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Aim and Scope

The Journal of Business Chemistry (JoBC) focusses on current developments and insights at the intersection of management and chemistry, biotechnology or pharmacy.

The JoBC provides an international forum for researchers and practitioners in companies, research institutes, public authorities, consultancies or NGOs to present and discuss current challenges as well as potential solutions in an interdisciplinary manner. Thus, the JoBC aims to foster the dialog between science and business, to support management practice in the chemical and pharmaceutical industry and to indicate where further research from academia is needed. The JoBC offers high quality publications with academic standards, a fast publishing process and global reach. With this multidisciplinary and boundary-spanning approach, the Journal of Business Chemistry intends to become the leading journal for decision makers in the chemical and pharmaceutical industry.

Publisher

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Letter from the Editors

15th Volume of the Journal of Business Chemistry – Review and Outlook

The Journal of Business Chemistry is publishing its 15th volume with the first issue of the year 2018. Since 2004 the Journal passed an exciting way, enjoyed a lot of support from the academic and industrial world, and addressed topics of recent interest. The Journal is in a process of constant evolvement, e.g. attracting new authors to present their manuscripts and reaching an even wider readership through multiple channels. One of the latest highlights is the collaboration of the Institute of Business Administration at the Department of Chemistry and Pharmacy (University of Münster) and the Center for Industry and Sustainability (Provadis School of International Management and Technology, Frankfurt/Main). The exploitation of the synergies paves the way for improving the quality of the journal even further. In this issue, we present Business Chemistry in all its facets as well as the increasing demand of interdisciplinary skills in the chemical industry. Therefore, we invited authors from the academic and industrial context to share their perspective on Business Chemistry and recent developments in the chemical industry. In addition, we would like to draw our readers' attention to the recent book release of "Business Chemistry: How to Build and Sustain Thriving Businesses in the Chemical Industry" (for further information please see the last page at this issue).

In the first article "Re-inventing chemistry - an industry in transition" the editors of the Journal of Business Chemistry give an overview of the past 14 volumes. The analysis focuses on different aspects: the type of article, the level of analysis, the focus topics, and the demographic data of authors. The results provide interesting insights about our Journal in general and our prospective development.

The Commentary "Business Chemistry: The successful establishment of an interdisciplinary field" presents Business Chemistry as a course of study in the German and Swiss region. From an academic perspective, professors and their research assistants introduce our readers to the establishment of Business Chemistry at universities, the overcoming of obstacles and the slight differences in study programs. Especially the consolidation of the different perspectives on Business Chemistry makes the article a pioneering contribution.
"Motivation for Innovations – Experiences and Reflections" takes a quite different perspective. Firstly, Meyer-Galow, as a founder and promoter of business chemistry as academic discipline, highlights the importance of motivation and its influence on innovation in general. Secondly, he emphasizes the value of recognition for successful innovations by presenting the Meyer-Galow-Prize for Business Chemistry and the prize-winning Innovators.
The last article in the commentary section "The road ahead: Digitalization fuels innovation" provides an overall picture of recent developments in the chemical industry. Martin Vollmer describes the influence of digitalization, the challenges of sustainability and the opportunities of big data. Also he stresses the increasing importance of agility and fluidity in organizations.

In the Practitioner's Section we are pleased to present our readers a recent study, which analyze career opportunities for Business Chemists. Elisabeth Moshake und Nadine Schäfer address in their article "Quo vadis Business Chemistry?" the issue in which positions Business Chemists are employed. The results of the conducted online survey offer interesting insights on internships, additional qualifications and entry opportunities.
The second article "Chemistry 4.0 – Growth through innovation in a transforming world" from Henrik Meincke, Johann-Peter Nickel and Peter Westerheide deals with the mega trends of digitalization and circular economy in the chemical industry. Moreover the authors provide a deep understanding of the processes in the chemical industry and on how companies can seize the trends as opportunity rather than being frightened by them.

Please enjoy reading the first issue of the fifthteenth volume of the Journal of Business Chemistry. We are grateful for the support of all authors and reviewers for this new issue. If you have any comments or suggestions, please do not hesitate to contact us at contact@businesschemistry.org.

