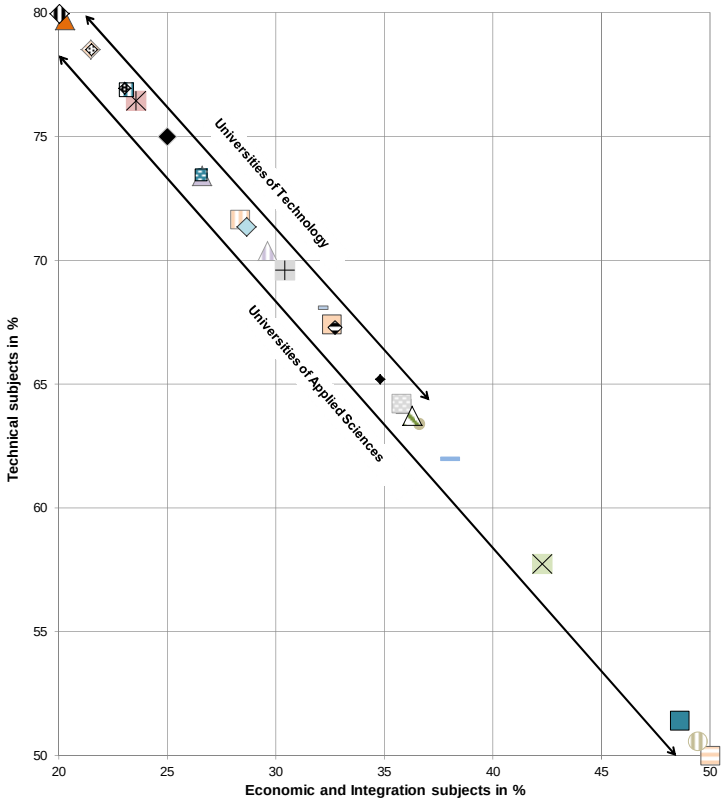
- management", "investment and financing", "supply management", "marketing management", "human resource management", "management accounting", "macroeconomics", "general management and organization").
- Integration subjects (4th main category) are subjects with interdisciplinary questions which have to 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", "knowledge and time management").
- "Attributable" subjects (1st and 2nd sub-category) have to be seen as restricted elective subjects of the respective subject main categories (Figure 1).
- Mixed restricted-elective and free-elective subjects (3rd sub category) are subjects which either can be chosen out of a catalogue with subjects attributable to several main categories (e. g. five subjects out of ten are attributable to economics and the other five subjects are attributable to technical subjects) or are free-elective and therefore cannot be attributed to one subject category because no general statement is possible.
- Internships, bachelor thesis and master thesis (complementary category) 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.

4.2 **Applying the "iem education model" to analyze austrian degree programs**

The analysis applying research procedure described in Section 3.1, leads to Figure 2, which shows the results of the analyzed IEM degree programs of HEIs in Austria.

As highlighted in Figure 2, the IEM degree program's qualification profile of Universities of Technology has a focus that lies between 65% and 80% on technical subjects, though one University of Technology offers one combined degree program with 51% technical subjects. Universities of Applied Sciences, however, 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" (Computer and Information Sciences – CIS, Civil Engineering – CE, Electrical Engineering, Electronic Engineering – EE, Mechanical Engineering (and Production) – MEP, Chemical Engineering – CE, Environmental Engineering – ENE) attributable to the respective IEM degree program and the kind of degree program (bachelor, master or combined bachelor and master).



