Degree Program Documentation Bachelor in „Management and Technology“ (TUM-BWL)

Part A
TUM School of Management
Technical University of Munich

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General Information:

- Department: TUM School of Management
- Program Name: Management and Technology
- Degree: Bachelor of Science (B. Sc.)
- Standard duration & credits: 6 Semesters and 180 Credit Points (CP)
- Form of study: Full-time
- Admission: Aptitude Assessment
- Start of program: Winter Semester (WiSe) 2023/2024
- Language: English, German/English – depending on the engineering, life or natural science focus
- Main Location: Munich
- Responsible for the program: Prof. Dr. Philipp Maume
- Contact person for queries regarding this document: Michaela Krieger
- Version/Status of: 17.02.2023

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1 Objectives of the degree program

1.1 Purpose of the degree program

The manifold interdependencies between the individual corporate divisions as well as the progressive dissolution of traditional departmental boundaries in companies are changing the nature of the qualifications required and demand interdisciplinary thinking and action from its actors. Particularly at the interface between the economic and the engineering, natural or life sciences departments, communication and know-how barriers repeatedly arise in practice, resulting from a lack of knowledge of the respective other discipline and a lack of understanding for the respective other subject culture. Business economists who work in the management of globally active companies increasingly have to make decisions at the interface between management and the engineering, natural and life sciences. Managers who, in addition to their business skills, have a fundamental understanding of engineering, the natural sciences or the life sciences can, in interdisciplinary teams with engineers, physicians, life scientists or natural scientists, understand the viewpoints of the specialist disciplines much more quickly and translate them into adequate management decisions. In this way, they help to create and maintain competitive advantages for companies and avoid higher costs, lower quality and loss of time.

The study program *Management and Technology* deals with the fundamentals of business administration and its interfaces with various engineering and natural science fields as well as the life sciences, especially medicine. The focus of the program is on the fundamental economic areas of financing and accounting, innovation and entrepreneurship, economics and regulation, production and logistics, marketing, strategy and human resources management, as well as their interdependencies with the engineering, natural and life sciences areas of chemistry, informatics, electrical and information technology, mechanical engineering, computer engineering and medicine.

The program also addresses a number of important developments and problems for society as a whole, which are at the interface between management and technology and require holistic solution strategies. These include, for example, the use of natural resources, the economic consequences of climate change as well as incentives to counteract them, the reliable and environmentally friendly supply of energy, ensuring mobility, the effects of the digital revolution, the provision of infrastructure and communication networks, and the improvement of processes in the healthcare system. These developments represent important framework conditions that companies must take into account in their strategic planning. In addition, students should be enabled to contribute their acquired know-how not only to the concrete solution of operational problems, but also to the solution of these problems for society as a whole. Only through a combination of business management and engineering, natural and life science knowledge and skills, as provided by the program, can innovative solutions to the problems be developed and successfully implemented. The study program thus offers the opportunity to meet the social challenges described by overcoming disciplinary boundaries, which in

many cases have hindered or prevented the development and, above all, the implementation of solutions.

In addition, an interdisciplinary education in engineering/natural sciences/life sciences as well as business administration is an ideal prerequisite for business start-ups. The bachelor's degree program in *Management and Technology* is fundamentally interdisciplinary. Although the focus is on business administration, the integration of a large focus area in the actual business administration modules as well as in the engineering, natural and life science areas builds bridges to technology and the natural and life sciences, which has recently been the starting point for more and more start-ups.

The bachelor's degree program in *Management and Technology* prepares students both for entry into a profession directly after graduation and for corresponding master's degree programs. The School of Management also offers a consecutive master's program.

1.2 Strategic importance of the program

The TUM School of Management offers a comprehensive portfolio of study programs, including its Bachelor, Master and professional study programs. This reflects the idea of lifelong learning and implements the mandate of the Bavarian Higher Education Act („Bayerisches Hochschulgesetz“) to offer degree courses and professional education.

The previous education and thus the different admission requirements of our applicants shape the different programs of the TUM School of Management, which can be divided into four categories according to their content:

(1) Interdisciplinary management programs focusing on natural sciences, engineering and/or life sciences: These include the bachelor's program in *Management and Technology* (formerly TUM-BWL) at the Munich campus and the Heilbronn campus, the bachelor's program in *Sustainable Management and Technology* at the Straubing campus, the master's programs in *Management and Technology* (formerly TUM-BWL), *Finance and Information Management*, and *Consumer Science* at the Munich campus, the master's program *Management and Digital Technology* (starting from summer semester 2024) at the Heilbronn campus, and the master's program in *Sustainable Management and Technology* at the Straubing campus.

(2) Programs for students who are looking for basic management training to complement their bachelor's degree after completing their first degree in the natural, engineering or life sciences: The master's program in *Management* at the Munich Campus and the Heilbronn Campus fall into this category.

(3) Programs in the area of continuing education for applicants with one to three years of professional experience: This category includes the Master's program in *Management and Innovation* (Double Degree HEC) at the campus in Munich as well as the Master's program in *Management*

and Innovation (TUM Track) at the campus in Heilbronn, which have young professionals with initial professional but not (yet) any management experience as their target group.

(4) Programs in the area of continuing education for applicants with more than three years of professional experience: This category includes the MBA programs *Executive MBA*, *Executive MBA in Business and IT*, and *Executive MBA in Innovation and Business Creation* at the Munich campus, which have professionals with (initial) management experience as their target group.

The program portfolio of the TUM School of Management is shown in Figure 1.

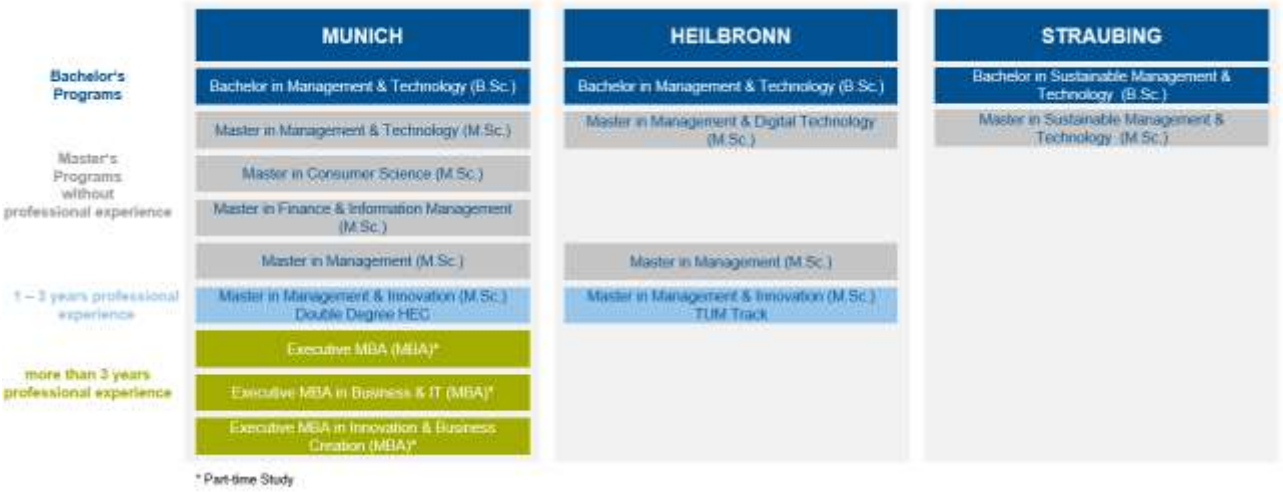

Figure 1: Program portfolio of the TUM School of Management at the university locations in Munich, Heilbronn and Straubing: Bachelor's programs (dark blue), Master's programs without work experience (gray), continuing education programs with work experience (light blue), MBAs with work experience (green).

The TUM School of Management is firmly rooted in the technological and entrepreneurial ecosystem of TUM and has a unique focus on the interface between management, engineering, natural and life sciences. The School of Management aims to bridge the traditional gap between the fields of management and technology. Graduates will learn to create and integrate solutions across disciplines and acquire a broad range of skills to advance their careers after graduation. Enthusiasm for innovation and technology shall be translated into concrete results by teaching the necessary management skills. An interdisciplinary teaching approach is used to train future managers who are equally comfortable working with management experts, engineers and natural scientists.

An internationally oriented management education should be the foundation of the higher education of our future shapers of social change: In this regard, the TUM School of Management is committed to imparting professional and interdisciplinary competencies for an evolving, technology-driven knowledge society, thus fulfilling its mission as a driver of innovation for the economy.

All of these goals are addressed in an almost ideal way in the faculty's flagship program, the Bachelor in *Management and Technology*, and then pursued further in the consecutive Master's program.

