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International Council of Academic Departments in Engineering and Management (FFBT WI e. V.), German Association for Engineering Management (VWI e. V.) (Eds.)

# Qualifications Framework Engineering and Management

FFBT WI

VWI Verband Deutscher Wirtschaftsingenieure e.V.

*International Council of Academic Departments in Engineering and Management (FFBT WI e. V.), German Association for Engineering Management (VWI e. V.) (Eds.)*

Qualifications Framework Engineering and Management

Steinbeis-Edition

## Authors

Prof. Dr. Daniel F. Abawi

Prof. Dr.-Ing. Volker Ahrens

Prof. Dr. Stephan Altmann

Prof. Dr.-Ing. Rudolf Bäßler

Prof. Dr. Malte Brettel

Prof. Uwe Dittmann

Prof. Dr. Hermann Englberger

Prof. Dr.-Ing. Wolf-Christian Hildebrand

Prof. Dr.-Ing. Yvonne Leipnitz-Ponto

Prof. Dr.-Ing. Andreas Merchiers

Prof. (FH) Gunter Olsowski

Prof. Dr.-Ing. Dieter Pumpe

Prof. Alfred Schätter

Prof. Dr.-Ing. Burkhard Schmager

Prof. Dr. Christian Schuchardt

Prof. Dr. Christian von Hirschhausen

Prof. Dr. Matthias Werner

Prof. Dr.-Ing. Hartmut Zadek

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**Imprint**



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# Preface
# Prof. Uwe Dittmann (FFBT WI e. V.)

Future is development – this credo also applies to our education system. Institutions of higher education can only produce graduates for the labor market with the ability to face current business challenges, consciously take on responsibility, and actively help forge our future when the key players carefully observe social trends and, in the case of higher education, continue to develop and refine the strategy and objectives of their degree programs.

The International Council of Academic Departments in Engineering and Management (Fakultäten- und Fachbereichstag Wirtschaftsingenieurwesen e. V., FFBT WI e. V.) is aware of its critical scientific and societal responsibility with regard to forging this future. We took the final revision of the University Qualifications Framework by the Culture Ministers Conference as an opportunity to align the third edition of the Qualifications Framework for Engineering and Management to these newly adopted guidelines. The qualification profile focuses on describing the skills and competences students in Engineering and Management programs develop during their studies. The goal is to teach students to reflect and act in an innovative manner and, in this way, help them continue to grow and develop throughout their professional lives with the help of scientific methods.

A qualifications framework is a systematic description of a graduate's qualification profile. In the increasingly diversified system of higher education, it is especially important for individual degree programs – and particularly for such an interdisciplinary and integrative-oriented independent study program as Engineering and Management – to clearly and transparently formulate the standards that must be satisfied in its curriculum in order to bear the prestigious title of „Engineering and Management". This qualifications framework serves as a set of guidelines and a quality assurance instrument. It contains a list of the target learning outcomes, a description of the knowledge and skills graduates should possess, a description of formal aspects such as workload

reflected in ECTS credits, admittance criteria, degree designations, and other formal qualifications.

The intention of the framework is to provide orientation when developing and further refining a curriculum and, at the same time, to clearly differentiate the Engineering and Management degree from other degrees. It should also provide a reliable "quality seal" showing that a completed degree in the field continues to represent the highest possible level, one that creates excellent career opportunities for graduates. There is a reason why Engineering and Management is currently one of the three most sought-after degree programs in German-speaking countries with an equally strong reputation among companies.

Engineering and Management programs consist of four defined core areas: engineering sciences, natural sciences and mathematics; business, law and other social sciences; the integration courses, which represent the heart of the program and cover interdisciplinary research questions and interdependencies in a holistic manner; and finally, soft skills and foreign languages. The Qualifications Framework for Engineering and Management provides detailed criteria for how the core areas are weighted and formulates the targeted learning outcomes in the form of knowledge, skills and competences that graduates should acquire in bachelor's and master's programs. It also describes the possibility of pursuing a PhD.

I would like to thank all colleagues from our member universities in Germany, Austria and Switzerland who took part in the numerous working group meetings to revise and further develop the Qualifications Framework for Engineering and Management, which was first published in 2012. With our shared critical perspective and constructive suggestions, we have collaboratively reached our goal of putting together a document that does justice to the current requirements of our educational system while adequately integrating impulses from the sciences and society.

I would like to express my particular gratitude to my colleague, Alfred Schätter, who was a driving force in promoting the results of the working groups. He has

consolidated the ideas and contributions of our members and, in doing so, has had a considerable impact on the completion of this third edition.

Our collaboration is however by no means complete; on the contrary, it is part of an ongoing, evolutionary process of further developing this field of study. Beyond the regular updates of this qualifications framework, the next point on the agenda is to prepare a systematic overview, which would enable us to clearly define the concept of the Engineering and Management degree program according to international standards and make such programs comparable beyond the borders of the German-speaking world.

*Pforzheim, April 2019*
*Chairman of the International Council of Academic Departments*
*in Engineering and Management (FFBT WI e. V.)*
*Prof. Uwe Dittmann*

# Preface
# Dr.-Ing. Frauke Weichhardt (VWI e. V.)

I am pleased to present to you the 1st Englisch edition of the Qualifications Framework for Engineering and Management. The qualifications framework is an important contribution to the definition of study contents and structures of combined management and engineering study programs and thus makes an important impact on the quality assurance in this study area. At the interface between technology and management, training in Engineering and Management has proven successful for many industries now for over 90 years.

The original study concept from the 1920s has been re-defined early in Germany in the 1950s by a three pillars concept of the Berlin model according to the academic directors of the Berlin program Horst Wagon and Helmut Baumgarten. The qualifications framework presented here is intended to go one step further. In addition to the Berlin model, a fourth pillar is added to define the course of study: Besides the traditional study areas such as "Technology" (thus STEM subjects), "Business Administration" and "Integration Studies" now the additional study area of "Soft Skills and Foreign Languages" has been integrated. This takes the global developments in industry and society since the conception of the Berlin Model into account.

The German Association for Engineering Management (Verband Deutscher Wirtschaftsingenieure e. V., VWI e. V.) is the German Association of graduates holding combined academic management and engineering degrees. Only five years after the founding of the first program of this kind in Berlin in 1927, the association took up its work to ensure the academic, practice-oriented and professional development of Engineering and Management within the framework of quality assurance. It has been committed to the quality assurance and further development of such interdisciplinary academic programs ever since.

This qualifications framework, which was created in cooperation with the International Council of Academic Departments in Engineering and Management (FFBT WI e. V.), offers prospective students and universities the oppor-

tunity to obtain information about study contents and structures, in order to create a high-quality offer.

It is important for me to emphasize that this present work was created by a large number of authors from different teaching institutions. Thus, different perspectives illuminate Engineering and Management and, due to their diversity, ensure an excellent result in the definition of the course of study.

My thanks therefore go to all the authors who have worked hard and attended various meetings to produce this outstanding work, thus contributing to the quality assurance of the course for future students.

*Berlin, July 2020*
*President of the German Association for*
*Engineering Management (VWI e. V.)*
*Dr.-Ing. Frauke Weichhardt*

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# 1 The Purpose of Qualifications Frameworks

Qualifications frameworks are used by German institutes of higher education as a reference to categorize and compare the qualifications and competences of graduates from different federal states, educational institutions and subject areas. They are key instruments used to achieve the central objectives of the Bologna Process:

- Making universities and colleges more transparent and integrated
- Supporting student mobility
- Improving the comprehensibility and comparability of degrees
- Recognizing academic achievement and grades
- Describing the qualification profile, qualifications to be achieved (learning outcomes), and the competences and skills, graduates should possess.

Qualifications frameworks are used by German university degree programs as the basis for designing their programs and to support the further development of their curricula.

These higher education qualifications frameworks should not be confused with the European Qualifications Framework (EQR)[1], which pursues other objectives. The European Qualifications Framework was created to make academic qualifications in the European Education Area comparable. Its purpose is to provide a common reference that can be used as a "translation tool" for different national qualification systems and their assessment levels. This applies to school education, higher education, as well as vocational training.

In order to achieve this, the EQR defines eight reference levels of learning outcomes needed to obtain the qualifications corresponding to each level in all

1 Europäisches Parlament / Rat der Europäischen Union: Empfehlung des Europäischen Parlaments und des Rates vom 23. April 2008 zur Errichtung des Europäischen Qualifikationsrahmens für lebenslanges Lernen. In: Amtsblatt der Europäischen Union. C111/1–7. Brussels, 2008.

qualification systems.[2] The cross-departmental German Qualifications Framework (DQR)[3] was given the responsibility of implementing the European Qualifications Framework nationally.

The German Conference of Ministers of Education and Cultural Affairs (KMK) had already adopted its own "Qualifications Framework for German Higher Education Qualifications (HQR)"[4] in 2005. This document specifically lists the university-level qualifications and refers to the EQR and the DQR. In terms of the described higher education requirements and competences, reference levels 6, 7 and 8 in the DQR correspond to level 1 (bachelor's level), 2 (master's level) and 3 (doctoral level) in the Qualifications Framework for German Higher Education Qualifications (HQR).

The HQR was revised in February 2017 based on the version from April 21, 2005, placing particular emphasis on an "academic self-image" that can be defined as the "academic professionalism" of university graduates.[5] This includes competences in research-based learning, self-directed behaviour, and the ability to critically reflect on scientific findings and make responsible decisions.

The International Council of Academic Departments in Engineering and Management (FFBT WI ) has developed a qualifications framework for Engineering and Management (QF E&M) based on this general qualifications framework.