Key to the symbols:

- Campus 02 University of Applied Sciences (MEP) (BA)
- Campus 02 University of Applied Sciences (CIS) (BA+MA)
- FH Burgenland University of Applied Sciences (ENE) (BA+MA)
- FH Burgenland University of Applied Sciences (ENE) (MA)
- University of Applied Sciences Upper Austria (MEP) (BA+MA)
- University of Applied Sciences Upper Austria (EE) (BA+MA)
- FH Joanneum University of Applied Sciences (ENE) (BA+MA)
- FH Joanneum University of Applied Sciences (MEP) (BA+MA)
- Carinthia University of Applied Sciences (MEP) (BA)
- University of Applied Sciences Kufstein (MEP) (BA)
- Salzburg University of Applied Sciences (CE) (BA+MA)
- University of Applied Sciences Technikum Wien (MEP) (BA+MA)
- Vorarlberg University of Applied Sciences (MEP) (BA)
- University of Applied Sciences Wiener Neustadt (MEP) (BA+MA)
- MCI Management Center Innsbruck (MEP) (BA+MA)
- Alpen-Adria University Klagenfurt (MEP) (BA)
- Johannes Kepler University Linz (ChE) (BA+MA)
- University of Mining Leoben (MEP) (BA+MA)
- University of Mining Leoben (ENE) (BA+MA)
- University of Mining Leoben (EE) (BA+MA)
- Graz University of Technology (CE) (BA+MA)
- Graz University of Technology (EE) (BA+MA)
- Graz University of Technology (CIS) (BA+MA)
- Graz University of Technology (MEP) (BA+MA)
- Graz University of Technology (MEP) (BA+MA)
- Vienna University of Technology (MEP) (BA+MA)
- Vienna University of Technology (CIS) (BA+MA)

Figure 2. Comparison of qualification profiles of IEM degree programs in Austria [18].

5. A TWO-SIDED VIEW ON THE QUALIFICATION PROFILE OF IEMs IN AUSTRIA

Figure 2 shows the range of qualification profiles of all IEM degree programs of HEIs in Austria. In order to check if the offered IEM degree programs provide the qualification profiles corresponding to market needs, IEM professionals and IEM students (Section 5.1), as well as HRMs (Section 5.2), have been asked about aspects of an ideal recommended IEM qualification profile.

5.1 The view of iem professionals: aspects of an "ideal" iem qualification profile

The opinion of IEM professionals and IEM students on "hot IEM topics" shown through specified information regarding an "ideal" IEM qualification profile is displayed in this section by means of the following five aspects: A. Competence profile, B. "Ideal" ratio of technical and economical subjects, C. Importance of teaching content in the interface between technical and economical subjects, D. Fields of operation of IEM professionals and E. Individual competences throughout IEMs career path.

A. Competence profile: IEM professionals were invited to assess the ideal distribution of social and methodological competences and expertise according their current job. A split evaluation is provided in order to assess if the ratio between the aforementioned competences changes throughout the career path. Therefore, a separated evaluation of IEM professionals (which were separated from the IEM students) on the job and retired IEM professionals has been made. IEM professionals on the job specified an almost exact equal share among the aforementioned competences as ideal for their current job position (Figure 3, a.).
Like the IEM professionals on the job, retired IEM professionals specified the same equal distribution of competences needed in their last job position (Figure 3, b.). Hence, an equal importance of social and methodological competences and expertise can be stated as constant throughout an IEM professional career path. Results on the same topic from the year 2005 and 2010 from the IEM studies conducted by the Institute of Business Economics and Industrial Sociology at TUG [7, 19] also state an equal importance of the aforementioned competences.
Therefore, the ideal share of social and methodological competences and expertise for an IEM professional is not only constant throughout the career path but also throughout time, or at least concerning the last 10 years, as the study of 2005 [19] resulted in a ratio of 33% "social competence", 31% "methodological competence" and 36% "expertise" and the study performed in 2010 [7] resulted in 34.8% "social competence", 32.2% "methodological competence" and 33% "expertise".

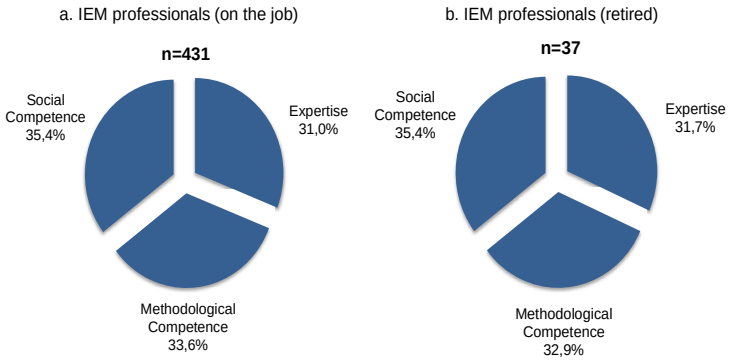


Figure 3. Personal assessment of IEM professionals on the job (n=431) and retired (n=37) regarding the "ideal ratio" of social and methodological competences as well as expertise [21].