TUM's mission statement of being an entrepreneurial university is also reflected in the Bachelor's curriculum. For example, entrepreneurship is already taught in a compulsory module in the first semester and the UnternehmerTUM business plan seminars can be incorporated at various points in the program. It is thus also a central concern of the program to promote the entrepreneurial spirit of students.

TUM has a high reputation in the engineering, natural and life sciences core areas. However, innovations in the field of mechanical engineering, for example, often lack a clear customer orientation and a convincing marketing strategy for inventions. In addition, there is often a lack of functioning project controlling in large-scale projects. The interdisciplinary study program *Management and Technology* is designed to address this problem and build a bridge between technology, natural and life sciences and management.

TUM has an outstanding faculty for informatics. Here, new technologies such as Internet of Things, Robotics, Artificial Intelligence and Blockchain/Distributed Ledger require more and more collaborations with business economists to develop new business models.

TUM's “Klinikum rechts der Isar” is also one of the best university hospitals in Europe. In the field of medicine, too, the optimization of operational processes, cost reduction strategies, personnel management and controlling are becoming increasingly relevant for the efficient care of patients. The specialization in medicine in the Bachelor of *Management and Technology* is intended to make a contribution to this.

A new campus has been established with the Heilbronn campus that focuses on medium-sized companies and the challenges of digitalization in research and teaching. A modified version of the *Management and Technology* degree program is offered there with an engineering focus on digital technologies.

2 Qualification profile

The qualification profile complies with the requirements of the Qualifications Framework for German Higher Education Qualifications (Hochschulqualifikationsrahmen - HQR) according to the resolution of 16.02.2017 of the German Rectors' Conference and the Standing Conference of the Ministers of Education and Cultural Affairs. According to the HQF, the qualification profile for the Bachelor in *Management and Technology* can be defined on the basis of the requirements (I) Knowledge and Understanding, (II) Use, Application and Generation of Knowledge, (III) Communication and Cooperation and (IV) Scientific Self-conception/Professionalism. The formal aspects according to HQR

(admission requirements, duration, degree options) are detailed in chapters 3 and 6 as well as in the corresponding subject examination and study regulations.

The bachelor's degree program in *Management and Technology* lasts three years with 180 credit points and is a fully-fledged first professional degree. It opens up a broad professional field of activity and prepares students both for work as a generalist, for example in a management consultancy, and for activities in the various specialist disciplines of business administration (e.g. marketing activities, auditing). In addition to the business administration topics, transfer knowledge to other areas, especially in the field of technology or in the natural or life sciences, should also be built up. The program is characterized by a high degree of internationality, but important national fundamentals are also covered, which can be intensified by taking the appropriate elective modules. The program has a fundamental research orientation. Essential research findings of the professors involved are incorporated into the teaching. However, emphasis is also placed on an application orientation of the taught contents as well as on the promotion of a sense of responsibility and entrepreneurial spirit. Furthermore, this bachelor's degree prepares students for entry into a more in-depth master's program.

Accordingly, the following competencies are taught in the *Management and Technology* program:

2.1 Knowledge and understanding

Graduates have a broad knowledge and understanding of business fundamentals. They know financial reporting and cost accounting systems. Graduates are familiar with the elementary concepts of entrepreneurship including basic psychological processes and characteristics of entrepreneurs as well as possible development paths of start-ups. They know the ethical significance of economic theories and are aware of the social responsibility of companies (CSR). They are familiar with the basic principles of empirical research, planning hierarchies and the basic concepts of logistics, the basics of financing theory, financial planning, financial control and project evaluation. Graduates understand the basic concepts of marketing (e.g. customer value, segmentation, marketing mix) and innovation (e.g. market and competition analysis, research and development processes).

Students are able to assess the applicability of advanced methods and regulations in self-selected focal areas of business administration and/or technology. They are equally trained to apply the most important terms and methods in related, but also business-relevant fields, such as economics, law and statistics/mathematics. In particular, they are familiar with the fundamentals of microeconomics and macroeconomics (e.g. market equilibria, price formation, the influence of currency and interest rate changes on economic developments), the fundamentals of German or international business and private law and essential fundamentals of descriptive and inferential statistics as well as business and engineering mathematics. Graduates are also able to identify the connections between these fields and business issues. They are familiar with machine learning as a subarea of artificial intelligence. They understand the importance of machine learning as an indispensable tool for gath-

ering a higher level of insights from structured and unstructured data than is achievable with conventional business intelligence solutions. Graduates are able to understand, overview, and fundamentally apply important basic computer science terms, concepts, and thinking, specifically object-oriented programming, databases & SQL, and basic algorithms and data structures to develop their own programs with database connectivity. They also have a critical understanding of key principles and methods in a self-selected engineering, natural or life science subject (chemistry, informatics, electrical and information engineering, mechanical engineering, computer engineering or medicine), designated as a specialization in the individual case.

Graduates of the **Chemistry specialization** understand the scientific fundamentals of the core areas of chemistry and demonstrate an interdisciplinary understanding between natural science and economics. They can apply elementary knowledge of general and inorganic chemistry, organic chemistry, biology and biochemistry, physical and technical chemistry. In addition, they know the necessary mathematical and physical principles in order to be able to correctly classify chemical facts against this background. They can also explain basic biochemical and molecular biological principles and techniques. They can apply practical manual skills in the laboratory and operate common laboratory equipment. They understand basic chemical analysis (e.g., sampling, sample preparation, measurement) and can also perform evaluation and validation of experimental results and data. They recognize the important large-scale processes of basic inorganic and organic chemicals and understand kinetic and thermodynamic fundamentals of chemical processes (e.g., simple and complex reaction kinetics, catalysis, reactor types, operation of reactors, and polymerization processes). Furthermore, they can reproduce the basic experimental operators of inorganic and organic chemistry as well as protein biosynthesis.

According to their personal elective profiles, graduates either understand basic aspects of the different areas of biotechnology (e.g. green, red, white biotechnology incl. development and typical issues) or know relevant models of inorganic molecular compounds and main and subgroup elements (models of structures and bonds, regularities and peculiarities).

In the **Electrical and information technology specialization**, students acquire fundamental knowledge in the field of engineering mathematics such as integrals and differential equations as an essential basis for further understanding of subject-specific modules. Building on this, students learn the basic elements of electrical engineering and information technology in the form of analog circuits, electric, magnetic fields, direct and alternating current applications, information technology such as algorithms and data structures, and signals. They understand and know how to apply basic physical principles in these areas. They also know and understand the associated basic problem solving methods. Students are then able to reproduce the knowledge they have acquired and to apply simple systems based on the basic elements themselves. In the further course of study, students deepen the application orientation of these competencies, for example with the topics of energy, photovoltaics, communication technology or nano-electronics. Here, the students get to know concrete engineering problems and their solution approaches, apply them in an engineering-like manner and can intensify the interlocking of management and an engineering science in an interdisciplinary context.

In the **Mechanical Engineering specialization**, students learn fundamentals specific to mechanical engineering. The students are familiar with technical mechanics and are initially able to formulate and solve mechanical problems in engineering science problems independently at an abstract mathematical level. The students are able to work out solutions for the design of components suitable for production, loading and assembly, to select and design suitable machine elements and to represent them using CAD systems. However, students can also produce and solve technical drawings and complex tasks in descriptive geometry by hand, taking into account all relevant guidelines and standards. They know how to interpret the drawings and derive consequences for production and costs. The basic interrelationships of manufacturing processes along a production line are also known.

Graduates of the **Informatics specialization** have basic knowledge of a programming language (e.g. Java, SQL, C) as well as object-oriented principles. They know the procedure for developing software and can transfer known procedure models to a context of action. They understand different approaches to database design as well as some database systems and query languages. They know the different types of information systems, their components (e.g. man-machine communication, attributes) and areas of application (e.g. navigation system) and are able to apply practical modeling techniques to different decision situations (e.g. process optimization, cost-benefit calculation). They possess fundamental knowledge of reference models and are able to design software architectures at the system level. Graduates also possess technological competencies: They understand the interaction of hardware and software and know the elements and methods in the field of computer architecture and operating systems. They know the theoretical foundations of data modeling and can design databases and integrate them into information systems. They can analyze, model and implement distributed systems, and design and use middleware.

In the **Computer Engineering specialization**, students acquire basic knowledge of a programming language and knowledge of fundamental concepts such as representation of data, functions, objects, algorithms, architecture of computer systems, mathematics for natural sciences and economics, information management, information engineering, data analysis and visualization, electronics and control theory. Students know the basic elements of electrical engineering and information technology especially analog circuits, electric, magnetic fields and direct and alternating current applications. They are able to recognize the interrelationships of their main subject, to reproduce learned knowledge and to apply simple systems based on the basic elements themselves, for example in the form of circuit analysis or the application of signal processing methods to simple data sets. Students will also be able to apply the aforementioned competencies in English.