The QF E&M is intended for all types of universities (public and private) and describes the knowledge, skills and competences that graduates with a bachelor's or master's degree can be expected to have. It takes account of the fact that some aspects of degree programs at universities of applied sciences[6] and cooperative universities are often "more practically-oriented", while university

2 Cf. ibid. C111/5 f.
3 Cf. Arbeitskreis Deutscher Qualifikationsrahmen (AK DQR): Deutscher Qualifikationsrahmen für lebenslanges Lernen. (Adopted on March 22, 2011).
4 Cf. Hochschulrektorenkonferenz, Kultusministerkonferenz, Bundesministerium für Bildung und Forschung: Qualifikationsrahmen für Deutsche Hochschulabschlüsse. (Adopted on April 21, 2005).
5 Cf. KMK: Qualifikationsrahmen für Deutsche Hochschulabschlüsse (Resolution on 16.02.2017), p. 3 f.
6 This includes Applied Universities and Technical Universities.

degree programs tend to be "more research-oriented", and, where possible and useful, highlights such characteristics.

This current revision of the QF E&M is based on the revised version of the Higher Education Qualifications Framework for German Higher Education Qualifications from February, 2017 and focuses on emphasizing the characteristics of a university-level education and the competences it develops, and in doing so creates an independent profile.

The QF E&M is divided into two main sections. Section 2 describes the Engineering and Management major and provides uniform guidelines for the content and structure of the studies. It contains recommendations for a core curriculum but does not propose how departments should assign program content to different academic levels (bachelor's, master's, doctoral). These decisions are left up to the respective universities.

Section 3 essentially provides a general qualifications profile for bachelor and master-level graduates from Engineering and Management programs. This section thus provides an introduction to the QF E&M in a narrower sense, and thus also forms the basis for awarding accreditation and quality seals in the field of Engineering and Management.

This can thus be used as a basis for performing internal and external quality assurance in Engineering and Management programs.

The QF E&M provides an orientation guide with the purpose of improving the comparability of Engineering and Management programs nationally and internationally.

The QF E&M is based on the following documents (in chronological order):

- KMK – German Conference of Ministers of Education and Cultural Affairs: Model Ordinance Federal Treaty on Accreditation of Degree Programs[7]

7 Cf. KMK: Musterrechtsverordnung gemäß Artikel 4 Absätze 1–4 Studienakkreditierungsstaatsvertrag on 01.01.2018 (Resolution on 07.12.2017).

- Qualifications Framework for German Higher Education Institutions[8]
- Qualifications Framework for Social Work[9]
- Engineering and Management in Training and Practice. Professional profile survey carried out by the German Association for Engineering Management (VWI e. V.).[10]
- Supplementary discipline-specific guidelines for the accreditation of bachelor's and master's degree programs in Engineering and Management[11]
- New program structures for bachelor's and master's degree programs in Engineering and Management[12]

8 Cf. KMK: Qualifikationsrahmen für Deutsche Hochschulabschlüsse (Resolution on 16.02.2017).

9 Schäfer, Peter / Bartosch, Ulrich: Qualifikationsrahmen Soziale Arbeit. Würzburg, 2016.

10 Cf. Baumgarten, Helmut / Hildebrand, Wolf-Christian / von Hirschhausen Christian / Schmager, Burkhard: Wirtschaftsingenieurwesen. Hochschulausbildung, Wissenschaft und Praxis. 15th revised and updated edition. Berlin, 2019.

11 Cf. ASIIN e. V.: Fachspezifisch Ergänzende Hinweise des Fachausschusses 06 – Wirtschaftsingenieurwesen, Wirtschaftswissenschaften zur Akkreditierung von Bachelor- und Masterstudiengängen des Wirtschaftsingenieurwesens (Adopted on March 20, 2020).

12 Cf. Schuchardt, Christian / Baumgarten, Helmut / Hildebrand, Wolf-Christian: Neue Studiengangsstrukturen im Studiengang Wirtschaftsingenieurwesen mit den Abschlüssen Bachelor und Master. Berlin, 2006.

# 2 Engineering and Management Programs

## 2.1 Overview of Engineering and Management Programs

The major in Engineering and Management combines academic content from both business and technology. Students acquire knowledge from the engineering sciences, natural sciences, information technology, economics, law and social sciences, as well as soft skills, including international and intercultural competence, communication and team skills, presentation, negotiation and conflict management skills.

The typical tasks of Engineering and Management professionals include being able to integrate economic and technological solutions as well as sustainable systems for the business world and society in general. This work, which is increasingly being done in institutional, social and digital networks, includes, for example, designing complex plants and systems, taking on management and sales responsibilities, managing ambitious projects or analyzing technological questions from a business point of view.

In order to be able to solve these predominantly integrated tasks in a highly complex and networked environment, it requires technological, business, legal, social and communicative competences that fit the profile of Engineering and Management programs.

The historical academic profile of Engineering and Management can be traced back to the start of the 20th century. The increase in technological development and industrialization in the German-speaking countries also led to a demand for personnel and managers with technical and business knowledge and the

ability to integrate this knowledge.[13] The first integrated degree program was designed at the Technische Hochschule Berlin-Charlottenburg. The program, which opened in 1926, was based on the degree in mining engineering education, which had originally combined technology with investment calculation and management. Willi Prion (1879–1939) was the first to use the academic profile "Wirtschafts-Ingenieur" (loosely "business engineer") – a term which he derived after an intensive academic debate on the new integrated degree concept.[14]

Three core elements of the program were already recognizable in this concept:

- Combined technical and business education, supporting the ability to integrate the two academic areas,
- Interdisciplinary orientation as a basis for creative innovation between technology and the market,
- Teaching the basics of leadership in technology companies.

Integrating the different fields of knowledge in the various company departments continues to pose a challenge today. Engineering Management professionals must therefore be specifically trained to forge interfaces between the technological and business functions of a company.

In addition to professional competence, these professionals also require intercultural communication, social and management skills. Intercultural skills here in this context refer not only to country cultures, but also to specialist and functional cultures. Graduates from Engineering and Management programs should therefore be socialized into the discourse language and value systems of engineering sciences and business during their studies. This can only be achieved with an integrative education. Graduates are ideally prepared for integration and coordination responsibilities in companies and institutions due to their extensive educational training in theoretical, methodological and social skills in a variety of academic fields.

13 Cf. Zandin, Kjell B. (Ed.): Maynard's Industrial Engineering Handbook. 5th edition, New York, 2001.
14 Cf. Prion, Willi: Ingenieur und Wirtschaft. Der Wirtschafts-Ingenieur. Eine Denkschrift über das Studium von Wirtschaft und Technik an Technischen Hochschulen. Berlin, 1930, p. 146 ff.

Thanks to this approach, Engineering and Management studies have proven to be a sustainable academic innovation. This major is currently being offered by numerous universities in German-speaking countries. As of 2019, students at over 100 universities of applied sciences, around 30 universities, and a number of cooperative state universities and vocational academies can pursue this degree.[15] The increased number of degree programs and the disproportionately high (and increasing) number of people working in this field compared to other professions has led to the widespread acceptance and recognition of Engineering and Management as an occupational profile. A professional profile survey carried out by the German Association for Engineering Management (VWI e. V.) demonstrates the excellent job and career advancement opportunities for Engineering and Management graduates in a wide range of business sectors.[16]

The activities of the German Association for Engineering Management (VWI e. V.), founded in 1932, have strongly promoted the field of Engineering and Management and have led to a significant increase in its popularity.[17] One of these activities was the aforementioned publication of the 15th edition of the "Engineering and Management in Education and Practice"[18] professional profile survey, which provides a comprehensive overview of degree programs and career opportunities for Engineering and Management graduates. In particular, the investigation of the professional profile has had a very significant influence on the development of Engineering and Management programs in recent decades.

15 Cf. Baumgarten, Helmut / Hildebrand, Wolf-Christian / von Hirschhausen Christian / Schmager, Burkhard: Wirtschaftsingenieurwesen. Hochschulausbildung, Wissenschaft und Praxis. 15th revised and updated edition. Berlin, 2019, p. 24 ff.

16 Cf. ibid., p. 65 ff.

17 Cf. Zadek, Hartmut: Zur Entstehung des Wirtschaftsingenieurwesens – Prägende Persönlichkeiten. In: Zadek, Hartmut / Risse, Jörg (Eds.): Führungskräfte für ein integriertes Management – Wirtschaftsingenieurwesen in Wissenschaft und Unternehmenspraxis, Berlin, Heidelberg, New York, 2003, p. 98.

18 Baumgarten, Helmut / Hildebrand, Wolf-Christian / von Hirschhausen Christian / Schmager, Burkhard: Wirtschaftsingenieurwesen. Hochschulausbildung, Wissenschaft und Praxis. 15th revised and updated edition. Berlin, 2019.

## 2.2 Competence Profile of Engineering and Management Graduates

Engineering and Management graduates have the innovative potential to recognize current developments in technology and business, take entrepreneurial action, develop sustainable technological and economic solutions, and implement them in a highly-networked digital environment. The ability to take effective action is a prerequisite for being able to successfully implement innovative technologies and solutions on the market. This ability is a combination of professional, methodological and social competence and enables people to "act in a well thought-out and responsible manner in professional, social and private situations"[19]. This also means taking both the aspects of social change and the international dimensions of strategic and operational decisions in an increasingly global environment into account.