B. "Ideal" ratio of technical and economical subjects: 468 IEM professionals and IEM students answered the question as to which ratio of technical and economical subjects would have been ideal for their IEM degree program from their professional perspective. 77.6% are the opinion that an 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 and IEM students based on their professional experience (Figure 4).

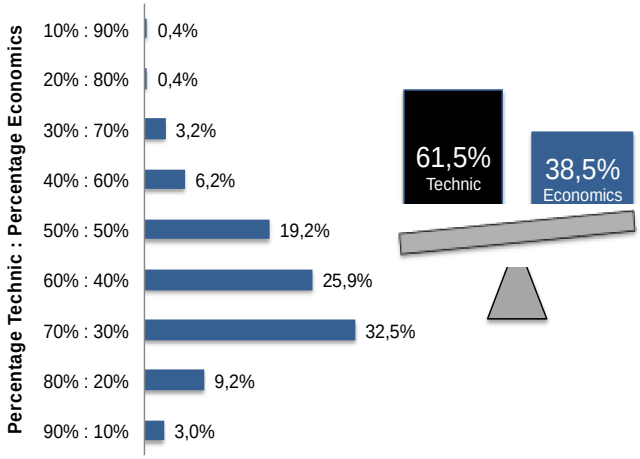


Figure 4. Ideal share of technical and economical subjects of IEM degree programs according to IEM professionals (n=468) [21].

C. Importance of teaching subjects with technical and economical contents ("technical-economical subjects"): The next aspect relates to the importance assessment of specific technical and economical subjects taught at HEIs.
The results are displayed in Figure 5. "Project management" (mean 4.53), "general management" (mean 4.10) and "general business economics" (mean 4.17) are considered by IEM professionals and students as the three most important subjects.

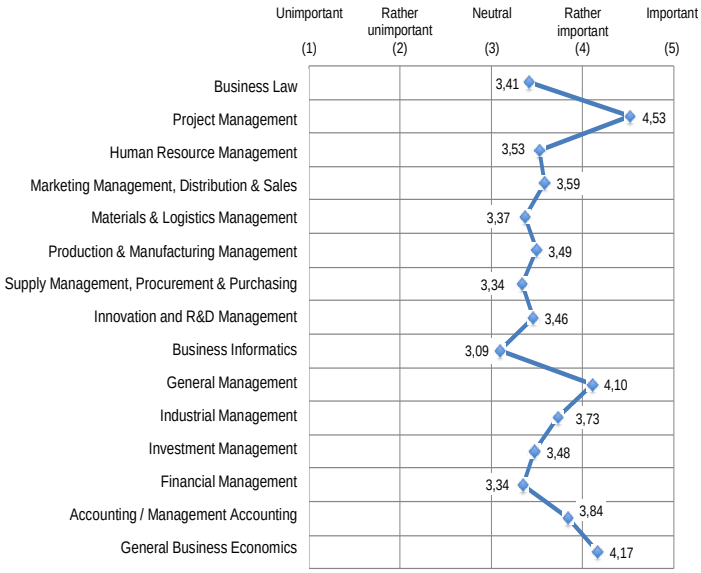


Figure 5. Importance of technical and economical subjects according to IEM professionals (n=468) [21].

D. Fields of operation (FOO) of IEM professionals: In the survey, IEM professionals were asked to indicate how many employments they had until then. On the left side of Figure 6, the fields of operation 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, Research and Development (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. This number rises dramatically in the second job, where 46.5% of the responding 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 FOOs in R&D, Engineering and Process.