Students in the **Medicine specialization** have basic scientific knowledge in the areas of chemistry and biology as a theoretical basis for core medical topics and clinical linkages. They are able to understand and describe the structure of the human locomotor system (movements through the use of muscles, functional anatomy, metabolic processes in the body, etc.) and understand the basic effects of preventive and rehabilitative measures on the body. Graduates understand the structures, functions and relationships from anatomy and physiology of the human body. They understand the

most important technical terms of medical terminology and thus have a basic understanding of medical science. This includes the basics of positional designations and reference systems in anatomy, the historical origins of medical terminology in Greek and Latin, important prefixes and suffixes, and established terminology in human medicine. The students are able to name the different specialist disciplines and their fields of activity and special features. They are able to describe the organization and operation of medical facilities as well as clinical pictures and their practical therapy. They recognize the interfaces between business administration and medical practice and are able to explain them. Finally, the students also master the basics of informatics for the systematic development and communication of information in modern health management. This enables them to develop solutions for advancing digitization in healthcare.

2.2 Use, application and generation of knowledge

Graduates of the bachelor's program in *Management and Technology* are able to derive research questions, form hypotheses and test them, especially in the focal areas of their choice, using predominantly quantitative methods when dealing with business management problems on the basis of central business and economic theories (e.g. company and agency theory, institutional economics, behavioral science theories). They complete application-oriented project studies and develop solutions for complex tasks in teams by making scientifically sound assessments and transferring the most important terms, concepts and methods of business research to practice. They are able to apply the most important management tools (e.g. optimization and present value calculations, responsible human resources and corporate management) to real-world problems and critically assess their functioning. Graduates use machine learning to identify patterns and regularities and develop solutions based on existing data sets and algorithms. They can select relevant data and algorithms, parameterize them, monitor the process and develop solutions from them. Graduates are also able to apply the most important procedures and techniques in their own chosen engineering, natural or life science subject and, in the case of medicine where patient contact is legally excluded, at least to understand medical methods and medical actions. They are able to analyze a complex and real problem from business administration or at the interface between business administration and engineering or natural and life sciences, to independently research information for this purpose, to show possible solutions and to structure and present these.

Graduates derive research questions at the interface of business administration and technology/natural/life sciences. Typical questions are, for example, the effects of business incentives and instruments on technological, natural and life science phenomena (e.g. effects of incentives on emissions, on innovations or on hygiene in the medical field) or the optimization of multidimensional problems (e.g. transport logistics, range planning of e-cars, occupancy of hospital beds). To test these research questions, they develop hypotheses based on theories and test them using various methods. These include analytical models, case studies, surveys or interviews, statistical analyses such as univariate tests or regression analyses, or various simulation and optimization methods. For predictive models, they are also able to apply the most important methods of machine learning and critically

evaluate their results. Graduates apply research methods, and present and explain their research results.

Students of Informatics, for example, are able to understand problems in software development and to find solutions independently. In doing so, they draw on a repertoire of common programming algorithms and usual procedures in software development and are able to adapt and further develop them contextually to an application. In particular, graduates are able to differentiate between the various solution approaches using runtime analyses and the complexity of the required algorithms in order to select and implement a suitable approach.

Students in the Mechanical Engineering specialization are able to understand the development process of technical products and the complex relationships between the individual components. They have knowledge of common CAD methods with the help of which they can design components independently.

Graduates of the medical specialization are at the interface between medical care and management and are able to transfer the in-depth business and fundamental medical knowledge acquired during their studies in the fields of public health (national and international health care systems), technology assessment (HTA) and corporate health management to tasks in modern health care management. This enables them to provide professional support for control and change processes.

2.3 Communication and cooperation

Graduates of the Bachelor of *Management and Technology* possess intercultural sensitivity and work successfully and appreciatively with people from other cultural backgrounds. By participating in joint modules with students of engineering, natural or life sciences, they also experience the different discussion cultures and languages in these fields. In the event of conflicts and in projects - especially at the interface between technology/natural/life sciences and business administration - they are able to objectively reflect and take into account different points of view and the interests of other parties involved. Furthermore, they cultivate responsible dealings with others and take ethical aspects into account when making decisions. They find relevant solutions which they can explain convincingly to both experts and representatives of other disciplines on the basis of their well-founded theoretical knowledge. In this way, students of the Medicine concentration are sensitized to the special features of medical practice and the environment of human medicine through cooperation and exchange with medical professionals. Graduates of the informatics concentration, for example, are trained through the methodology of agile software development to grasp problems in software development and to penetrate them to the extent that they can communicate in a mixed environment of developers and people from other disciplines. Based on their knowledge of the common machine elements, their structure and function, the students of the major in mechanical engineering are able to lead a technical discussion with engineers. The basis for this are the acquired skills in technical drawing as well as an overview of the different stages of product development.

2.4 Scientific self-conception/professionalism

Graduates are able to work on projects with determination and perseverance. They are able to independently set work and behavioral goals and achieve these goals based on a self-developed schedule. In addition, students can identify their own strengths and weaknesses and, depending on these, build up more expertise or set other priorities in their work. They are aware of the consequences of entrepreneurial decisions and reflect on their professional activities against the background of social and ethical responsibility.

In the Informatics concentration, students learn to derive well-founded decisions based on runtime and complexity analyses, for example. In doing so, they rely on case studies from the historical development of computer science in order to correctly assess the scope and risks of an efficient and professional implementation. The focus is regularly on the comprehensibility of the implemented solution (quality/understandability of the source code) as well as the responsible use of the given resources. Thus, social and ethical factors are also included in order to prepare for later practice, e.g. in software companies. Students of mechanical engineering can independently derive suitable calculation models for engineering questions - with the help of the tools of technical mechanics. This enables them to make statements about the stresses that occur and to dimension a component in a way that is application-oriented, economical and ecologically sound. By interlocking business administration and basic medical training in theory and initial practice, graduates of the medical specialization develop a feeling for development opportunities, requirements and limitations in professions in the healthcare sector, which they learn to think through and assess. Graduates learn to think entrepreneurially and can contribute to the economic success of consulting firms, healthcare associations, health insurance companies, panel doctors' associations, research institutes, public authorities or the pharmaceutical industry as competent managers. Especially when it comes to management tasks in hospitals, clinics, laboratories, sanatoriums, retirement and nursing homes, rehabilitation centers and social institutions, graduates benefit from the acquired ability to weigh different factors for entrepreneurial success and their consequences against each other. This is also done against the background of their knowledge of business ethics and theories of justice, and is then the basis for meeting the conflicting demands of profitability and social responsibility in the increasingly commercialized healthcare sector.

3 Target group

3.1 Target audience

The target group for the bachelor's degree program are high school graduates as well as nationally and internationally qualified students with analytical skills, a high affinity for mathematical and quan-

titative approaches, and the ability to communicate complex chains of reasoning in a clear and comprehensible manner. In addition, applicants should show an interest in business administration as well as engineering, natural sciences and life sciences. The simultaneous development of these skills is crucial in order to be able to implement the business side of the studies on a quantitative and qualitative level and at the same time to have the enthusiasm and motivation to deal with an engineering, natural or life science subject.

3.2 Prior knowledge of applicants

An aptitude assessment procedure (in accordance with the currently valid statutes on aptitude assessment for the bachelor's degree program in *Management and Technology* at the Technical University of Munich) ensures that applicants have mathematical-logical skills, their problem-related application to issues at the interface of engineering/natural sciences/life sciences and economics, and a clear and precise ability to reason. The applicant's suitability for study is assessed in the first stage of the procedure by the grade point average and grades in the school subjects German or English and mathematics, and optionally in chemistry, biology, physics or informatics. In addition, extracurricular qualifications or additional qualifications relevant to the course of study are taken into account in the first stage. For each applicant, a maximum of one relevant vocational training or apprenticeship, an internship of at least twelve months relevant to the subject, successful participation in the MINT study program (orientation semester at TUM), successful participation in the competitions "Jugend forscht", "Jugend gründet", "Mathematik-Olympiade" or a comparable competition relevant to the study program with at least distinction at the state level are recognized as extracurricular qualifications or additional qualifications relevant to the study program. After evaluation in the first stage, applicants are either admitted immediately, rejected or invited to a group selection interview, depending on the score achieved.

It is possible to complete the bachelor's program entirely in English. Applicants must therefore have a high level of fluency in the English language.

3.3 Target figures

In Munich, the Bachelor's program is basically designed for beginner cohorts of approximately 600 enrolled students. Currently, the School of Management educates approximately 39% of its students at the bachelor's level, 56% of its students at the master's level, and 5% of its students in executive education (as of winter semester 2022/23).

Since the introduction of the bachelor's degree program in Technology and Management-Oriented Business Studies or *Management and Technology* in 2008, the School of Management has recorded a consistently high number of applications, which most recently rose to a record level of more than 2,300 (see Figure 2).