One of the central guiding principles of Engineering and Management programs is to develop such interdisciplinary competences during the course of the studies. This promotes both creativity in terms of being able to solve technological and business-related problems as well as developing innovations. Having an interdisciplinary competence profile can also help graduates better explain the rationale for new solutions as well as assert their usefulness within a company. In addition, knowledge of the market is absolutely essential when trying to successfully launch new ideas in a customer-oriented and competitive environment.

The business world and society in general need graduates with the ability to take on management tasks and to be able to implement entrepreneurial decisions. Managers also have to be able to make decisions in situations free from the constraints of traditionally separate business subjects and develop mechanisms that help them systematically gain experience, prepare for decisions,

19 KMK: Handreichung für die Erarbeitung von Rahmenlehrplänen der Kultusministerkonferenz für den berufsbezogenen Unterricht in der Berufsschule und ihre Abstimmung mit Ausbildungsordnungen des Bundes für anerkannte Ausbildungsberufe. (Resolution on 23.09.2011), p. 15.

redesign structures and processes and measure their effectiveness – all in a complex, international, digital and networked environment.

Graduates with degrees in Engineering and Management are well-prepared to handle such complex management tasks thanks to their integrative, interdisciplinary education – even if they typically only take on true management tasks some years after starting their careers once they have gained professional experience in specific company positions or projects.[20]

## 2.3 Interdisciplinary and Integrative Approach

Engineering and Management primarily combines the academic fields of engineering and management and is therefore an interdisciplinary and integrative course of study. Traditionally, an interdisciplinary education is based on the understanding that there are similarities in the structural patterns (isomorphs) between the knowledge disciplines, and that it is possible and reasonable to make use of such pattern similarities in a scientific and practical manner.

The physicist and philosopher, Carl Friedrich von Weizsäcker attached particularly general importance to this approach. He argued that structural sciences would not only be referred to as pure and applied mathematics, but also as the field of science which was not yet fully understood in its structure, and which was referred to by names such as systems analysis, information theory, cybernetics and game theory. They were, so to speak, the mathematics of dynamic processes that are controlled by human decision, by planning, by structures or finally by random choice. He therefore considered them to be structural theories of temporal dynamic transformation. Their most important practical tool was the computer, whose basic theory is one of the structural sciences. Anyone who wanted to promote the progress of science in a country had to promote

20 Zadek, Hartmut: Karrierechancen für Wirtschaftsingenieure. In: Zadek, Hartmut / Risse, Jörg (Eds.): Führungskräfte für ein integriertes Management – Wirtschaftsingenieurwesen in Wissenschaft und Unternehmenspraxis, Berlin, Heidelberg, New York, 2003, p. 195 ff.

these sciences as a matter of urgency.[21] By providing cross-disciplinary forms of expression, structural sciences enable communication across disciplinary boundaries and recognizing commonalities.

These structural theories, methods and tools form the basis of interdisciplinary work. These include, for example, mathematics and systems theory and, within these disciplines, sub-disciplines, such as operations research, systems engineering or current methods in the field of data analytics that make use of the available data sources in a digitally networked environment ("big data").

Traditionally, Engineering and Management has always been ideally suited to handle questions which, in view of the complexity of the interdependencies of technological progress, economic growth and social change, cannot be answered by a single science alone.[22] This comes from its combination of sound knowledge in the basic disciplines and interdisciplinary, integrative competences.

However, as previously described in Section 2.1, the typical tasks of Engineering and Management professionals involve integrating business and technological solutions and sustainable systems for business and society – increasingly in international settings and involving the interactions of multiple players in institutional, social and digital networks. Such integrative qualifications are urgently needed today, for example, due to the rapid developments in the field of digitization and in projects in connection with the German Industry 4.0 Initiative.[23] A study among larger German companies shows a considerable need for innovation and investment in this area and points to the high demand for young graduates with exactly these qualifications.[24]

In order to be able to master such challenges in this environment, professionals need sound theoretical knowledge, skills and competences in the respective

21 Cf. Weizsäcker, Carl Friedrich von: Die Einheit der Natur. 4th edition, Munich, 1971, p. 22.

22 Geschka, Horst / Müller-Merbach, Heiner: 18 Thesen zum WI-Studium – Memorandum des VWI zum Studium des Wirtschaftsingenieurwesens. In: technologie & management, 48th volume, 1999, No. 5, p. 48–50.

23 Cf. Bauernhansl, Thomas / ten Hompel, Michael / Vogel-Heuser, Birgit (Eds.): Industrie 4.0 in Produktion, Automatisierung und Logistik: Anwendung – Technologien – Migration. Wiesbaden, 2014.

24 Cf. Bitkom – Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e. V.: Industrie 4.0 – Status und Perspektiven (Studie). Berlin, 2016.

individual disciplines. They also need to be able to recognize connections and interactions between technological options and business requirements and implement these for integrated, networked solutions. In order to do this, their training should include integrative competences in the sense of a holistic management approach.

This integrative approach is introduced as the "core area of integration" in section 2.6 of the QF E&M, the description of the degree program curriculum.

## 2.4 Range of Occupations for Graduates

Graduates from Engineering and Management programs find employment in all business areas thanks to their interdisciplinary education. The following list, taken from the Professional Profile Survey 2015, shows the types of employment most frequently chosen by graduates in the industrial, business and service sectors[25] (in descending order):

- Project management
- Sales
- Controlling
- Corporate Management
- Transportation / Logistics
- Production
- Purchasing
- Marketing
- Consulting
- Finance

25 Cf. Baumgarten, Helmut / Hildebrand, Wolf-Christian / von Hirschhausen, Christian / Schmager, Burkhard: Berufsbilduntersuchung Wirtschaftsingenieurwesen in Ausbildung und Praxis. 14th edition, Berlin, 2015, p. 65 f.

- Organization
- Research & Development
- Computer Science / IT
- Human Resources

There has been a rapid development in digitalization in almost all business areas over the past years. With their integrative training, Engineering and Management graduates are particularly suitable for these types of jobs. We thus expect to see a strong increase in demand for people with this degree in the following areas:

- Industry 4.0 / Internet of Things and
- Data Analytics

These positions would be in a wide range of industries and in most company departments.

It should also be noted that the interdisciplinary training in Engineering and Management programs makes graduates particularly well-suited to run their own businesses.

Engineering and Management professionals often end up working at the numerous interfaces between management and technological areas. They also work in areas that have developed independent and overarching cross-sectional functions for everyday business, such as logistics, supply chain management, quality management or production management – as well as, specifically, in the context of projects resulting from digitalization and the Industry 4.0 initiative.

Engineering and Management professionals make a strong contribution to solving interdisciplinary technological, business and legal issues at all company levels. They are particularly adept at recognizing and solving interdisciplinary and integrative problems. This includes, for example, analyzing complex deci-

sion-making situations, developing and evaluating alternative solutions as well as carrying out implementation and controlling tasks.

The increasing complexity, connectivity and digitalization of technology, business and society call for high-level interdisciplinary and integrative work qualifications. Engineering and Management programs have historically been, and in their current form are also set up to prepare students to face exactly these challenges.

Graduates are thus particularly well-prepared to handle the requirements of an integrative and holistic management system.

## 2.5 Conceptual Classification of Program

By design, Engineering and Management programs combine two very different disciplines. This leads to a conflict of goals, as such 2-tier bachelor's / master's degree programs in the German-speaking world must be completed in the same standard period of time as individual (e. g., Engineering itself) degree programs.[26] Furthermore, the KMK specifications of a minimum module size, normally five ECTS points[27], often does not match the requirements of a broad-based degree program such as Engineering and Management.

The interdisciplinary and integrative orientation of the Engineering and Management major is supported by interlinking the academic content of business and engineering courses. In addition to providing subject-specific content and methods from various disciplines, integration courses educate students to think beyond traditional academic boundaries. This is the central qualification of Engineering and Management graduates.

26 Cf. KMK, Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland: Musterrechtsverordnung gemäß Artikel 4 Absätze 1–4 Studienakkreditierungsstaatsvertrag on 01.01.2018 (Resolution on 07.12.2017).

27 Cf. KMK: Ländergemeinsame Strukturvorgaben für die Akkreditierung von Bachelor- und Masterstudiengängen. (Resolution on 10.10.2003, in the version of 04.02.2010), p. 1 in the appendix.

This qualification is realized for example by having students carry out projects with students from engineering, business and other social science majors. By coordinating and designing such technological and business projects and processes, students gain valuable communication and integration skills that become an asset in their future professional careers.

The following core areas, explained in more detail in section 2.6 below, are the main components of the Engineering and Management studies:

- Science, Technology, Engineering and Mathematics (STEM),
- Business Management, Law and other Social Sciences,
- Integration Courses,
- Soft Skills and Foreign Languages.

In addition to lectures, didactic elements include seminars, seminar-like courses, project work, case studies, business games and laboratory practice as well as internships and writing a thesis. The seminars, project work, case studies and laboratory exercises all take place in small groups. We believe that this significantly improves the quality of teaching, since these types of teaching and learning are characterized by more intensive coaching and stronger interaction between learners, which increases the knowledge acquired in specific applied scenarios.

## 2.6 Course Content including Core Areas, Internships and Thesis

Engineering and Management graduates require professional, methodical and social skills in order to find employment in industry. These skills are taught via a curriculum with the following characteristics:

The program, which consists of four core areas as well as internships and a final thesis, is described in more detail in the following sections. The concept of the

Engineering and Management program is not based on two parallel economic and engineering sections, but on the interdisciplinary connection between these subjects. This can be illustrated by the structures and characteristics of the core areas, presented below.