Ruth Herrmann	Thomas Kopel	Bernd Winters
(Executive Editor)	(Executive Editor)	(Executive Editor)

Journal of Business Chemistry

Letter from the Editors

Re-inventing chemistry – an industry in transition

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After founding the Journal of Business Chemistry in 2004, we are proud to present the 15th volume of the Journal of Business Chemistry (JoBC) this year. Since then, 41 issues have been published with 160 contributions. In precise terms: 69 research papers, 63 articles within the practitioner's section, 27 commentaries and one interview have been submitted, reviewed, edited, and finally been made available for the business chemistry community. The Journal of Business Chemistry was established to examine the chemical and related industries in order to shed light on their management and industrial characteristics. The industry has changed significantly since its beginnings in the 19th century and will continue to change in the future – an industry in transition.

In the present article we take a step back to review how the Journal of Business Chemistry contributes towards establishing the academic field of 'successful management practice in the chemical industry'. For this overview we analyzed each published article in detail regarding the type of contribution, the level of analysis, the detailed function in case of the micro level, the first author's gender and affiliation, and the regional and sectorial focus of the respective study. In addition, we ask questions about the future: How will the field of chemistry develop further? What are the challenges for science, business and society? Questions that inspired Harvard professor Georg Whiteside in his famous article "Reinventing chemistry" to propose a fundamental change in how we think about chemistry and to shift the focus away from solving problems on a molecular level to a systemic problem solving approach.

The Journal of Business Chemistry provides an international platform for students, researchers, and practitioners in universities, research institutes, companies, associations, public authorities, NGOs and consultancies. It enables dialogue between academia and business. In so doing, scholars gain access to one of the most important industrial sectors and can obtain new academic insights with which to expand management research. Managers in the chemical and related industries benefit from both the academic perspective and the practitioner's view alike. Figure 1 provides an overview of the contribution types. About 43% of all articles deal with scientific research and their implications for the chemical and related sectors. The practitioner's section, where current developments in the industry are described and examined, represents around 39% of all articles. To inform the business chemistry community from various perspectives and to trigger fruitful discussions, 17% of all contributions are commentaries and roughly 1% are interviews. We believe that this vital mix of contributions makes the Journal of Business Chemistry attractive to its readers and will – of course – constantly review the mix based on the feedback we receive and are open to integrate other contribution types as well.

The chemical and related industries, such as pharmaceutical and biotech, are characterized by a continuous change on the macro, meso, and micro level. In order to equip readers with an encompassing understanding, the Journal of Business Chemistry provides new insights either stemming from research or practice regarding the three levels of analysis, which are displayed in figure 2.

The macro or contextual level refers to factors that can have an impact on companies' performance but are beyond their control. Examples are economic, technological, social as well as regulatory developments such as climate change or the demographic shift in different economies. 40% of

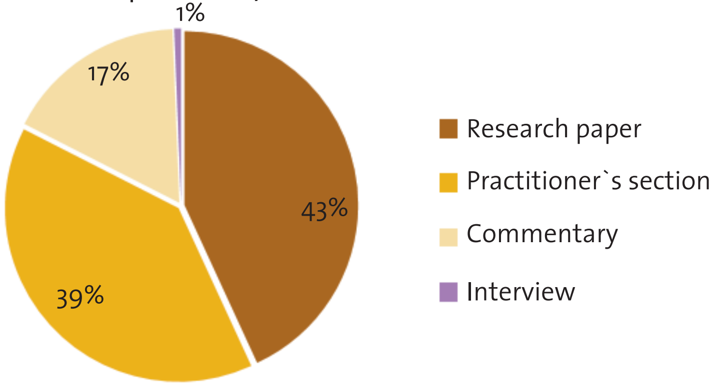


Figure 1 Overview of contributions (source: own representation).

all articles relate to the macro level and link relevant trends to different subsegments in the chemical industry. We believe that from this macro level different and partly contradictory factors will shape the future of the chemical industry. Currently, the digitalization and the concept of the circular economy receive a lot of attention. But the influence of these trends varies across industry segments. However, there is consensus about an environment which is described by volatility, uncertainty, complexity and ambiguity (VUCA). In the future, the Journal of Business Chemistry will continue paying attention to the latest trends, in particular digitalization and circular economy.