In their third job, 70% of the responding 320 IEM professionals already hold a leading position and FOOs in executive and strategic management rise to almost 17%. In their fourth job, 74% of the 212 IEM professionals participating in the survey 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.

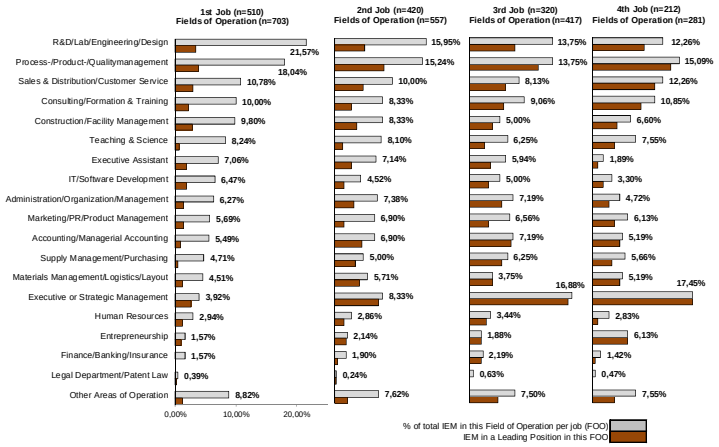


Figure 6. Fields of operation per employment of professional IEMs in Austria [20].

E. Individual competences throughout an IEM's career path: The last question for IEM professionals dealt with the importance assessment of individual as well as person-related competences in their current employment. Due to the common knowledge that the importance of individual competences evolves and shifts focus depending on the career development, it was intended to display this focus shifting according to the career path. Therefore, data of IEM professionals who started their first job within the last five years (since 2009; n=56), data of all IEM professionals on the job (n=431) and data of IEM professionals retired (n=37) has been collected and evaluated separately in order to assess if a focus shifting of needed individual competences is given or not (Figure 7).

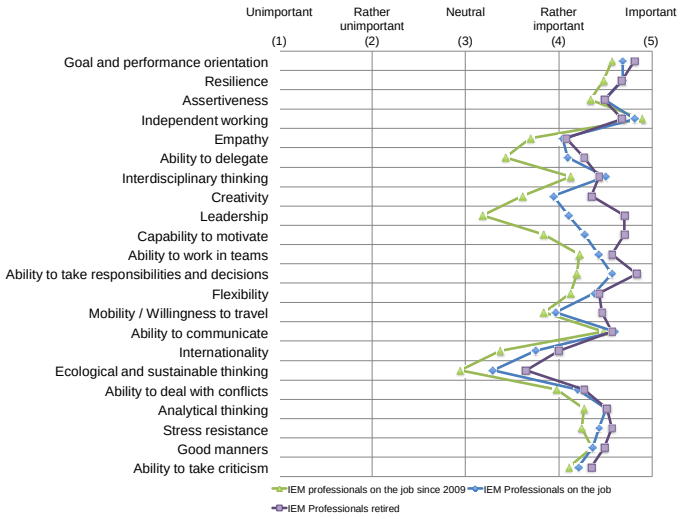


Figure 7. Importance of individual competences throughout an IEM's career path [21].

The results (Figure 7) show a clear shift from the left line, which represents IEM professionals who started their first job since 2009, to the average opinion of all IEMs still on the job (line in the middle) up to retired IEMs, the outer right line. It becomes evident that the "ability to delegate", "leadership" and "ecological and sustainable thinking" are not important competences for a fresh IEM graduate but become increasingly important while advancing along the career path.

Likewise, almost all the other illustrated individual competences become more important throughout the career path, except for “independent working”, which becomes less throughout the career path. Furthermore, the “ability to communicate” is the only competence which keeps the same importance throughout the career path.

5.2 **The view of hrms: aspects of an “ideal-typical” iem qualification profile**

The view of HRMs on an “ideal-typical” IEM qualification profile is displayed in the following six aspects: A. Competence profile, B. “Ideal” ratio of technical and economical subjects, C. Importance of “technical-economical subjects”, D. Importance of person-related competences of IEM graduates and E. Success factors in an application procedure.