**Academic content from the core areas of science, technology, engineering and mathematics (STEM) provide an understanding of technical processes, interrelations and contexts:**

The content of the sciences and engineering courses is essentially determined by the specific engineering part or the respective specialization focus within the Engineering and Management degree program. These include mathematics, computer science, physics, chemistry, materials engineering, design, electrical engineering, manufacturing processes and process engineering. A degree in Engineering and Management can focus either on mechanical engineering, electrical engineering or civil engineering or on another technology-oriented major, such as recycling and environmental engineering, food technology, automotive engineering, plastics technology, communications engineering or information and communication technology.[28]

**Academic content from the core area of business and management, law and other social sciences provide an understanding of economic, legal and social factors and framework conditions:**

The core areas of management, law and other social sciences include general business administration, accounting and controlling, economics, marketing, corporate management, business law and sociology. Here, too, the breadth and depth of the studies can be varied within a certain framework by selecting different subject combinations. This generally leads to a specialization in a specific area of study, such as international management or product management.

28 Further listings of study programs can be found in: Baumgarten, Helmut / Hildebrand, Wolf-Christian / von Hirschhausen, Christian / Schmager, Burkhard: Wirtschaftsingenieurwesen. Hochschulausbildung, Wissenschaft und Praxis. 15th revised and updated edition. Berlin, 2019.

**Academic content from the integration core area is intended to supplement and ensure that engineering and management content is connected and interrelated:**

The essential characteristic of the Engineering and Management program is the integrated core area of the studies. Courses here build upon the practice of thinking and working in an interdisciplinary manner, which includes scientific methods and approaches with the goal of teaching students to solve interdisciplinary problems in a holistic way. The focus is on understanding and connecting the terminology systems and methods from different disciplines. Against this background, it is important to note that the presentation of technical and economic content in an integrative manner is already taken into consideration when designing the courses in the first two core areas mentioned above, for example by demonstrating the economics of technological processes or the controlling of production processes.

The integration courses, which present technology and business in terms of their interrelationship, form the integrative character of the Engineering and Management studies and help achieve the interdisciplinary aspect. Typical integration courses include Operations Research, Project and Process Management, Entrepreneurship and Corporate Strategy, Enterprise Resource Planning, Manufacturing Management, Computer Engineering and Business Informatics, Patent Law, Supply Chain Management, Production Management, Factory Planning, Systems Engineering, Technical Sales or Logistics.

**The focus of the soft skills and foreign languages core area is to develop interdisciplinary and intercultural communication skills:**

The integrative innovation and leadership competence typical for Engineering and Management professionals requires not only technological and methodological skills but also distinct social (or soft) skills. This includes above all the ability to communicate technological and business content both within and outside the company in an interdisciplinary and intercultural manner, and also in different languages.

Typical content for this core area include foreign languages, communication and presentation skills, leadership, ethics, team organization, intercultural engineering, intercultural communication or intercultural social competence.

**Practical-orientation is acquired via internships integrated into the curriculum or required by the university's academic guidelines:**

In addition to academic content, internships in the field of Engineering and Management are part of the program. A 3-month minimum company internship during the bachelor's program is recommended. In the case of part-time or dual programs (done both at a university and a company), professional work experience can be credited as an internship. It may make sense to divide the internship period between different companies.

**The ability to work independently as an academic researcher by completing written assignments and a challenging thesis:**

These written works must meet scientific requirements and can be either research-oriented or application-oriented. The focus can be on one or more core areas of Engineering and Management, whereby the integrative study approach should be recognizable in the student's formulation of the topic.

One particular challenge when designing the curriculum is limiting the scope of the studies while at the same time maintaining the depth of the various subject areas, then integrating these at an appropriate level of quality. This means that the required basic courses should be carefully selected and should focus on the in-depth content in possible specializations. It also makes sense to divide the content into the part learned in the classroom and that which is acquired outside of class.

## 2.7 Recommendations for Program Structure and Core Curriculum

### 2.7.1 Simultaneous Program Structure

The Engineering and Management major is typically set up as a simultaneous degree program. The simultaneous structure, containing technological, management and integrative content, has the decisive didactic advantage of creating interdisciplinary networking during all phases of the studies. This makes systematic connections and cross-references between the disciplines clear for students and enables them to anchor the different technical and methodological skills and competences in a step-by-step, parallel manner during the entire period of study – both in the field of engineering and business fundamentals as well as in the theoretical and application-oriented specializations.

Simultaneous degree programs in particular, with their parallel and integrative development of engineering, management and social sciences skills and competences, promotes creative lateral thinking. This is an essential part of the concept of Engineering and Management studies and enables graduates to assume integrative and coordinating roles in business and society, especially in the areas of innovation and leadership.

In terms of logic and structure, the interdisciplinary simultaneous Engineering and Management major corresponds to the studies created by Willi Prions for the first Engineering and Management program at the Technische Hochschule Berlin-Charlottenburg in 1926 (cf. Chapter 2.1). This simultaneous approach to Engineering and Management led to the so-called Berlin Model, which served as a model for the development of Engineering and Management studies at many universities.[29]

29 Baumgarten, Helmut / Hildebrand, Wolf-Christian / von Hirschhausen Christian / Schmager, Burkhard: Wirtschaftsingenieurwesen. Hochschulausbildung, Wissenschaft und Praxis. 15th revised and updated edition. Berlin, 2019, p. 24 ff.

### 2.7.2 Consecutive Program Structure

It is also possible to obtain a degree in Engineering and Management within the framework of a postgraduate or master's program – usually after completing a first degree in Engineering.

Postgraduate programs in Engineering and Management are traditionally designed for engineering graduates and primarily focus on business and management-oriented content and methods. In the case of students with a first degree in engineering that contained a higher proportion of mathematical subjects as well as engineering content, the Engineering and Management master's programs must offer a postgraduate degree focusing primarily on business and integrative aspects. In the case of bachelor's programs with a higher proportion on business-related courses, the opposite applies. Accordingly, the amount of recommended ECTS points (credit points) and the weighting percentage must also be applied. (For information on the overall weighting of course content, see section 2.7.4).

### 2.7.3 Content Orientation

Traditionally, both the focus and the designation of the Engineering and Management major was oriented towards the traditional engineering disciplines of mechanical engineering, electrical engineering, civil engineering, process engineering, technical chemistry, environmental engineering, transport (engineering) as well as information and communication technology. The International Council of Academic Departments in Engineering and Management (FFBT WI e. V.) supports maintaining the existing successful majors and disciplines as well as developing new and innovative fields of studies. These include biotechnology, bionics, mechatronics, sustainable resource management and digitalization. This can be seen in the further development, diversification and the growth of the various disciplines over the past decades.

The concept of consecutive programs is particularly relevant for the area of Engineering and Management because of its interdisciplinary complexity.

Bachelor's and master's degree programs form a 10-semester unit consisting of a six-to-eight semester bachelor's program and a corresponding two-to-four semester master's program. We recommend bachelor's program with at least six theoretical semesters for undergraduate studies in Engineering and Management. An integrated internship semester should be added for more application-oriented programs.

The following section presents examples of possible program structures for Engineering and Management studies with different course load proportions at both the bachelor's and master's level.

### 2.7.4 Recommendations for Core Curriculum

In section 2.6, the main course content for Engineering and Management studies is broken down into core areas, internships and final thesis, based on a curricular analysis. This is intended to facilitate the classification of different Engineering and Management programs.

The professional associations for Engineering and Management of the German-speaking countries call for programs in Engineering and Management to offer degrees in which the overall program content is broken down as follows: technical content that encompasses at least 40 %[30], management representing at least 20 %, and integration courses and soft skills that make up at least 10 % of the total content.[31]

The following tables provide a listing of course content – along with their proportion of the curriculum – for bachelor's and master's programs in Engineering and Management. These lists are presented to provide a general orientation and can be used for comparison purposes. Variations between different programs can and will occur, however this list does contain recommendations for

30 Prerequisite is a content of at least 40 % STEM subject areas compared to the minimum number of credits required for a degree.

31 Cf. Verband Deutscher Wirtschaftsingenieure VWI e. V., Österreichischer Verband der Wirtschaftsingenieure WING, VWI Vereinigung Wirtschaftsingenieure Schweiz: Dreiländererklärung der Berufsverbände im Wirtschaftsingenieurwesen im deutschsprachigen Raum. (Adopted on 28.10.2010).

minimum course content. The categories and values provided in the tables are derived from the competences required for graduates to be able to carry out professional work in each of the subject areas.

The standard length of time necessary to complete a combined bachelor's and master's program is ten semesters with a total of 300 ECTS credit points. The typical bachelor's degree program lasts either six, seven or eight semesters, involving a total load of 180, 210 or 240 ECTS credit points respectively (30 ECTS credit points per semester). Accordingly, the master's programs are normally completed in two, three or four semesters with 60, 90 or 120 ECTS credit points respectively (30 ECTS credit points per semester). Students must complete 60 ECTS credit points per academic year.