The meso or transactional level covers topics around 'market forces' rooted in a company's operating business, such as suppliers, customers, competitors, distribution, alliances and cooperations, and the management thereof. Since the journal's founding, 13% of its published articles have dealt with the meso level. In the past, various articles explored different facets of collaboration, e.g. how to collaborate with lead users or how knowledge is shared in heterogeneous collaborations. Ecosystems and clusters as drivers for innovation will likely continue to gain traction in the upcoming years. Originally stemming from biology and ecology, the ecosystems analogy has been widely adopted in business studies and practice. In ecosystems where companies work collaboratively with various partners, as they possess required complementary capabilities, the complexity of the system increases dramatically. In tightly interwoven ecosystems characterized by highly interconnected stakeholders, companies with the ability to manage complexity will be more innovative and thus enjoy a powerful competitive advantage in their field. We are looking forward to contributions from theory and practice on this issue and expect that the "meso level" will increase in importance for theory and practice

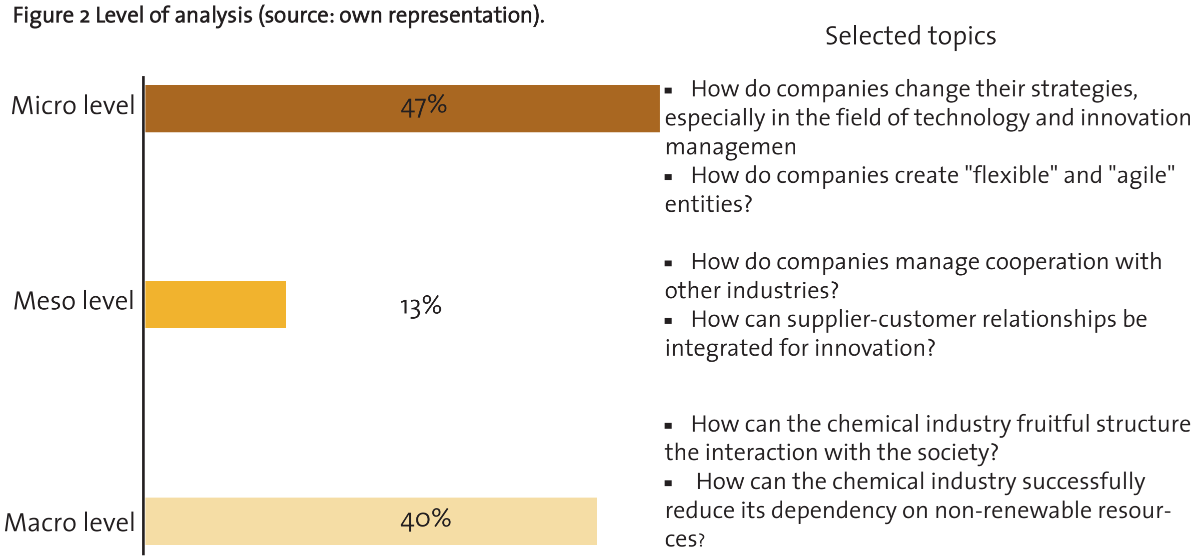
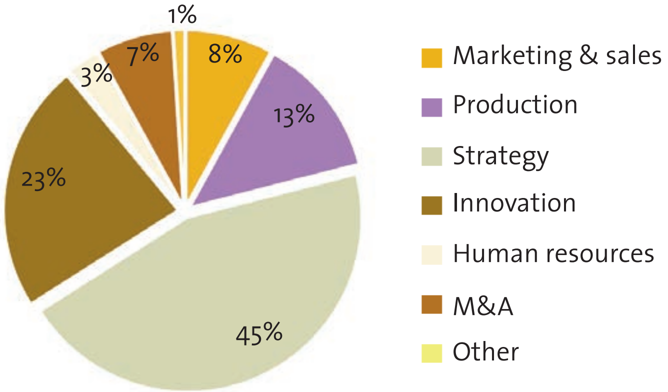


Figure 2 Level of analysis (source: own representation).

Figure 3 Detailed micro level analysis (source: own representation).



as new competitive arenas may be found in the thematic area or regional ecosystem.