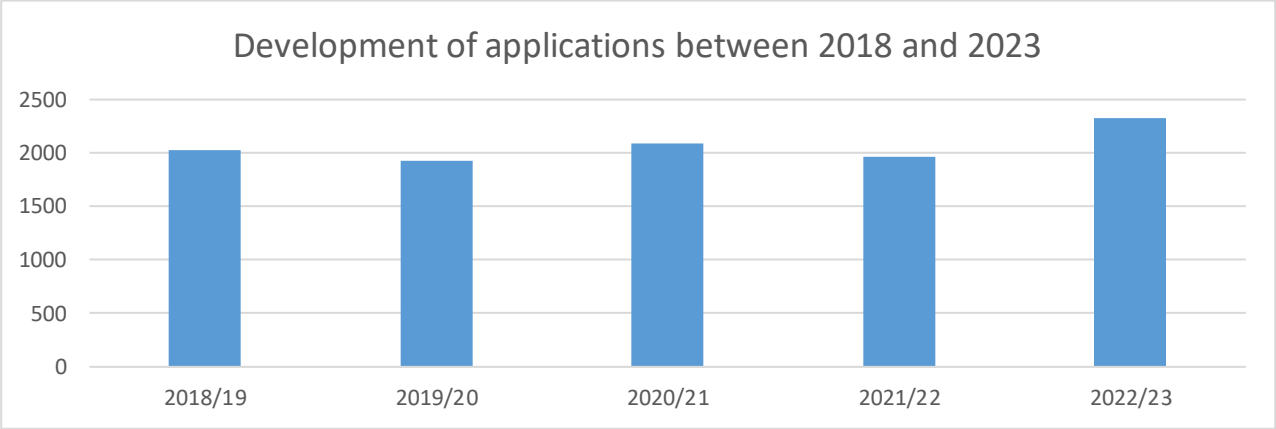

Figure 2: Number of applicants for the bachelor's degree program *Management and Technology* in the winter semester

Of the students enrolled in winter semester 2022/23, 378 (67%) come from Germany, 51 (9%) from the European Union and 137 (24%) from non-EU countries. In addition, the attractiveness is also expressed in the high acceptance rate when a place is offered (Fig. 3).

For comparison: While the acceptance rate for the Bachelor in Management in Technology in winter semester 2022/23 was 70%, only ~60% of the applicants at the entire TUM decided to accept the study place offered to them.

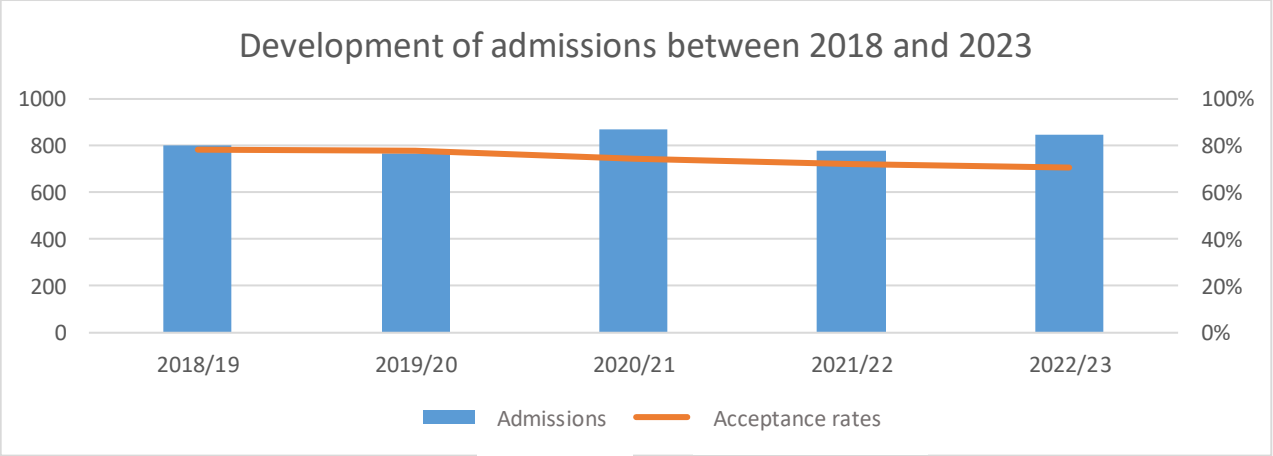

Figure 3: Admissions and acceptance rates for the Bachelor in *Management and Technology* degree program

4 Demand Analysis

Competencies at the interface between economics and engineering and natural sciences are more in demand than ever in times of technological change. Compared to pure business economists, engineers or natural scientists, these profiles always have a great competitive advantage on the labor market when positions are to be filled that are characterized by the interaction between business administration and technical or scientific business areas. Particularly at the interface between commercial and technical or scientific business areas, however, practice is characterized by high know-how and communication barriers caused by a lack of expertise and insufficient understanding of the other area. Industry experts, employers, and graduates of the *Management and Technology* program confirm the great competitive advantage of a degree program that establishes language skills between business people, engineers, and scientists. In the meetings of the Advisory Board of the School of Management, the Board members emphasize the need to recruit graduates with a basic understanding of business administration and technology in the field of digital technologies, in order to fill innovation-intensive areas of the company, such as research and development, with them and to be able to make the knowledge gained economically useful. In addition to the suitability of the content, graduates of the Bachelor in *Management and Technology* can also be employed in internationally operating companies immediately after graduation due to the possibility of completing the program in English.

Ultimately, the bachelor's degree program in *Management and Technology* offers a specialization option that should better prepare graduates for the demands of the modern working world. The conditions of global competition are changing rapidly in the digitalized world - regardless of the size of the company. This includes not only the innovations of all business areas through digitalization, but also the influences of trends such as Industry 4.0 and the Internet of Things, as well as the use of digital technologies such as blockchain, artificial intelligence and virtual reality, to name just the most important. In order to remain competitive, companies therefore need qualified graduates who are familiar with these trends, understand how the technology works, and can also respond adequately to the business challenges of the global market. In a survey of the largest family businesses in Germany, around 43% of companies stated that the central obstacle to digitization is a lack of knowledge among employees in this area.[1]

[1] Source: IfM Bonn - Institut für Mittelstandsforschung Bonn (2017). The Major Family Businesses in Germany - Business Survey 2017: Digitalization.

Within the framework of Horizon 2020, the EU Commission has defined seven so-called "societal challenges" that Europe is currently facing. These are:

- Health, demographic change and well-being.
- Food security, sustainable agriculture and forestry
- Secure, clean and efficient energy
- Intelligent, green and integrated transport
- Climate protection, environment, resource efficiency and raw materials
- Europe in a changing world - inclusive, innovative and reflective societies
- Secure societies - protecting the freedom and security of Europe and its citizens

These challenges will also broadly define the respective national and international labor markets and economic sectors. A central factor here is the successful development and use of technology as a whole and digital technologies in particular. For example, in transportation, algorithms are being used to automatically calculate the best transportation and supply routes to more efficiently handle larger freight and smaller deliveries. Modern agriculture relies on drones to better monitor growth in fields and predict weather changes in advance. The finance and insurance industries are adopting technologies such as blockchain, artificial intelligence, and deep learning into existing processes at an increasing rate to track transactions, set up contracts, and estimate investments. Technology-enabled solutions will continue to be developed at a rapid pace in all of the above areas and industries, and will increasingly transform economic sectors. With chemistry, informatics, electrical engineering and information technology, mechanical engineering, computer engineering and medicine, the ideal basis is created for the particularly sought-after cross-industry activities in the aforementioned mega-clusters such as "Mobility Transformation", "New Health" or "Digital Marketplace". While a classical business economist is familiar with the topic of intellectual property, graduates of the Bachelor of *Management and Technology* with a specialization in chemistry, for example, also know about the structure of chemical databases, with the help of which molecules, their physical properties and also references to patents can be stored and retrieved. This is of direct advantage in corporate practice in the field of research and development, in order to protect oneself from criminal consequences due to copyright infringements and "technology theft".

In addition, the surveys among graduates of the former Bachelor TUM-BWL at the TUM Campus Munich indicate the high attractiveness of the graduates on the labor market. Not least because of the very good career prospects, around 25% of graduates enter the job market directly after graduation and of these 25%, three quarters have already signed an employment contract with their future employer before graduation. In addition to direct entry into various departments (e.g. accounting, controlling, finance, R&D or marketing departments of companies or other organizations), it is also possible to enter a trainee program (rotation in various departments) or consulting. On average, 60%

of graduates who go directly into the job market work in an interface position between management and technology.