A. Competence profile: According to the respondents, the “ideal ratio” of social and methodological competences and expertise of IEM graduates is nearly equally shared. Competences of an IEM graduate should ideally be split into 34.3% “social competences”, 31.9% “methodological competences” and 33.8% “expertise” (Figure 8), which leads to the simple statement that all three competences are equally important. The study of Bauer, Zunk and Fürst from 2010 [7] displays the same results as for 2005 [19], which again indicates that the opinion upon the ideal ratio of the aforementioned competences has been constant over a decade.

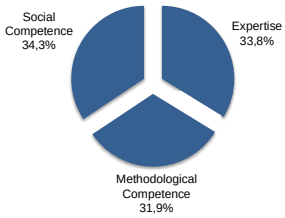


Figure 8. Personal assessment of HRM regarding the “ideal ratio” of social and methodological competences as well as expertise of IEM graduates (n=124) [21].

B. “Ideal” ratio of technical and economical subjects:

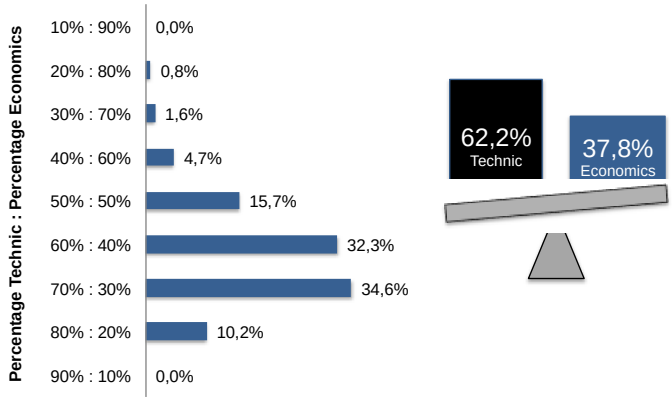


Figure 9. “Ideal“ ratio of technical and economical subjects of an IEM degree program according to HRMs (n=127) [21].

According to the respondents, the ideal ratio of technical subjects and economical subjects (i.e. “integration subjects” are included in the economical subjects) is 62.2% technical subjects and 37.8% economics subjects for an IEM degree program. This distribution reflects the ideal ratio of the two subject categories for an IEM graduate for 127 representatives of companies that compiled the questionnaire. Furthermore, the percentage distribution among all the given answers is displayed in Figure 9.

C. Importance of “technical-economical subjects”: Figure 10 shows the assessed importance of the listed technical-economical subjects. The results display that company representatives think that the subjects “project management”, and “general business economics” are more than rather important and “general management” and “production and manufacturing management” are “rather important” for an IEM graduates qualification profile.

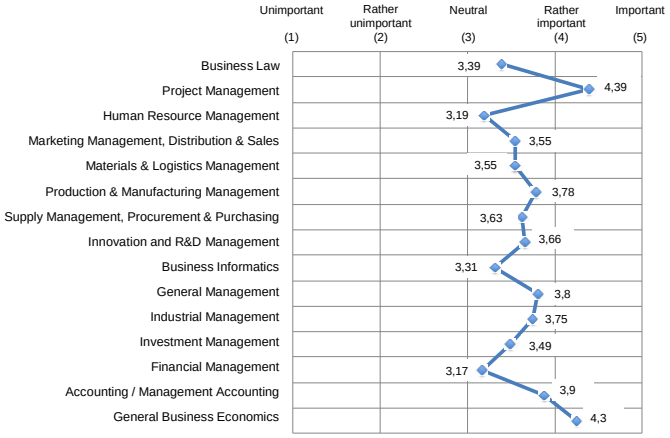


Figure 10. Importance assessment of technical-economical subjects by HRMs (n=127) [21].

D. Importance of person-related competences of IEM graduates: Figure 11 displays the importance of person-related competences for IEM graduates according to the company representatives.