The individual modules listed in the tables below do not necessarily have to be assigned to a specific core area; they can also be distributed proportionately within various core content areas. The ECTS credit point difference between the minimum requirements and the ECTS credit points of a specific program, which is determined by the duration of that program, can be distributed flexibly according to the specific focus of the program.

| **Core Course Content for Combined Bachelor's + Master's Degree** | **Minimum Number of ECTS credit points** |
|---|---|
| Science, Technology, Engineering, Mathematics (STEM) | 67 |
| Business, Law and other Social Sciences | 57 |
| Integrative Courses | 34 |
| Soft Skills and Foreign Languages | 19 |
| Internships (awarded ECTS credit points) | 15 |
| Thesis | 25 |

Table 1: Minimum Number of ECTS Credit Points for a combined Bachelor's and Master's Program in Engineering and Management.

| Core Course Content for Individual Bachelor's Degree | Minimum Number of ECTS credit points |
|---|---|
| Science, Technology, Engineering, Mathematics (STEM) | 55 |
| Business, Law and other Social Sciences | 45 |
| Integrative Courses | 25 |
| Soft Skills and Foreign Languages | 10 |
| Internships (awarded ECTS credit points) | 15 |
| Bachelor Thesis | 10 |

Table 2: Minimum Number of ECTS Credit Points for a Bachelor's Program in Engineering and Management.

| Core Course Content for Individual Master's Degree | Minimum Number of ECTS credit points |
|---|---|
| Science, Technology, Engineering, Mathematics (STEM) | 12 |
| Business, Law and other Social Sciences | 12 |
| Integrative Courses | 9 |
| Soft Skills and Foreign Languages | 9 |
| Master Thesis | 15 |

Table 3: Minimum Number of ECTS Credit Points for a Master's Program in Engineering and Management.

The following minimum standards have been defined for continuing education master's programs based on this model, according to the program's acceptance requirements:

Students with a bachelor's degree from a traditional economics or business-oriented program must complete a minimum of 67 ECTS credit points in the core area of Science, Technology, Engineering and Mathematics (STEM). These are minimum requirements from Engineering and Management bachelor's and master's programs. Students can however receive credits for these courses if they can display proof of having completed these ECTS credit points in previous studies or from otherwise meeting corresponding requirements. Such regulations would be part of a program's admission regulations.

Students with a bachelor's degree from a traditional engineering degree program must complete a minimum of 57 ECTS credit points in business courses (minimum requirements from Engineering and Management bachelor's and master's programs). Here students can also receive credits for these courses if they can display proof of having completed these ECTS credit points in previous studies or from otherwise meeting corresponding requirements. Such regulations would also be part of a program's admission regulations.

Upon completing the master's program in Engineering and Management, students must be able to verify that technological content represents at least 40 %, of the total content from all core areas, including their first academic qualification. This corresponds to the minimum requirements for academic content in Engineering and Management programs defined by the professional Associations for Engineering and Management in the German-speaking countries[32].

This proportional list shows that the foundation of interdisciplinary Engineering and Management degree program is STEM content – with the STEM core area – at a minimum of 40 % – accounting for the biggest part of the core curriculum. So-called integration subjects, such as systems engineering, factory planning or logistics, also contain a large amount of STEM content. Internships and the final thesis also deal with technological issues.

32 Cf. Verband Deutscher Wirtschaftsingenieure VWI e. V., Österreichischer Verband der Wirtschaftsingenieure WING, VWI Vereinigung Wirtschaftsingenieure Schweiz: Dreiländererklärung der Berufsverbände im Wirtschaftsingenieurwesen im deutschsprachigen Raum. (Adopted on 28.10.2010).

# 3 Qualification Profile of Engineering and Management Graduates

## 3.1 General Competence Model

The authors of the QF E&M were on the one hand guided by the need to define essential key data that provides an orientation framework for the widely differing Engineering and Management programs and, on the other hand, to ensure that this document leaves sufficient room for future curricular developments. This is intended to take the special importance of an interdisciplinary and practically-oriented major into account. The current QF E&M is a recommendation intended to ensure the equivalence of bachelor's and master's degree programs in Engineering and Management which, as a general rule, contain different academic content. Against this background, the quality of the respective degree programs mainly depends on the extent to which the implementation and design of the QF E&M takes the constantly changing demands in the field of Engineering and Management into account.

When looking at different programs, the first basic distinction is between more research-oriented and more practically-oriented Engineering and Management programs. Regardless of orientation, each program should foster the ability to carry out research and develop new and sophisticated methods and complex systems. The corresponding design of the teaching content, use of case studies and projects, as well having students complete engineering and business related internships and gain other relevant practical experience all support a practical orientation. The curricula in all programs should therefore contain a sufficient number of both theory-oriented and application-oriented modules.

The program objectives are determined by the knowledge, skills and competences that graduates need for their careers or for continuing studies.

Bachelor's and master's programs also differ in terms of their focus and content depth. The following section provides a general qualification profile for graduates from such bachelor's and master's programs in Engineering and Management. The description of graduates' competences and skills is based on the competence model of the newly revised Qualifications Framework for German Higher Education Qualifications (HQR) from February 2017[33], which is displayed in the diagram below.

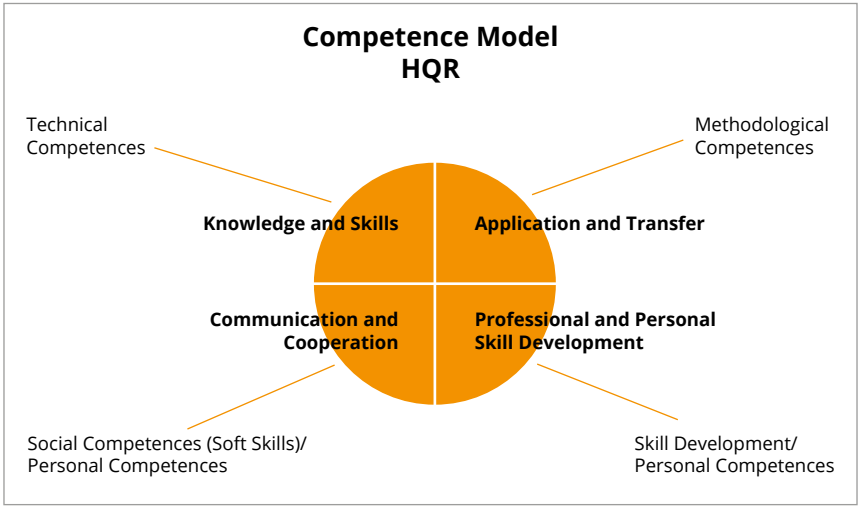


Fig. 1: Basic Model of Competences (Qualifikationsrahmen für Deutsche Hochschulabschlüsse (KMK 2017, p. 4, according to H. Roth, 1971)).

The HQR "competence dimensions" shown in Fig. 1 above are implemented and specified in the QF E&M using the following model (Fig. 2 below). A taxonomy based on the work of Bloom[34] and the competence categories of the German Qualifications Framework for Lifelong Learning[35] is used to describe the competences and skills.

33 KMK: Qualifikationsrahmen für Deutsche Hochschulabschlüsse (Resolution on 16.02.2017).

34 Cf. Bloom, B. S. / Engelhart, M. D. / Furst, E. J. / Hill, W. H. / Krathwohl, D. R.: Taxonomy of educational objectives: The classification of educational goals. In: Handbook I: Cognitive domain. New York, 1956.

35 Cf. Arbeitskreis Deutscher Qualifikationsrahmen (AK DQR): Deutscher Qualifikationsrahmen für lebenslanges Lernen. (Adopted on March 22, 2011), p. 5 ff.

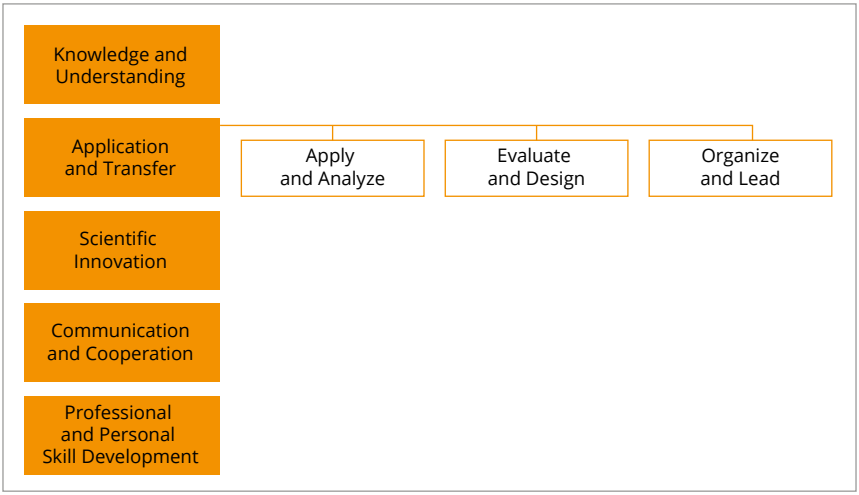


Fig. 2: Descriptive model of competences and skills for graduates in Engineering and Management programs.

In the competence area "Knowledge and Understanding", graduates demonstrate that they have the necessary specialist knowledge in the discipline of Engineering and Management building on different university entrance qualifications and previous practical, professional experience, and that they can critically analyze and grapple with issues in the field. This is the basis for being able to achieve the other qualification goals in Engineering and Management studies.

Graduates are expected to have the ability to apply their scientific knowledge to help solve practical problems, in particular those at the interface between the engineering sciences and business. This is part of the competence area "Application and Transfer", which is divided into the skills "Apply and Analyze", "Evaluate and Design" and "Organize and Lead", each representing part of the problem solving process. The competence area "Organize and Lead" is regarded as an essential component of the Engineering and Management program profile. This set of skills is necessary for graduates to be able to deal with ever more complex processes and increasingly network-like organizational structures that require lateral thinking and actions based on trust, being able

to take different points of view into account, and promoting jointly supported decisions.[36]

The aim of the competence area "Scientific Innovation" is for students to acquire and further develop competences in research-based learning, e. g. to ensure that scientific methods can be applied in the context of Engineering and Management, or that new knowledge can be generated using scientific methods. While bachelor's programs are primarily concerned with teaching foundational competences so that students can adapt scientific methods to practical questions in a self-directed manner, master's programs focus on combining familiar solution-oriented methods and being able to develop new methods and solutions and thus create scientific innovation.