The "employability" of graduates of the Bachelor's degree program in *Management and Technology* can thus be rated as very high and will continue to increase due to the continuously increasing challenges (mobility, demographic change, digitalization ...) at the interfaces between the disciplines. Through the teaching of basic management skills, a wide range of business, technical, life and natural science specialization options, experience in dealing with other cultures and the explicit promotion of English language skills, graduates of the Bachelor in *Management and Technology* at TUM Campus Munich are prepared for jobs in companies of different sizes, market orientations and industries.

In general, the bachelor's degree program in *Management and Technology* prepares graduates in terms of content and methodology for further master's studies in business administration. Graduates of the master's program in *Management and Technology* in Munich are particularly well prepared, since this master's program, which is also offered at the School of Management, continues the same principle as the bachelor's program: a business degree with an engineering and/or natural science subject. Graduates of the Bachelor in *Management and Technology* can alternatively also access the *Master in Consumer Science* in Munich and the *Master in Bioeconomy* and *Master in Sustainable Management and Technology* in Straubing.

5 Competitor analysis

5.1 External competitor analysis

In Germany, a large number of different bachelor's degree programs are offered that focus on training at the interface between business administration and the engineering, natural or life sciences. These bachelor's degree programs are mostly courses that focus on engineering, the natural sciences or life sciences. Thus, more than 50% (usually 60-70%) of the courses offered are modules from this field, while the remaining courses are from the business sciences. Examples of this are, above all, courses in industrial engineering, business informatics, or health economics. One exception is the Digital Management program, which also has a focus on management.

Table 1 shows the differences in individual important study programs:

University	Degree	Engineering, natural or life sciences orientation
Clausthal (TU)	Digitales Management	Informatik, Data Science
Karlsruhe (KIT)	Wirtschaftsingenieur	Informatik, Maschinenbau, Elektro-und Informationstechnik, Bauingenieur- und Umweltwissenschaften, Chemieingenieurwesen, Verfahrenstechnik
Aachen (RWTH)	Wirtschaftsingenieur	Maschinenbau, Bauingenieurwesen, Elektrische Energietechnik, Werkstoff- und Prozesstechnik
Darmstadt (TU)	Wirtschaftsingenieur	Maschinenbau, Bauingenieurwesen, Elektro- und Informationstechnik
Universität Hohenheim	Wirtschaftsinformatik	Informatik
Universität Mannheim	Wirtschaftsinformatik	Informatik
Universität Stuttgart	Technisch orientierte Betriebswirtschaftslehre	Maschinenbau
Kaiserslautern (TU)	Betriebswirtschaftslehre mit technischer Qualifikation	Maschinenbau, Verfahrenstechnik, Elektrotechnik, Informatik, Bauingenieurwesen
Universität Bayreuth	Gesundheitsökonomie	Gesundheitsökonomik, Management in der Gesundheitswirtschaft, Gesundheitswissenschaften
Universität Wuppertal	Gesundheitsökonomie und Gesundheitsmanagement	Versorgungsforschung und Qualitätsmanagement, Gesundheitsmanagement und Gesundheitspsychologie, Gesundheitsökonomische Evaluation und entscheidungstheoretische Modellierung
Universität Köln	Gesundheitsökonomie	Kasuistik, Gesundheitsökonomie, Gesundheitssysteme, Studies Abroad in Health Care Management
Universität Erlangen-Nürnberg	Medizintechnik	Medizinelektronik und medizinische Bild- und Datenverarbeitung (Fokus: Informatik/Elektrotechnik) Medizinische Gerätetechnik, Produktionstechnik und Prothetik (Fokus: Maschinenbau/Werkstoffwissenschaften)

Table 1: Selected bachelor's degree programs at the interface between engineering, natural sciences and business administration

A significant difference between the bachelor's degree program in *Management and Technology* and the industrial engineering programs lies in the focus of the content. The bachelor's degree program in *Management and Technology* consists of approximately 2/3 economics content (and related

areas such as law) and 1/3 technical content. The programs listed in the table, on the other hand, have the opposite distribution or focus on engineering/science.

In bachelor's degree programs in business informatics, exemplified here by the University of Hohenheim and the University of Mannheim, the focus is increasingly on information technology; only a few economics and law subjects are included in the curriculum. In contrast, students of the bachelor's degree program in *Management and Technology* acquire the broad knowledge of a business economist with an additional qualification in computer engineering or informatics.

In the technical-oriented business administration program at the University of Stuttgart, the economics and law components are weighted similarly to those in the *Management and Technology* program, but the engineering orientation in Stuttgart is limited to mechanical engineering, whereas the Munich bachelor's degree offers a wide range of options with six different specializations.

The Bachelor in *Management and Technology* with a focus on medicine is to be distinguished from programs that focus on "Health Care" (health, care and rehabilitation) or "Fitness & Sports". The study focus is oriented towards "Technology" and aims to utilize TUM's research expertise in the field of medicine. While many degree programs focus solely on the scientific contexts of management tasks in the healthcare system (such as a number of health economics programs, e.g. at the universities of Bayreuth, Wuppertal and Cologne), or combine engineering know-how with medical topics (such as MedTech programs, e.g. at the universities of Wuppertal and Cologne), the focus is on the scientific contexts of management tasks in the healthcare system (such as a number of health economics programs, e.g. at the universities of Bayreuth, Wuppertal and Cologne). In addition to a business education, the medical focus of the Bachelor in *Management and Technology* provides a solid foundation in the core area of medicine with an outlook on the technological and digital innovations in this field.

Due to its special characteristics, the *Management and Technology* degree program also attracts great interest from international applicants. On the one hand, this is due to the fact that it combines business administration with the renowned technical core disciplines of TUM and thus benefits from this strong "academic brand". In addition, the program offers a wide range of specializations and electives and prepares students for effective collaboration between management and technologies in order to address important societal challenges. Students of the Bachelor's program in *Management and Technology* should be enabled to use their acquired knowledge not only to solve specific business problems, but also to solve challenges facing society as a whole. Due to the possibility to complete the program entirely in English, the program will certainly attract a further increasing number of international applicants in the future and should thus - in line with the School of Management's vision - contribute to being an internationally visible business school at the interface between management and technology.

5.2 Internal competitor analysis

The Technical University of Munich offers four additional undergraduate Bachelor's programs at the interface of economics and engineering and/or natural and/or life sciences: the Bachelor's program *Management and Technology* of the School of Management at the TUM Campus Heilbronn, the Bachelor's program *Sustainable Management and Technology* at the TUM Campus Straubing, the *Business Information Systems* program, supervised by the Faculty of Informatics, and the *Mechanical Engineering* program with a focus on mechanical engineering and management, supervised by the Faculty of Mechanical Engineering.

In contrast to the bachelor's degree in Heilbronn, where only the natural science/engineering subject Digital Technologies is offered, students in the Bachelor in *Management and Technology* in Munich have a choice of six majors: Chemistry, Informatics, Electrical Engineering and Information Technology, Mechanical Engineering, Computer Engineering and Medicine. Thus, the two bachelor's degree programs are not in direct competition with each other, but offer students two different approaches with regard to the "Technology" interface. Whereas in Munich teaching is specific and differentiated according to the engineering, natural or life sciences focus, the "Digital Technologies" focus in Heilbronn aims to combine content from electrical and information engineering, mechanical engineering and informatics in such a way that the various components of digital technologies are covered across all faculties.

The bachelor's degree program in *Sustainable Management and Technology* focuses on the sustainable management of natural resources such as soil, water, air and biodiversity. Due to the clear focus on environmental economic issues (macroeconomic vs. business management), there is no competition with the Bachelor in *Management and Technology* in Munich.

The other two degree programs at TUM at the interface between economics and engineering or natural sciences have a very low proportion of economics and law modules: The proportions are only 13% (*Business Information Systems*) and 12% (*Mechanical Engineering and Management*). Students in these disciplines thus attend a kind of mirror-image counterpart to the bachelor's degree program in *Management and Technology* - a full-fledged education in computer science or mechanical engineering with a few additional qualifications in economics or law. These two degree programs are therefore not in competition with the bachelor's degree program in *Management and Technology*, but offer students with a more technical interest complementary courses.

At TUM, there is also no competing program to the Bachelor in *Management and Technology* with a focus on medicine. In the Master in Medical Technology and Assistance Systems (*Medizintechnik und Assistenzsysteme*), as in external programs, the combination of engineering knowledge with medical topics serves the MedTech field and thus a different interface.