It is important for companies to respond to changes on a micro or organizational level, which focuses on companies as such. Therefore, companies ought to reallocate resources in accordance with new realities. Most articles, about 47%, analyze the micro level. Business functions and organizational capabilities play a pivotal role in companies' value creation process. How business functions are set up, embedded in organizations, and executed has profound implications for performance and output.

Figure 3 gives an overview of which business functions have been addressed by the articles. The detailed micro level analysis shows that strategy and innovation are the prominent topics with 45% and 23% of all articles, respectively, followed by production (13%), marketing and sales (8%), mergers and acquisitions (M&A) (7%), human resources (3%), and others (1%).

Even though the chemical industry is influenced by a set of different forces, it appears likely that formulating the right strategy and allocating resources will remain the key drivers for achieving sustainable competitive advantage. The dominant trend of digitalization brings about an urgent need to find the right strategy. For a long period of time, the asset-intense chemical industry has profited from a comparatively stable environment and business model: chemical knowledge was translated into products, which were produced efficiently in highly integrated industrial parks, while constant consumption by customers and end-consumers ensured attractive growth rates. In recent years, the business models of companies in the chemical, pharmaceutical and biotech industries have become multidimensional – not only the technical function of a molecule, but the created value in a specific field becomes the anchor for value creation and capture. Additionally, a digitally enabled platform economy could radically alter the production circumstances. In future scenarios, the production of chemicals might be offered as a service; according to this, the mere knowledge about a chemical formula and its ownership would be the key driver for value creation and capture as opposed to the conventional model with an integrated production. Considering this, the drawback of capital-intense production facilities with their associated inflexibility resolves unexpectedly. Consequently, entrepreneurs could be encouraged starting their own business in the realms of chemistry.

Given these developments, the scope of M&A activities could change from economies of scale to economies of scope. As prevailing economic conditions (e.g. low interest rates) trigger a seemingly never-ending wave of mergers and acquisitions, and company valuations reach ever increasing records, companies look for efficiency gains through economies of scale. Companies in the chemical industry which start gearing their M&A activities towards economies of scope could gain a sustainable competitive advantage. Therefore, companies ought to reconsider their concept of a chemical company. It is vital to evolve from a mere producer of chemicals to a solution provider. The chemical industry is no longer characterized by and dependent on advancements in the academic field of chemistry – although it will be a substantial part of the solution. Rather, the future of the industry will depend on its ability to integrate findings from other related disciplines. As the chemical industry is regarded conservative, fundamental changes in the guiding principle might be accompanied by cultural issues. Thus, successful companies will possess distinct transformation capabilities. According to this notion it is decisive for future success to attract the right people. For upcoming generations sustainability, the sense and impact of their work to find solutions for the grand societal challenges is becoming one major motivator. Employees regarded as high potential possess not only in-depth knowledge of their respective discipline, but also the courage and ability to question prevailing opinions, work and thinking routines. In the context of digitalization, job profiles will look completely different than 10 years before. Employees with an interdisciplinary education will be well prepared for future tasks. In best case, a thorough chemical understanding is combined with other disciplines, such as digital literacy. There will be a high demand for professionals like a 'digital chemist'.

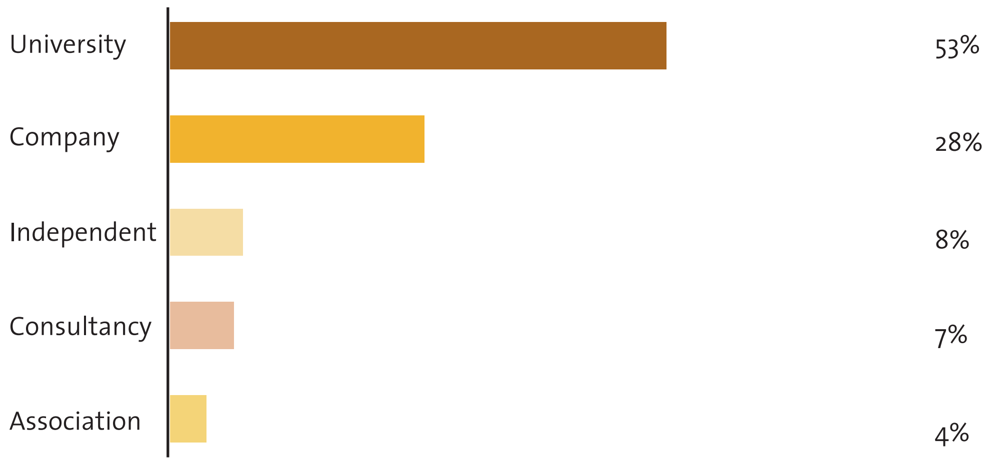
Authors are one essential factor for creating high quality publications. Figure 4 presents the gender of the first author. The chemical and related industries are often conceived as very conservative and male dominated. Up until now, 82% of all contributors have been male, while 18% are female. Increasingly, vacant management positions are filled by women. The Journal of Business Chemistry promotes the equality between men and women in science and practice. Therefore, we encourage women to submit their manuscripts.