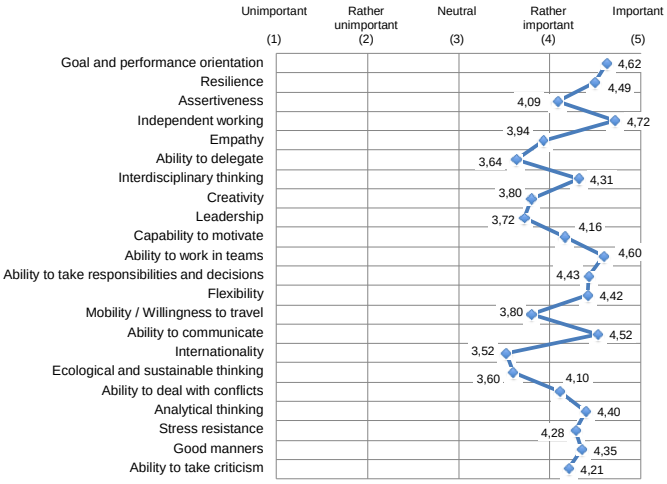


Figure 11. Importance of individual / person-related competences of IEM graduates (n=124) [21].

The most important individual competence is “independent working”, followed by “goal and performance orientation” and the “ability to work in teams”. “Internationality (i.e. the ability to work with and to move in different cultures)”, “ecological and

sustainable thinking", "leadership" and the "ability to delegate" are slightly less important than the aforementioned competences.

E. Success factors in an application procedure: According to the respondents, the "personal characteristics", as well as "practical experiences", are much more important in an application procedure than the "HEI" where the IEM graduated from (Figure 12). Additional qualifications, such as "language skills", "specific computer programs" and "experiences abroad", are also considered as rather important in the application procedure.

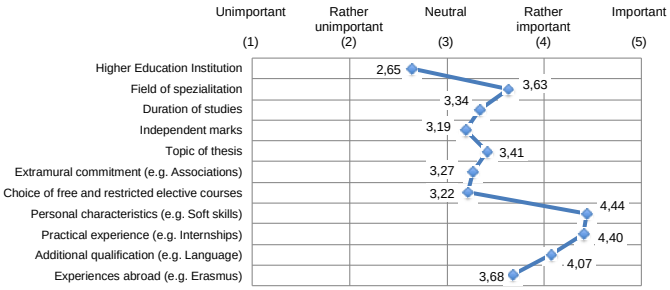


Figure 12. Importance of study and person-related success factors in an application procedure (n=124) [21].