6 Structure of the degree program

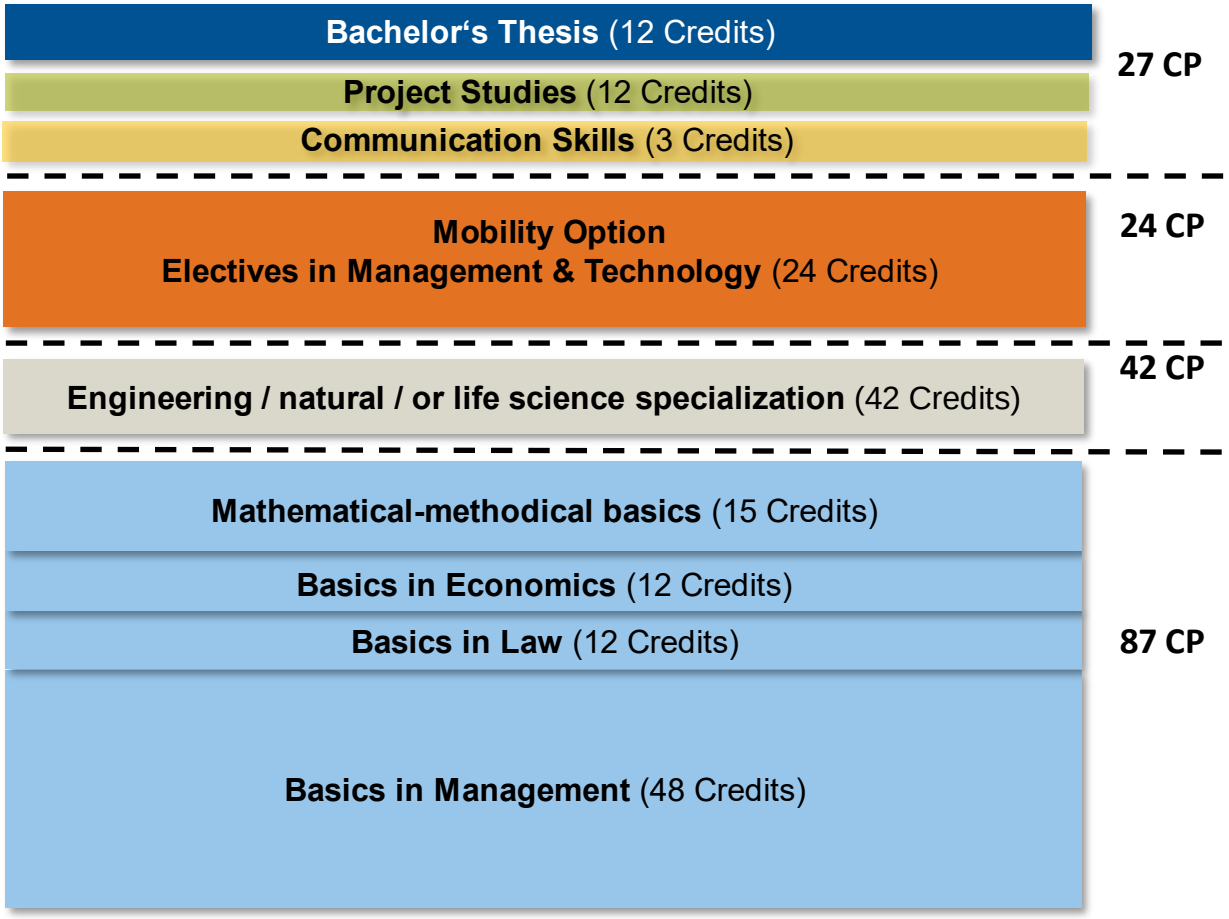

Figure 4: Structure Bachelor in *Management and Technology*

The undergraduate bachelor's program comprises six semesters and consists of the following two sections: In the first four semesters, students are taught the basics of management, economics, law and mathematics, as well as the fundamentals of their chosen engineering, natural or life sciences subject. In order to take account of digitization and the ever-increasing volumes of data that need to be managed, and to convey knowledge about "Data Science/Analytics" in a more structured and interlinked way, Machine Learning has become part of this basic training. From the fourth semester onwards, students are taught more advanced knowledge, skills and methods in their chosen engineering, natural or life sciences subject, and they specialize in various elective subjects in economics and technology. In addition, methodological, social and personal skills are increasingly taught within the framework of a project study program and through "Communication Skills". The fifth semester is also a mobility window in which students can study abroad. The training in the Bachelor's program

is completed in the sixth semester by the Bachelor's Thesis, which must be completed within three months.

In order to achieve the competencies presented (cf. chapter 2 on the qualification profile), various teaching/learning formats are offered in the degree program. Basic knowledge in the individual business disciplines as well as in related areas is conveyed through lectures or learning paths in the form of texts and videos (in flipped classroom formats). In addition, skills for applying the knowledge gained to standard problems are practiced in accompanying exercises and tutorials. The technical and methodological competencies in the business administration subjects are taught in seminars as well as in project studies and the Bachelor's thesis. The last two forms of teaching/learning also serve to develop the above-mentioned social and personal skills. The knowledge and skills in the chosen engineering, natural or life science subject are first taught through lectures and exercises and then deepened through supplementary internships and seminars, so that the students can develop appropriate subject and methodological skills. In detail, the different teaching/learning forms - which are listed in detail in the module descriptions - are used in the study program in the following way. The specialized knowledge and skills in business administration are imparted through a broad basic education in the disciplines of financing, bookkeeping and accounting, cost accounting, marketing, operations research and decision analysis, innovation management, production and logistics as well as entrepreneurship. Overall, graduates master the basics of accounting, including double-entry bookkeeping and various cost accounting systems. They know the basic concepts of entrepreneurship including basic psychological processes and characteristics of entrepreneurs as well as possible development paths of entrepreneurial firms, they know the ethical significance of economic theories, they know important corporate strategies as well as the basics of employee motivation, teamwork and decision-making behavior and communication, they know the basic concepts of empirical research, they know planning hierarchies and the basic concepts of logistics. They can use optimization methods to solve multidimensional problems. They know the basics of financing theory, financial planning, financial control as well as project evaluation and are proficient in financial and investment mathematical methods. They understand the basic concepts of marketing (e.g. customer value, segmentation, marketing mix) and innovation (e.g. market and competition analysis, research and development processes). In addition to the classical disciplines, training content is included that has an explicit connection to the research profile of the Faculty of Business and Economics (Operations Research and Decision Analysis, Innovation Management, Logistics and Entrepreneurship) and also has an interface with the engineering, natural and life sciences subjects.

Compulsory modules in important related fields of business administration are integrated into the program. These include the fields of economics, law and mathematical-methodical basics. These subjects are indispensable for a comprehensive education in business administration. For example, business administrators must be able to deal with legal implications (e.g. contract law, corporate law) and assess business developments in a macroeconomic context (e.g. effects of trade restrictions, exchange rate and interest rate changes). In addition, quantitative knowledge and methods are of

great importance, especially in view of the increasing evidence-based nature of management decisions and the growing importance of data analysis, and are emphasized accordingly due to the quantitative orientation of the education at the School of Management. The knowledge, skills and competencies in mathematics and statistics are also a prerequisite for other business subjects (Investment and Financial Management, Applied Econometrics) as well as for some of the engineering, natural and life science subjects to be chosen (e.g. Informatics, Mechanical Engineering and Medicine).

Specialization in Technology

In the second semester, students choose one of the six engineering, natural or life science subjects offered. The choice of the English-language focus Computer Engineering enables the complete study of the program in English. Students acquire basic knowledge in one of the six engineering, natural or life science subjects offered. Each major includes an introduction to computer science to ensure basic knowledge of simple data structures and object-oriented programming. This is the only way for business administrators to meet current requirements in an increasingly digitalized working environment. The focus modules are usually the original lectures, exercises and practical courses that are offered to students in the corresponding undergraduate degree programs in engineering, natural sciences or life sciences. Since students learn these fundamentals largely together with students in the corresponding undergraduate program, they simultaneously become involved in the diverse communication and problem-solving culture in their respective engineering, natural science, or life science subject. In four out of six concentrations, a basic education in the scope of 6 modules, which are very close to the undergraduate bachelor programs, is given, which, supplemented by an elective module, results in the necessary 42 CP. The first exception is Medicine, where only compulsory modules are included due to the specifics (limited study capacities, distribution of study sections between TU and LMU and different schools). The second exception is Computer Engineering, where there is only one large compulsory module with 12 CP. This is a modification of the central basic courses from the German Bachelor of Informatics in English ("Einführung in die Informatik für Informatiker" and "Praktikum: Grundlagen der Programmierung"), tailored to the needs of business economists. Due to the limited availability of English-language modules with suitable content, students in this concentration are free to select the remaining 30 CP from a list of electives, which are continuously reviewed and replaced or supplemented as necessary.

The engineering, natural or life science subjects are offered at the following locations.