In terms of author's affiliation, depicted in figure 5, 53% of all authors work at universities, 28% are employed at companies, 7% are consultants, 9% work independently, and 4% are employed at associations. These percentages indicate the strong foundation in academia, while still being open for multifaceted practitioners' views.

With regards to the continent of residence, Europe stands out with 75%. Our authors mainly live in the Germany, United Kingdom or Switzerland. Due to the fact that the Journal of Business Chemistry was founded by the Institute of Business Chemistry in Münster, Germany, it is not surprising at all that this country stands out in terms of authors living there. Another reason is the establishment of Business Chemistry as a course of study in the German and Swiss region, which gives an additional explanation for predominance of German authors. The interdisciplinary approach of Business Chemistry or similar study programs is generally not pursued in North and South America. However, 11% of authors are living in North or South America, while authors mainly live in the USA. 7% of authors reside in Asia, and most of them in China. Other authors (7%) come for instance from Australia, South Africa, Abu Dhabi, Israel, or Tasmania. In the future, we would appreciate contributions from locations outside of Europe. Authors living in the US, China, and India are still underrepresented compared to Europe.

Figure 4 Gender of authors (source: own representation).

Figure 5 Authors affiliation (source: own representation).



Nowadays, the economy is highly globalized. This is especially true for asset-intensive industries like chemicals and research-intensive segments like pharmaceuticals, and the biotech industry. While in the past, the USA and Europe have experienced high growth rates because of being continuously innovative either incrementally or radically, the demand and innovation activities are shifting to Asia, namely India and China. Contributions with a regional focus help to understand local characteristics, whereas studies conducted worldwide can indicate global trends and developments. Figure 7 visualizes the regional focus of published articles. 6% of authors conducted a study on global level. 59% of studies focusing on Europe as a region. The number of studies in North America and Asia are comparable with 7% and 6%, respectively. Other locations, for instance Australia, Brazil, Cuba, and Taiwan, account for 13%, and 9% do not have a regional focus and are rather conceptual. As the Middle East was not represented adequately with respect to its upstream industry, future articles are welcomed to examine the implications of the current business environment for the oil and gas industries in that region. We expect a decrease in importance of the European and American markets for the benefit of China, India and other growing countries in Asia. Accordingly, the latter are should be more emphasized and analyzed in future contributions with regards to the economic importance of the respective markets. Nevertheless, it will be interesting to see how the chemical industry will cope with current conditions and translating the risks into opportunities.

Figure 8 displays the sectorial focus of study. On an aggregated level it is distinguished between the chemical, pharmaceutical, and biotech industry as well as studies conducted across industry sectors, and other related industries. Not surprisingly, 65% of submissions examined the chemical industry, while 11% analyzed the pharmaceutical industry and 6% the biotech industry. 11% of studies were conducted across industries, while 7 % of studies belong to other industries, such as healthcare, food or nanotechnology. In future we expect more studies relating to cross industries as industrial boundaries are becoming increasingly blurred. Additionally, collaboration across industrial sectors will be a crucial for sourcing complementary capabilities in order to trigger innovations.

Figure 6 Authors' continent of residence (source: own representation).