Professionals in today's modern knowledge society and the rapidly developing world of work, however, also require people skills to be successful. These skills, such as goal-oriented communication and being able to work collaboratively with other individuals and groups, are part of the competence area "Communication and Cooperation". In addition to teaching so-called soft skills, courses in this area also focus on developing competences in the area of leadership. This is essential, since Engineering and Management professionals often work in management positions during their professional lives.[37]

An important goal of university degree programs is to encourage the personal development of its students. The competence area "Professional and Personal Skill Development" covers this area which includes the ability to act and make decisions in an unconstrained, self-determined, professional and responsible manner and to reflect critically on issues of professional behaviour with regard to social expectations and consequences.

36 Cf. Baumgarten, Helmut / Hildebrand, Wolf-Christian / von Hirschhausen, Christian / Schmager, Burkhard: Berufsbilduntersuchung Wirtschaftsingenieurwesen in Ausbildung und Praxis. 14th edition, Berlin, 2015, p. 8ff.

37 Cf. ibid., p. 71 ff.

Finally, it should be noted again here that the QF E&M is compatible with existing international frameworks[38] and can therefore also be used in the process of internationalization, e. g. in order to investigate degree programs in other countries that are comparable in profile and quality.

## 3.2 Bachelor's Programs

Graduates who have completed a bachelor's degree program should have both the professional qualifications required for an entry-level position as well as the background and skills to pursue an in-depth, scientific master's degree in a consecutive Engineering and Management program or a degree in another field.

Bachelor's degree programs should be designed based on a set of requirements derived from the practical, everyday needs of working professionals. The studies should prepare graduates for the complexities they will encounter in companies / organizations and, in a broader sense, to help them deal with a constantly changing world.

As described in section 3.1 above, general learning outcomes for graduates of bachelor's programs are classified according to the following core areas: "Knowledge and Understanding", "Application and Transfer", "Scientific Innovations", "Communication and Cooperation" as well as "Professional and Personal Skill Development". The sections below provide a detailed description of the learning outcomes for each of these categories.

### 3.2.1 Knowledge and Understanding

Graduates with a bachelor's degree in Engineering and Management should know the fundamentals of the natural sciences, engineering and management. This knowledge enables them to not only understand how a business works

38 Cf. Europäisches Parlament / Rat der Europäischen Union: Empfehlung des Europäischen Parlaments und des Rates vom 23. April 2008 zur Errichtung des Europäischen Qualifikationsrahmens für lebenslanges Lernen. In: Amtsblatt der Europäischen Union, C111/1–7. Brussels, 2008.

and the types of issues they will be confronted with there, but also the skills to be able to manage these issues and everyday tasks in a methodical manner. Students gain a background in both engineering and management as well as the interface between the two areas. This interface is developed in the integration courses, which provide a cross-disciplinary interlinking of course content while promoting a methodical work approach.

The following provides an overview of the academic and technical knowledge and skills that graduates from Engineering and Management bachelor's programs should aquire during their studies:

- Broad-based background in specific areas of mathematics, computer science, natural sciences and engineering sciences with an individual specialisation in theory and practice (knowledge of the STEM subjects: Sciences, Technology, Engineering, Mathematics, as well as Computer Science).
- The fundamentals and principles of the selected engineering disciplines as well as the research methods used in these disciplines.
- The ability to identify, summarize and conceptualize scientific content in the STEM areas (models, methods, research literature, technological structures and processes).
- Sufficiently broad knowledge of the fundamentals of information technology.
- The fundamentals, theories and methods used in the fields of business, economics and management, as well as individual specializations. Students are able to explain these concepts and classify them in the context of a company.
- Knowledge of the essential tasks and responsibilities of different company departments, as well as an understanding of operational, management-related processes and their possible interactions.
- Background in the legal basics of business administration and management and the ability to classify these in regard to a company's business decisions.
- Broad-based background in selected integration subjects which connect economic, technological, as well as social aspects and processes.

- The ability to compare and classify techniques and methods used in interdisciplinary topics.
- They are familiar with technological, economic, ecological and social contexts and their interrelationships.
- They have an understanding of concepts and methods from different fields and are able to integrate them.

### 3.2.2 Application and Transfer

Graduates with a bachelor's degree in Engineering and Management can apply their specialist knowledge to professions in the STEM fields, business or integrated fields, and develop or improve solutions to problems in their areas of specialization. According to the process model described in Chapter 3.1, a distinction is made between the skill areas of "Apply and Analyze", "Evaluate and Design" and "Organize and Lead". These are described below:

#### Apply and Analyze:

Graduates from bachelor's programs in Engineering and Management are able to:

- Use the STEM-related fundamentals, theories, methods and tools to deal with technological issues.
- Evaluate, differentiate and categorize STEM-related problems in business contexts.
- Use modern information technologies in an effective manner.
- Make use of economic and management-related fundamentals, theories, methods and tools to deal with company-related issues.
- Evaluate, differentiate and categorize business, economic and management-related issues in business contexts.
- Apply legal knowledge to business-related issues.

- Identify and classify business and technological problems.
- Interpret and analyze activity fields with complex correlations and interdepencendies between business, technology and social aspects.
- Systematically engage with, analyse and evaluate structures and processes.
- Use integrative, cross-functional and interdisciplinary concepts and models to develop integrated solutions to deal with interdisciplinary problems.

**Evaluate and Design:**

Graduates from Engineering and Management programs are also able to:

- Interpret and evaluate business / management and / or technological problems in a company-related context.
- Assess, plan and select complex business / economic and / or technical systems.
- Initiate and develop business / economic and / or technological solutions in a company-related context.
- Interpret and evaluate legal problems in a company-related context.
- Interpret, evaluate and prioritise influences and interrelationships in complex business, technological and social fields of application.
- Conceive, design, implement and evaluate scientifically sound models, concepts and approaches to solve cross-functional and cross-disciplinary problems.
- Recognize complex problems in a technological and business / economic context and to develop initial interdisciplinary, holistic and methodical measures to improve the situation (problem-solving skills and the ability to take action).
- Develop and implement application-oriented solutions based on specified process and data analyses.

**Organize and Lead:**

Finally, graduates are also able to:

- Make rational and ethical decisions and to think critically in order to find effective solutions for interdisciplinary and general problems (critical thinking skills).
- Take different perspectives into consideration when developing and implementing solutions for problems in a company-related context.
- Achieve synergy effects by cooperating with stakeholders in both business-technological and social contexts.
- Select and apply strategies in everyday business situations (strategic thinking and leadership skills, being able to take action).
- Work both independently and as a member of international and / or interdisciplinary groups, to organize and implement projects effectively, as well as to grow into a professional capable of handling leadership responsibilities.

### 3.2.3 Scientific Innovations

Engineering and Management programs provide graduates with the skills needed to be able to do scientific work. They have the ability to carry out a literature research and search for a topic using electronic media, plan, carry out and evaluate experiments, and collect and evaluate empirical data using quantitative and qualitative methods. This scientific background gives them the tools to investigate real-world research questions.

The following section summarizes the research-based knowledge and skills graduates acquire during their studies in Engineering and Management. Graduates from these programs can:

- Make use of basic knowledge in the field of exploratory and confirmatory empirical research, and are familiar with the scientific process.

- Understand and apply different research approaches and perspectives used in technological, business / economic and integrative contexts.
- Conduct literature researches and use specialist information sources for their work.
- Collect, structure, evaluate and interpret relevant primary and secondary data sources in technological and business areas based on scientific methods.
- Plan, carry out and evaluate experiments.
- Understand and communicate research results and take them into account in their everyday work.
- Apply relevant scientific methods and new results from the areas of engineering, business or economics to practical problems, taking management, ecological, technological and social requirements into account (scientific transfer competence).
- Select and apply suitable modelling, simulation, planning and design methods.

### 3.2.4 Communication and Cooperation

Graduates from Engineering and Management programs face a wide range of challenges in the professional world. These include the knowledge economy, digitalization and other regular changes at the workplace. In order to carry out these tasks responsibly, it is essential that they are able to communicate in a goal-oriented manner and work collaboratively with different people and groups. Teamwork and communication skills play a particularly decisive role in the interdisciplinary work environment in which Engineering and Management graduates are employed. This skill set is also the basis of working at the management level, which Engineering and Management graduates are particularly well prepared for.

During their studies, graduates acquire essential communication qualifications. They possess:

- Oral and written communication techniques and can apply them in case studies and project work.
- The ability to articulate themselves logically and rationally both orally and in writing, communicate with colleagues about business content or problems, even in foreign languages and across cultures (communicative competence).
- Communication skills in foreign languages (primarily English) involving technological and business content both inside and outside the company.
- Basic knowledge about team structure and teamwork, and an ability to form effective teams.
- The ability to work effectively with different types of people in a variety of situations and international environments in an interdisciplinary and constructive manner (cooperation and teamwork skills).
- Basic knowledge in the areas of intercultural engineering and intercultural communication, and can explain and highlight intercultural differences in business situations.
- The ability to work in international teams.
- The prerequisites to assume leadership responsibilities.