- Chemistry: Garching site
- Informatics: Garching location
- Electrical Engineering and Information Technology: Munich/Garching site
- Mechanical Engineering: Garching location

- Computer Engineering: Garching site
- Medicine: Munich location

The structure of each specialization is as follows:

The **Chemistry specialization** imparts fundamental scientific knowledge in the field of chemistry and serves to promote interdisciplinary understanding between the natural sciences and economics. The basics in the core areas of chemistry are covered in the modules "Allgemeine und anorganische Chemie", "Einführung in die Organische Chemie" and "Biologie für Chemiker". Students gain an understanding of the important large-scale processes of basic inorganic and organic chemicals, protein biosynthesis, as well as kinetic and thermodynamic principles of chemical processes. In the module "Chemisches Praktikum für TUM-BWL", students acquire the practical manual skills in the laboratory, gain insight into the basic experimental operations of inorganic and organic chemistry, the operation of equipment and the evaluation of experimental results. The module "Analytische Chemie" provides students with the basic knowledge of chemical analysis of sampling, sample preparation, measurement, evaluation and validation of data. The module "Chemie in Alltag und Technik" shows the students an overview of reactor types, operation of reactors and polymerization processes as well as the basic elements of simple and complex reaction kinetics and catalysis with regard to the most important industrial processes. After selecting the module "Molekulare Biotechnologie", students understand the differences between the various areas of biotechnology (e.g. green, red, white biotechnology) as well as their historical development and can assign questions to the respective areas. Graduates who have taken "Anorganische Molekülchemie" have a basic knowledge of all relevant models for describing the structures and bonding relationships in inorganic molecular compounds and of the regularities in the periodic table of the main group elements and special features of the subgroup elements.

In the **Informatics specialization**, after "Information Management for Digital Business Models" and "Introduction to Programming", some of the core subjects of informatics are attended together with the informatics students (e.g. software engineering, databases, operating systems and system software). These compulsory modules, amounting to 36 CP, provide students with the formal, algorithmic and technological competencies specified in the qualification profile. For the remaining 6 CP, students can choose between modules from the classical informatics education such as "Functional Programming and Verification" or "Introduction to Computer Architecture". On the other hand, more specific topics such as IT security can be deepened within the framework of the elective module ("IT Security" or "Secure Mobile Systems").

The **Electrical Engineering and Information Technology specialization** starts with Mathematics II, followed by Fundamentals in Electrical Engineering ("Principles in Electrotechnology"), Signals and Systems ("Nachrichtentechnik"), and Information Technology. The triad of circuit theory, system theory and signal theory provides students with a systemic application framework even beyond the

boundaries of electrical engineering and information technology. At the end, specialized modules finally span the spectrum of electrical engineering and information technology to enable an individual focus in the elective module. In this last specialization module, students can choose from a wide range of areas, including electromobility, micro- and nano-electronics, communication technology, computer technology and human-machine interaction.

In the **Mechanical Engineering specialization**, basic competencies in the field of machine design are acquired. Particular emphasis is placed on building up competence in the areas of technical mechanics (“Technische Mechanik”), production technology (“Produktionstechnik”), CAD and machine drawing (“CAD und Maschinenzeichnen) and machine elements (“Maschinenelemente”). Technical mechanics teaches students the ability to formulate and solve mechanical problems in engineering independently, initially at an abstract mathematical level. In the module "Einführung in die Produktionstechnik", the basic interrelationships of manufacturing processes along a production line are taught. In the module "CAD und Maschinenzeichnen", students learn in particular to interpret a technical drawing and its effects with regard to production, costs, etc. and to prepare it independently in compliance with all relevant guidelines and standards. They analyze complex tasks in descriptive geometry and solve them both manually and with CAD systems. They learn to evaluate the influence of different manufacturing processes on the design of components. Students will also be able to understand and assess basic interrelationships of machine elements after completing the corresponding module.This enables them to develop solutions for the design of components that are suitable for production, loading and assembly, to select and design suitable machine elements and to represent them using CAD systems.

In the **Computer Engineering specialization**, the basics of programming are taught first. The remaining 30 CP can be selected from a pool of modules from informatics and electrical and information engineering. In this way, students can consciously choose one of the two disciplines or move at the interface between them. The range of topics goes from basic scientific knowledge ("Mathematics of Natural and Economic Sciences II") to classical informatics or electrical engineering modules ("Introduction to Software Engineering" or "Principles of Electrotechnology") to very specific modules for students who, for example, want to deal with programming languages at an advanced level ("Advanced Concepts of Programming Languages").

The **Medicine specialization** first provides basic scientific knowledge in the areas of chemistry and biology with clinical links, which is mandatory for the understanding of the other modules. This is followed by basics in the core medical areas of „Körperstrukturen und -funktionen“, „Anatomie und Physiologie der inneren Organe“ as well as the area of medical terminology, through which students develop a basic understanding of medical science. In the further course of study, students acquire the basics of clinical medicine and epidemiology through the module "Medizinische Vertiefung", these provide insights into the medical activities, their tasks, issues and challenges. In the practical module "Medizin und Praxis", students learn about the social and organizational structures of a clinic. In addition to this medical content, the focus also includes the basics of information technology, since, for example, the systematic development and communication of information are important

aspects in modern health management. Last but not least, the advancement of digitalization is a central topic in the further development of healthcare.

Electives in Management and/or Technology / Mobility window

In the fifth semester, the electives in management and technology are scheduled with a total of 24 ECTS. In addition, this semester can also be used for the so-called "mobility window", e.g. a semester abroad can be completed. Students have the opportunity to further deepen knowledge acquired in the first semesters or to acquire new more specialized competencies. The following design options for the elective area of economics and technology are considered ideal:

(1) Use to choose further modules in the field of management. The School divides its research and teaching activities into five competence areas from which students can choose modules: "Economics & Policy", "Finance & Accounting", "Innovation & Entrepreneurship", "Marketing, Strategy & Leadership" and "Operations & Technology".

(2) Use to select other modules from the engineering or science fields, not necessarily only from the student's own chosen specialization.

(3) Use in freely selectable proportions both for modules from the economic field and from the engineering or natural science disciplines. In this way, students broaden their knowledge of the interface between management and technology according to their interests and, for example, examine it from the perspectives of different disciplines.

(4) Taking elective modules as part of the mobility window during a semester at a foreign university. The freedom of choice simplifies the recognition process for modules taken abroad. This option increases the attractiveness of a stay abroad to sharpen an international profile as well as to acquire knowledge in subject areas that are not primarily pursued at TUM. Through such a study period abroad, students are also intensively sensitized to intercultural issues and prepared for working in international teams.

As part of the **Communication Skills** module, students can enhance their communication skills through language courses, soft skills and business plan seminars.

The **project study** serves to combine acquired theoretical knowledge and practical experience. It can be completed flexibly in the fifth or sixth semester or following a semester abroad, which usually ends earlier than the semester at TUM. Representatives from corporate practice or research-related institutions accompany the study projects as mentors. The supervising professors and their scientific staff form the bridge to the academic training and supervise the corresponding projects through a regular and intensive exchange. The study projects should not only produce solutions for research or for companies, but also networks of relationships for later entry into the professional world or for internships in an advanced master's program. The project studies can also be completed abroad as part of the mobility window. Overall, it enables graduates to develop solutions to both academic and

practical problems. Feedback to date shows that the project study program has been very well received by the project partners. The students also see the project study as extremely important, on the one hand for the development of their technical and methodological skills and on the other hand because of the processing of a real complex problem in the group, which at the same time supports the development of their social skills.

Bachelor‘s Thesis

In this work, students deal scientifically with a specific economic topic or an engineering, life or natural science topic. For this purpose, the students formulate in writing the scientific state of knowledge and dis-course and develop a specific question based on this. The students treat the topic with the subject and methodological knowledge acquired in the course of their studies, using the scientific facts and methods acquired in the course of their studies, and develop an independent solution to the problem. Based on scientific research, they present facts and findings in writing, evaluate them and place the results obtained in the scientific and/or subject-specific practical discussion. As a result, students are able to work on a project independently, systematically and scientifically and to develop a solution approach on their own. The students work on the topic on their own, supported by feedback discussions with a supervising professor. The Bachelor's Thesis can be handed out and supervised by expert examiners of the TUM School of Management of the Technical University of Munich, by second members of the School as well as by expert examiners of other Schools who teach in the study program *Management and Technology*. Bachelor theses in cooperation with companies are generally possible.

Through their individual choice of courses and the option of studying up to 100% of the program in English, students also control the extent to which they acquire subject-specific, business-fluent English skills and in which subject areas.

In order to ensure that students can study as well as possible despite the different semester structures resulting from the six technology specializations, the TUM School of Management has drawn up ideal study plans. In addition, timetables are published each semester with the specific courses, rooms and dates. If the ideal timetable is not feasible for each student, he or she will be able to make the necessary changes to the curriculum by individually adapting his or her study plan in order to be able to acquire the recommended 30 CP per semester. For individual study planning and preparation of a semester abroad, the International Office and Program Management offer weekly consultation hours as well as regular information events and webinars. In addition, the Buddy Program offers the opportunity to be mentored by a student from a higher semester. The Buddy Program is organized by the School Office.