6. DISCUSSION AND CONCLUSION

This contribution provides a translation and definition of the German term "Wirtschaftsingenieurwesen" into the English term "Industrial Engineering and Management" (IEM). Consequently, the following job specification of IEM professionals, recommended by the Austrian IEM alumni association is presented: IEM professionals are engineers who are educated in economics and bear an academic title; moreover, they holistically connect their technical and economics competences in their job. Their academic education has to comprise more than 50% technical subjects, a minimum of 20% economics subjects and a minimum of 10% integrative subjects. Out of the aforementioned definition, the model called "3 pillars of IEM Education" (namely "Natural Science and Engineering", "Integration" and "Economics") was deduced (Figure 1). This model was then used to compare the current 27 IEM degree programs at Austrian HEIs recognized by the Austrian IEM alumni association on the basis of their "Technical" and "Economics + Integration" ratio of their qualification profile (Figure 2). In practice, the variety of qualification profiles of IEM degree programs of HEIs in Austria shown in Figure 2 can be used as a statement for the positioning of HEIs and students alike, enabling industry to choose which qualification profile they want and need. The clear profile of Universities of Technology displayed in Figure 2, for example, therefore leads to the assumption that Universities of Technology put their focus on a profound technical and engineering education, which is recognized by the industry. Beyond that, all HEIs have to emphasize their focus on 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 (Figure 6). Based on survey data from both samples (see Section 3.2 and 3.3), Figure 3 and Figure 8 suggest that the "ideal ratio" of social and methodological competences as well as expertise of the IEM graduates has to be balanced. The analyzed data from the survey among IEM professionals and HRM (displayed in Figure 4 and Figure 9) show that IEM professionals and students, as well as HRMs, recommend an ideal ratio of technical and economical subjects for an IEM degree program as approx. 62% to 38%. The teaching subjects "project management", "leadership and motivation", "business economics", "general management", "social skills", "personal development" and "linguistic skills", "presentation, rhetoric and communication" could be classified as crucial for a positive professional career development of IEMs. The same results could be noticed in the HRM inquiry, which also specified the importance of skills and competences in the aforementioned topics for IEM graduates (see Figure 5 and Figure 10). Figure 6 displays the FOOs of IEM professionals from their first job to their fourth job. The operational spectrum of IEM professionals is wide-ranging, from "R&D" and "production management" to "consulting", "human resource management" and "executive positions". Furthermore, Figure 6 makes evident that the career path of IEM professionals develops over time from operational tasks in the first job to leadership tasks in their following jobs. The data shows that already 46% of the responding IEM professionals hold leadership positions in their second job. The importance of social and individual competences of IEM professionals on the job change throughout their professional career. The survey identifies the biggest gap in the assessment of young IEM professionals on the job since 2009 and already retired IEMs in the needed leadership competences, which are not so important in the first job but become more and more important throughout the professional career of an IEM professional (Figure 7). Figure 11 addresses the assessment of the opinion regarding the importance of person-related competences of IEM graduates and makes evident that the most important individual competence is "independent working", which is followed by "goal- and performance orientation" and the "ability to work in teams". The survey among HRMs shows that personal characteristics and practical experiences of IEM graduates are the most important success factors in an application procedure (Figure 12).

Finally, the results of the ideal qualification profile recommended by IEM professionals and IEM students aptly reflects the recommended qualification profile by the Austrian IEM alumni association and, hence, it is proven that it is still up to date and should be maintained as a reference.

7. LIMITATIONS AND FURTHER RESEARCH

This study also has several limitations. As the survey focused on Austrian IEM professionals, registered alumni IEMs and HRMs, future studies should also be conducted across borders to make comparisons

possible. Conducting studies in other countries could result in a map of "many different names – and many different faces" [11] of IEM degree programs to help gaining transparency and comparability throughout Europe. Besides, a survey comparing the subjects' recommendations of IEM professionals and HRMs in Europe to the subjects being taught at Universities and Universities of Applied Sciences in Austria could be considered in a cross-national survey. The results from the descriptive analysis of the two surveys among IEM professionals and HRMs subsequently displayed in this paper, represent the opinion of (i) a maximum of 16.76% of IEM professionals and IEM students (respective response rate of the survey) and of (ii) a maximum of 3.41% of the HRMs (response rate of the respective survey). Therefore, all results presented in this paper lack a statistical substantial statement which represents the opinion of all IEMs and HRMs in Austria.

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Izoštravanje profila kvalifikacija za industrijsko inženjerstvo i menadžment: rezultati istraživanja u Austriji

Bernd Markus Zunk, Christoph Sadei

Primljen (25.05.2015); Recenziran (01.09.2015); Prihvaćen (11.09.2015)

Apstrakt

Od uvođenja akademskih programa za Industrijsko inženjerstvo i menadžment (IIM) na visokoškolskim ustanovama u Austriji 1950-tih godina, broj IIM programa konstantno raste. Ubrzani promenama obrazovnog sistema Evropske Unije koje su počele 1990. godine, problemi vezani za uporedivost IIM profila kvalifikacija su se povećali. Kako bi se izoštrio IIM profil kvalifikacija, ovaj rad predstavlja (i) preporuku za IIM profile kvalifikacija koja je odobrena od strane asocijacije za akademske programe u zemljama koje govore nemački jezik, (ii) strukturu za poređenje IIM akademskih programa, i (iii) rezultate dve onlajn ankete IIM profesionalaca i IIM studenata, kao i menadžera ljudskih resursa.

Ključne reči: *Visokoškolska institucija, industrijsko inženjerstvo i menadžment, profil kvalifikacije, akademski program.*