### 3.2.5 Professional and Personal Skill Development

One of the key goals of higher education is, beyond imparting specialist technical knowledge and scientific-methodological skills, to encourage the development of the complete person. This is particularly true in Engineering and Management programs, which train students to be able to take on management tasks and make business decisions. Programs consider an ethical attitude, self-reliance and professionalism as central foundations for being able to take responsible action in one's profession and in society in general. Therefore, graduates are also be able to:

- Carry out professional activities based on well-founded theoretical and scientific-methodological knowledge in the core areas of Engineering and Management.
- Build a professional self-image based on goal orientation, interdisciplinarity and a pronounced focus on providing solutions.
- Take the principles and values of business ethics into consideration when making decisions.
- Understand and assess the business, political, social and legal framework of the economy (assessment competence in the social environment).
- Perform intercultural engineering and intercultural communication and can explain and highlight intercultural differences in business situations.
- Work in international teams.
- Assume leadership responsibilities.

## 3.3 Master's Programs

Master's programs in Engineering and Management build upon a completed bachelor's degree and target the acquisition of in-depth analytical and methodological skills, while, at the same time, expanding on the specialist technical and professional knowledge gained in the first degree.

Graduates from master's programs have further developed the objectives of bachelor's programs in a longer process of professional maturity and have acquired greater confidence in their abilities to apply and implement specialist as well as non-technical skills. Thus, they are capable of carrying out scientific work and taking responsible action in their professional careers and in society in general.

Master's programs in Engineering and Management are designed to focus on new, complex tasks derived from practice and research. The studies should pre-

pare the students for the complexity of value creation networks and to deal with frequent, and often, unpredictable changes.

According to the structural specifications of the KMK regulations[39], master's programs can be designed as either a more "research-oriented" or "application-oriented" program.

The learning outcomes listed in the following sections describe the competences and skills for graduates from both types of Engineering and Management programs. The competences and skills described below are more or less developed, depending on the particular department's research or application orientation. Regardless of their orientation, all master's programs incorporate the latest research findings into their respective curricula.

### 3.3.1 Knowledge and Understanding

Master's programs in Engineering and Management build upon the knowledge acquired at the bachelor's level, significantly expanding their students' knowledge in line with the specific orientation of their particular master's program.

The following provides an overview of the academic and technical knowledge and skills that graduates from Engineering and Management master's programs acquire during their studies:

- In-depth theoretical and practical knowledge in selected areas of the natural and engineering sciences that build upon a broad-based knowledge of the fundamental concepts.
- Strong theoretical and practical knowledge about essential business and economic topics that also build on a broad-based knowledge of fundamental concepts.

39 Cf. KMK: Musterrechtsverordnung gemäß Artikel 4 Absätze 1–4 Studienakkreditierungsstaatsvertrag on 01.01.2018 (Resolution on 07.12.2017).

- In-depth knowledge about selected integration subjects which function as an interface between the business, technological and social aspects and processes of the studies.
- Broad-based methodological knowledge in selected disciplines based on the latest research findings.
- Thorough knowledge of the essential tasks and future challenges that could be faced by different departments in companies, as well as an understanding of the operational, business / economic, technological and management-related processes and their interdependencies.
- In-depth knowledge about coordination, communication, methodology and leadership.

### 3.3.2 Application and Transfer

Graduates with a master's degree in Engineering and Management can apply their specialist knowledge to professions in the STEM fields, in management or in integrated fields and develop or improve solutions to problems in their areas of specialization. According to the process model defined in Chapter 3.1, a distinction is made between the skill areas of "Apply and Analyze", "Evaluate and Design" and "Organize and Lead". These are described below:

**Apply and Analyze:**

Graduates from master's programs in Engineering and Management are able to:

- Identify, analyse, summarize and conceptualize complex technological and / or business problems in a broad range of environments containing partly new and / or unknown influencing variables in order to solve them in a holistic / integrative manner.
- Systematically engage with, analyze and evaluate scientific methods as well as operational structures and processes and to use them in new fields of application.

- Apply and promote management techniques in an international and intercultural environment.
- Evaluate legal issues in business contexts.

**Evaluate and Design:**

Graduates from master's programs in Engineering and Management are also able to:

- Recognise complex problems in a technological and / or business context and solve them in an interdisciplinary, holistic, innovative and methodical manner (problem-solving skills and ability to take action).
- Independently design and develop complex business and / or technological systems and to define the conditions to implement them.
- Develop, optimise, implement and evaluate complex application-oriented solutions based on specified structure, process and data analyses.
- Plan and control the use of modern information technologies.
- Take legal aspects into consideration when developing business and management-related solutions.

**Organize and Lead:**

In terms of the area of organization and leadership, graduates with a master's degree in Engineering and Management are able to:

- Make rational and ethically-oriented decisions in a complex environment with partly new and / or unknown influencing variables and to think critically in order to find innovative and effective solutions for interdisciplinary, qualitative and quantitative problems.
- Develop, shape and manage strategies in everyday business practice (strategic thinking skills, taking action and leadership).

- Manage individuals or groups in a target-oriented manner when dealing with business and / or technological problems in a company context.
- Take on the leadership role and act as moderator when developing and introducing holistically optimised solutions in companies.
- Achieve synergy effects by moderating and leading interdisciplinary teams and cooperating with stakeholders in a business-technical and social context.
- Assume leadership tasks in interdisciplinary and intercultural teams and organizations.
- Take legal aspects into consideration when managing individuals or groups in a target-oriented manner in companies.

### 3.3.3 Scientific Innovations

Graduates from Engineering and Management master's programs have expanded the methodological and analytical skills of their previous education, in particular thanks to the strong interlinking of research and teaching, and can now develop research perspectives and use these for their own research projects as well as for professional work.

Graduates from these master's programs are able to:

- Apply in-depth knowledge in the field of empirical research, familiarity with independent scientific methods as well as methods of inductive and deductive modelling.
- Collect, structure, evaluate, interpret and critically reflect on relevant primary and secondary research data according to scientific methods in both the engineering and business fields.
- Critically analyse and evaluate research results and develop further research questions.
- Select, apply and further develop suitable modelling, simulation, design and implementation methods.

- Apply and further develop scientific methods and new results in engineering and business to problems in research and practice, taking into account business / economic, ecological, technological and social aspects.
- Contribute to the practical, methodological and scientific development of business / economic engineering topics, pursue and advance these through their own work.
- Participate in research projects, independently develop new research outcomes and derive new research questions.

### 3.3.4 Communication and Cooperation

Graduates from master's programs in Engineering and Management also have well-developed skills in the areas of communication, cooperation and leadership.

Complex, integrative solutions to existing problems require experts from different fields and disciplines, each providing their professional, situational expertise. It is therefore necessary for Engineering and Management graduates to be able to communicate in a professional manner in interdisciplinary groups, and to be able to coordinate or lead such groups effectively.

For these purposes, graduates are trained to:

- Articulate themselves logically, rationally and persuasively orally and in writing at all times, and to communicate about the content and problems within their discipline both with colleagues at all hierarchical levels as well as with the general public, even in foreign languages and intercultural contexts (communicative competence).
- Work effectively, efficiently, constructively and in a solution-oriented manner with other individuals in decision-making situations, in an international environment, and across disciplines (cooperative competence and teamwork skills).
- Identify and discuss facts and problems from their field keeping intercultural contexts in mind.

- Apply and promote management techniques in an international and intercultural environment.
- Effectively coordinate interdisciplinary and intercultural teams and assume leadership tasks in teams and organizations.
- Organize, manage and lead teams (independently).

### 3.3.5 Professional and Personal Skill Development

Graduates with a master's degree in Engineering and Management possess additional non-specialized skills that are indispensable for successful professional work in an interdisciplinary environment. They have the ability to self-critically reflect on their professional actions, make use of their creative and decision-making freedom, and identify and evaluate alternative approaches, all based on sound functional and methodological knowledge.

The skills acquired here include the ability to:

- Independently identify and assimilate the economic, political, social and legal framework of the economy and take these into account when making business decisions (assessment competence in the social environment).
- Use and promote the possibility of shaping social relationships and assuming social responsibility in the professional environment (social competence).
- Act in a flexible manner according to the changing requirements in today's dynamic, globalized business world (change management competence).
- Reflect on their professional and research actions critically, find alternatives, evaluate them and justify decisions responsibly and rationally.
- Keep themselves up to date with the latest developments in science and research through independent learning (competence in independent, lifelong learning).
- Meet team members' training needs.

## 3.4 Doctorate / PhD Program

After completing an interdisciplinary master's degree at the interface of multiple disciplines, students have the option of pursuing a PhD degree in Engineering and Management. When making the decision whether to continue on for the PhD, students should keep in mind both the intellectual challenge of doctoral programs as well as the considerably higher starting salaries for applicants with this advanced degree.

Traditionally, both graduates with a master's or the older German "diploma" degree in Engineering and Management could pursue a PhD degree. However, it is currently not possible for graduates with a degree in Engineering and Management to enter a doctoral program. This is due to the fact that there is no clear consensus as to what can truly be regarded as Engineering and Management-oriented research. However, there are preferred disciplines and research questions which Engineering and Management graduates can use as orientation for their doctoral projects.

What they have in common is being at the interface between technology, management and their socio-economic design, e. g. through an innovation and technology policy. PhDs in Engineering and Management are therefore usually carried out at the interface between the engineering sciences, quantitative methods as well as the fields of business administration and economics.[40] This corresponds to the principle of the integration core area, which is a unique characteristic of the degree programs in Engineering and Management.

The thesis is focused on investigating new research questions and / or unclear issues that have not yet been scientifically dealt with. The focus is on developing new knowledge and, if necessary, new methods in the student's chosen field of specialisation and / or new forms of understanding contexts. The latter is particularly relevant for Engineering and Management graduates due to their interdisciplinary education. Doctoral students are expected to design, assess

40 Cf. Schuh, Günther / Warschat, Joachim (Hrsg.): Potenziale einer Forschungsdisziplin Wirtschaftsingenieurwesen. Munich, 2014.

and evaluate their results and solutions holistically and to reflect on them in multiple cycles.