7 Organizational affiliation and responsibilities

Program responsibility and coordination are the responsibility of the Dean of Studies of the TUM School of Management, who is supported by the School Office. The program director is also responsible for the program. On the level of the study program, the Bachelor Examination Committee and the Aptitude Assessment Committee of the TUM School of Management should also be mentioned. The Bachelor Examination Board of the TUM School of Management is responsible for the clarification of examination-related matters, whereby the recognition of examination achievements can be delegated to the module supervisors at the locations. The Aptitude Assessment Committee is responsible for the proper implementation of the aptitude assessment procedure.

Central administrative tasks are carried out in coordination with the Vice Dean of academic and student affairs, the Program Director and the responsible committees and commissions of the administration of the TUM School of Management, in particular the Divisions Undergraduate and Postgraduate Education, Quality Management and Marketing.

Information about the study program is published on the website of the TUM School of Management (www.wi.tum.de).

For administrative aspects of the study organization, both the central areas of the TUM Center for Study and Teaching (TUM CST) and institutions of the school are responsible (see following overview):

- General Student Counseling:
  Central:
  Study Counseling and information (TUM CST)
  E-Mail: studium@tum.de
  Phone: +49 (0)89 289 22245
  offers information and advice for:
  prospective students and enrolled students
  (via Hotline/Service Desk)
- Subject Academic Counseling:
  TUM School of Management – Program Management
  Michaela Krieger
  E-Mail: studentcounseling_bachelor@mgt.tum.de
  Phone: +49 (0)89 289 25071
- Counseling on studying abroad:
  Central: TUM Global & Alumni Office
  E-Mail: globaloffice@tum.de

Decentral: TUM School of Management – International Office:

Ute Helfers
E-Mail: outgoing@mgt.tum.de
Phone: +49 (0)89 289 25036

Gabriella Loparco (Student Exchange Programs: Outgoing – Europe, Freemover, Internships)
E-Mail: outgoing@mgt.tum.de
Phone: +49 (0)89 289 25036

Anna-Lena Köttig (Student Exchange Programs: Outgoing – NON-EU, Summer and Winter Schools)
E-Mail: outgoing@mgt.tum.de
Phone: +49 (0)89 289 25847

Josephina Buhr (Joint International Programs)
E-Mail: jip@mgt.tum.de
Phone: +49 (0)89 289 25079

Zuzana Zechovska (Student Exchange Programs: Incoming exchange students)
E-Mail: incoming@mgt.tum.de
Phone: +49 (0)89 289 28185

- Women's representative:

TUM School of Management
Dr. Christian Feilcke
E-Mail: office.ent@wi.tum.de
Phone: +49 (0)89 289 25706

- Counseling for barrier-free studies:

Central: Service point for disabled and chronically ill students and prospective students (*TUM CST*)
E-Mail: Handicap@zv.tum.de
Phone: +49 (0)89 289 22737

Decentral: TUM School of Management
Katja Leßke
E-Mail: katja.lesske@tum.de
Phone: +49 (0)89 289 25317

• Application and enrollment:	Central: Application and Matriculation (TUM CST) E-Mail: studium@tum.de Phone: +49 (0)89 289 22245 Application, matriculation, Student Card, leave of absence confirmation, exmatriculation
• Aptitude Assessment Procedure:	Central: Application and Enrollment (TUM CST) Decentral: TUM School of Management – Admissions Silvana Rueda Urrea E-Mail: admission@mgt.tum.de Phone: +49 (0)89 25350
• Tuition and Scholarships:	Department of Tuition and Scholarships (TUM CST) E-Mail: beitragsmanagement@zv.tum.de Scholarships and semester fees
• Central examination matters:	Department of Central Examination Matters (TUM CST), Campus Munich Graduation documents, examination notices, graduation certificates
• Decentral examination matters:	TUM School of Management – Grademanagement TUM Campus Munich E-Mail: grademanagement@mgt.tum.de Shan Huang Phone: +49 (0)89 289 23884 Inna Kravchenko Phone: +49 (0)89 289 25068 Janine Rothenburger Phone: +49 (0)89 289 25033 Michaela Gerhardt Phone: +49 (0)89 289 25068
• Examination board:	President: Prof. Dr. Philipp Maume Secretary: Dr. Christian Feilcke
• Quality management:	Central: Study and Teaching – Quality Management (TUM CST) https://www.tum.de/studium/tumcst/teams-cst/

Decentral: TUM School of Management Vice Dean of academic and student affairs: Prof. Dr. Jürgen Ernstberger

QM-Representative: Sonja Kopf
E-Mail: akkreditierung@mgt.tum.de
Phone: +49 (0)89 289 25075

Organisation QM-Circle: Michaela Krieger
E-Mail: michaela.krieger@tum.de
Phone: +49 (0)89 289 25071

Evaluation officer: Edo Octavianus
E-Mail: lehrevaluation@mgt.tum.de
Phone: +49 (0)89 289 25849

Coordination Module Management: Sonja Kopf
E-Mail: modulmanagement@mgt.tum.de
Phone: +49 (0)89 289 25075

8 Developments in the degree program

The TUM-BWL program has been in existence since winter semester 2001/02. It was initially offered as a diploma program with 240 CP (subject examination regulations (FPO) for the diploma and bachelor program Technology and Management-oriented Business Administration at the Technical University of Munich of August 23, 2001). Since winter semester 2008/09, the bachelor's degree program has been offered with 180 CP (Subject Examination and Study Regulations (FPSO) for the Bachelor's Degree Program in *Technology and Management-Oriented Business Administration* at the Technical University of Munich dated June 12, 2008/September 13, 2013 with various amendment statutes).

The mixture of business administration and engineering, natural and life sciences was retained after the Bologna reform, but the options in both areas were expanded over the years. The subjects of Chemistry, Informatics, Electrical and Information Technology, and Mechanical Engineering initially reflected the main focus areas of the TU Munich. In WiSe 2016/17, the Computer Engineering specialization was introduced, which can be studied entirely in English and thus enables the English Track. In WiSe 2017/18, the offer was expanded to include Renewable Resources at the Straubing Campus for Biotechnology and Sustainability. It picks up on the research focus there as well as the future opportunities on the labor market in the field of renewable raw materials. It also strengthens the new Straubing Campus for Biotechnology and Sustainability. In winter semester 2019/20, the focus on Medicine was introduced. It allows students to enter the rapidly growing healthcare market.

In addition, it is intended to initiate cooperations with the Klinikum rechts der Isar and also to increasingly address female first-year students in order to increase the quota of women in the degree program. The internationalization as a declared goal of the TU Munich has a successive and very concrete effect at various points in the curriculum of the Bachelor in TUM-BWL. For example, the mobility window was introduced in winter semester 2016/17 to make it easier for students to study abroad. With the simultaneous introduction of the English Track, the program was also opened up to first-year students without German language skills. Since the winter semester 2015/16, the proportion of international students has risen to over 27% (winter semester 2018/19) and has thus more than doubled.

The selection options for students in the economic-technical elective area have been expanded. Initially, in winter semester 2016/17, the obligation to choose electives from only one area of competence of the faculty was abandoned in order to offer a broader selection that can be used equally for a specialized profile formation or a generalist education. Currently, students can choose from electives of the following departments of the faculty:

- Innovation & Entrepreneurship
- Marketing, Strategy & Leadership
- Operations & Technology
- Finance & Accounting
- Economics & Policy

Another innovation was the expansion of the elective area to include offerings from partner faculties, which allows students with the relevant interest to pursue engineering, natural science, and life science content beyond the 42 credit points provided. In addition, the recognition of achievements from abroad was made much easier in order to promote international experiences for students.

For the start cohort from the winter semester 2023/24, the program was reviewed and thoroughly revised in all its components in order to meet current social challenges and trends. Among other things, the goal was to bundle module content from different areas in coordination with the participating partner schools in order to convey the topic of "Data Science/Analytics" in a more structured and interconnected manner. Machine learning was added to the mandatory basic training. Due to the importance of increasing digitization in all areas of life and work, an "Introduction to Computer Science (for other disciplines)" has also been integrated into all six specializations. With "Introduction to Programming", a program-exclusive module was introduced with the School of Computation, Information and Technology, which teaches programming skills that are of particular relevance to business administrators. By teaching in English, there is better comparability of competencies, grade distribution, and level of difficulty in the Informatics and Computer Engineering specializations. At the same time, a subject-specific English language competence is acquired. The management and

engineering electives have been expanded from 18 to 24 CP, which allows for an even more individualized focus and prevents the decision to spend a semester abroad from jeopardizing a degree in the standard period of study. In the course of all these changes, the name of the program has also been changed to "*Management and Technology*" in line with the related programs in Heilbronn and Straubing and its international character.