One of the professional requirements of doctoral candidates is to derive their own teaching / learning theory in the chosen area of specialisation, so that the knowledge acquired can be passed on in a well-founded manner. Doctoral students develop and expand their teaching competences by imparting their knowledge to other students as well as training practitioners in this field of knowledge. In order to generate scientific innovations, doctoral students also acquire skills in how to prepare and successfully submit research grant proposals.

In terms of the issues of leadership, Communication and Cooperation, PhD students additionally develop additional competences, such as leading interdisciplinary research teams or practically oriented teams in order to implement holistic solutions. They also lead working groups on innovative research topics and challenge and support their team members within this context. As part of their scientific self-image, they successfully publish their research findings at regular intervals in relevant journals in the field.

# 4 Summary and Outlook

This QF E&M describes the qualifications that students acquire from studying Engineering and Management in a systematic way. It is intended to be transparent and to make it easier to compare national and international degree programs. Furthermore, it provides the reader with an orientation of the essential academic content and clarifies the structure of the Engineering and Management studies at both the bachelor's and master's level. The aim is to present the target qualification profiles for graduates from bachelor's and master's programs in a general form, regardless of the attended type of university.

The explanation is based on thorough, detailed discussions with a large number of Engineering and Management program directors covering a wide variety of specialisations. The authors of this qualification document represent many different universities and colleges. The QF E&M was discussed and adopted at the annual conference of the International Council of Academic Departments in Engineering and Management (FFBT WI e. V.), representing almost 60 departments. Thus, the QF E&M reflects FFBT WI's shared understanding of Engineering and Management as an innovative field of study, characterized in particular by the core area of integration.

The QF E&M formulates the required competences in the form of a quality seal. It is an important element for the quality assurance of teaching and studies in the field of Engineering and Management, which is considered an independent scientific field. The idea behind the standards defined in the QF E&M are that a degree in Engineering and Management based on these standards would offer graduates the best career opportunities.

The standards contained herein are regularly discussed and further developed as part of a continuous improvement process. The circle of "stakeholders" involved in this process will be continually expanded in the future.

This type of degree program is referred to in various ways in other countries. Similar degrees are known as "Business Administration and Engineering",

"Industrial Engineering", "Engineering and Economics" or "Business Engineering". It should be noted that the English term "Industrial Engineering", with its focus on industrial production, represents only part of the broad spectrum of courses covered in the Engineering and Management program. The International Council of Academic Departments in Engineering and Management (FFBT WI e. V.) decided to use the title "Engineering and Management" exclusively in English for the degree program described in this book.

In addition to Central European universities used as a means of comparison, other European universities (e. g. in Northern and Southern Europe) and universities on other continents, e. g. from North and South America, Asia or Oceania, should also be included in future editions. The aim is to learn from each other and thus further strengthen the field of Engineering and Management in an international context. The English version of the QF E&M was prepared with this in mind – to ensure international quality standards and at the same time make the successful concept of Engineering and Management studies even more well-known internationally. The International Council of Academic Departments in Engineering and Management (FFBT WI e. V.) plans to further expand its international contacts and admit more foreign universities over the next few years.

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# Glossary

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|---|---|
| ASIIN e. V. | Akkreditierungsagentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften und der Mathematik e. V.<br>Accreditation Agency for Study Programs in Engineering, Computer Science, Natural Sciences and Mathematics |
| DQR | Deutscher Qualifikationsrahmen<br>German Qualifications Framework |
| ECTS | European Credit Transfer and Accumulation System |
| EQR | Europäischer Qualifikationsrahmen<br>European Qualifications Framework |
| FFBT WI e. V. | Fakultäten- und Fachbereichstag Wirtschaftsingenieurwesen e. V.<br>International Council of Academic Departments in Engineering and Management |
| HQR | Hochschulqualifikationsrahmen<br>Qualifications Framework of German Higher Education Qualifications |
| KMK | Kultusministerkonferenz<br>Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany. |
| MRVO | Specimen decree (persuant to Art. 4 of the interstate study accreditation treaty) by the KMK – Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany. |
| PhD | Philosophiae Doctor |
| QF E&M | Qualifications Framework Engineering and Management<br>Qualifikationsrahmen Wirtschaftsingenieurwesen |
| STEM | Science Technology Engineering Mathematics<br>Mathematik, Informatik, Naturwissenschaft, Technik (MINT) |
| VWICH | Vereinigung Wirtschaftsingenieure Schweiz<br>Swiss Association for Engineering and Management Professionals |
| VWI e. V. | Verband Deutscher Wirtschaftsingenieure e. V.<br>German Association for Engineering Management |
| WING | Österreichischer Verband der Wirtschaftsingenieure<br>Austrian Association for Engineering and Management Professionals |

# Index of Authors

**Prof. Dr. Daniel F. Abawi**
Professor for Computer Science and Business Information Systems
Program director Industrial Engineering and Management
IT representative of the management board
htw saar – University of Applied Sciences

**Prof. Dr.-Ing. Volker Ahrens**
Program director Industrial Engineering and Business Management
NORDAKADEMIE – University of Applied Sciences

**Prof. Dr. Stephan Altmann**
Professor of International Management
Program director Engineering and Management International
Director of International Relations
Mannheim University of Applied Sciences

**Prof. Dr.-Ing. Rudolf Bäßler**
Professor at the School of Engineering and Management
CEO Academy for Professionals (Further Education)
Rosenheim Technical University of Applied Sciences

**Prof. Dr. Malte Brettel**
Vice-Rector for Industrial Relations
Professor and Head of Group Innovation and Entrepreneurship Group (WIN) –
Center for Entrepreneurship
RWTH Aachen University

**Prof. Uwe Dittmann**

Chairman of the International Council of Academic Departments in Engineering and Management (FFBT WI e. V.)

Board member of the German Association of Academic Departments at Universities of Applied Sciences (KFBT e. V.)

Vice Dean School of Engineering

Pforzheim University of Applied Sciences

**Prof. Dr. Hermann Englberger**

Board member of the International Council of Academic Departments in Engineering and Management (FFBT WI e. V.)

Advisory Board Member of the German Association for Engineering Management (VWI e. V.)

Dean of the Munich School of Engineering and Management

Munich University of Applied Sciences

**Prof. Dr.-Ing. Wolf-Christian Hildebrand**

Board member of the German Association for Engineering Management (VWI e. V.)

Professor for Business and Management, Department of Logistics

Brandenburg University of Applied Sciences

**Prof. Dr.-Ing. Yvonne Leipnitz-Ponto**

Vice Chairperson of the International Council of Academic Departments in Engineering and Management (FFBT WI e. V.)

Professor of Process Engineering and Environmental Care, Energy and Utility Technology

Program Director Engineering and Management

University of Applied Sciences Ansbach

**Prof. Dr.-Ing. Andreas Merchiers**

Professor for Sustainable Production and Investment Planning

Head of Engineering and Management Programs

Bochum University of Applied Sciences

**Prof. (FH) Gunter Olsowski**

Board member of the International Council of Academic Departments in Engineering and Management (FFBT WI e. V.)

Head of program Engineering & Management

University of Applied Sciences Vorarlberg (Austria)

**Prof. Dr.-Ing. Dieter Pumpe**

Professor for Business Informatics

Program Director Engineering and Management

Beuth University of Applied Sciences Berlin

**Prof. Alfred Schätter**

Professor for Computer Science

Study Program Engineering and Management

Pforzheim University of Applied Sciences

**Prof. Dr.-Ing. Burkhard Schmager**

Board member of the International Council of Academic Departments in Engineering and Management (FFBT WI e. V.)

Member of the German Accreditation Council (Akkreditierungsrat)

Professor for Production Management

Department of Engineering & Management

Ernst-Abbe-University of Applied Sciences Jena

**Prof. Dr. Christian Schuchardt**

Vice Dean International Graduate Center (IGC) at UAS Hochschule Bremen

Professor for Marketing und International Management, UAS Hochschule Bremen

International Degree Program in Business Administration and Engineering (ISWI)

Board member of the German Association for Engineering Management (VWI e. V.)

**Prof. Dr. Christian von Hirschhausen**

Professor for Infrastructure Policy

Technische Universität Berlin

Research Director at the German Institute for Economic Research (DIW Berlin)

**Prof. Dr. Matthias Werner**

Professor of Controlling

Academic Dean of Engineering and Management in Electrical Engineering and Information Technology

Vice Dean of the Faculty of Electrical Engineering and Information Technology

HTWG Konstanz, University of Applied Sciences

**Prof. Dr.-Ing. Hartmut Zadek**

Vice President of the German Association for Engineering Management (VWI e. V.)

Institute of Logistics and Material Handling Systems

Head of study program Industrial Engineer in Logistics

Otto von Guericke University Magdeburg

The Qualifications Framework for Engineering and Management serves as a set of guidelines and a quality assurance instrument. The framework establishes minimum standards that must be fulfilled in the framework of a degree program in Engineering and Management at both universities of applied sciences and universities in German-speaking countries. It is intended to provide orientation when conceptualizing and further developing the curriculum in these programs.

The purpose of setting detailed minimum standards for the weighing of academic content serves to differentiate these programs from other similar academic programs. It is also intended to ensure that a completed degree in the interdisciplinary field of Engineering and Management is a prestigious seal of approval that offers graduates excellent career opportunities.

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