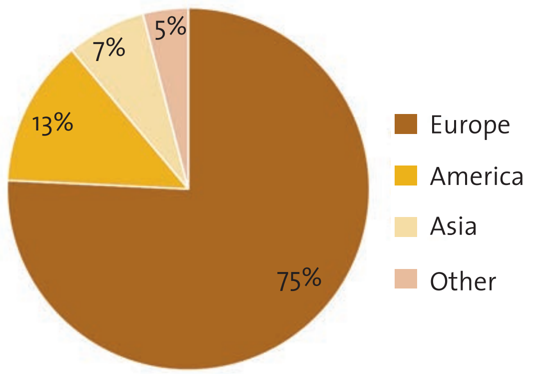


Figure 7 Regional focus of study (source: own representation).

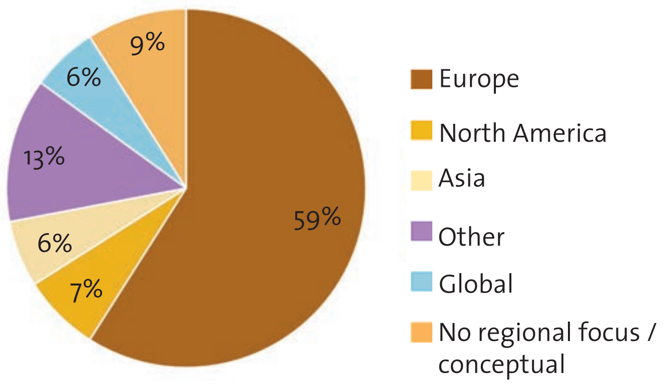
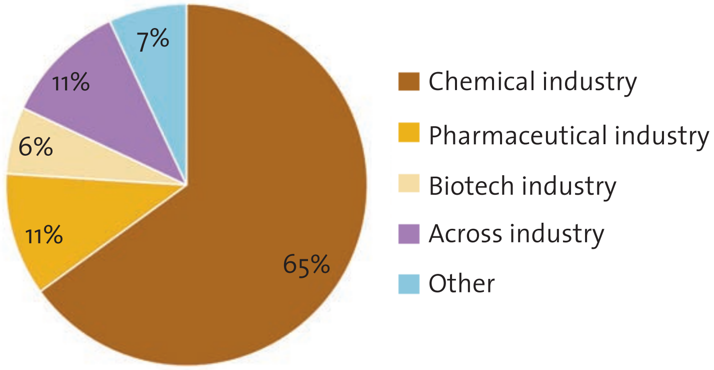


Figure 8 Sectional focus of study (source: own representation).



Over the course of 15 volumes, the Journal of Business Chemistry has accompanied and presented the development of the industry following a dual approach. The Journal of Business Chemistry provides a platform for discussion about future questions of the chemical industry. Therefore, the chemical industry should continue to examine: What will our role be regarding academia, the industry itself including suppliers and customers, and regarding society? Put differently, who do we want to be in the future? With regards to upcoming mega trends, there are plenty of topics and developments that may sharpen the field over the next 15 years. Still, one should keep in mind that changes in asset-intensive industries and large corporations will take a huge effort and time, and that daily business operations continue as a driver to realize efficiencies in productivity.

For a successful future, the chemical industry needs to do two things. First, the industry should continue to follow the path of opening itself to academia and chemical-related disciplines, to its and related industries, and towards society as a whole with all the stakeholders. Secondly, the chemical industry has to focus on one of its core abilities: the ability to continuously invent better solutions to specific problems. As history has shown, the chemical industry was able to substitute traditional materials like wood, paper, or metals with ones with better performance or higher efficiency. Now again, it is time to find better solutions to keep and enhance our living standard.

The Journal of Business Chemistry would like to thank all authors, reviewers, and editors who took part in the process of establishing the field of management issues in the chemical industry. Furthermore, we thank our multiple stakeholders for their positive feedback on our interdisciplinary ("business meets chemistry") and boundary spanning ("academia meets practice") approach.

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Commentary

Business Chemistry: The successful establishment of an interdisciplinary field

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The article presents the development of Business Chemistry at seven German and one Swiss universities. Besides highlighting the course of study in general and its development, the respective universities present benefits but also specific challenges they had to face when introducing Business Chemistry. Followed by a short introduction of Business Chemistry itself, its development and the status quo, every university presented their individual perspectives on the course of study. Overall, the article should provide our readers with an overview of Business Chemistry and sensitize them for the differences in the study programs, even though the courses of study were developed in accordance with all respective universities.

Introduction

Business Chemistry – a course of study settled in two disciplines. In general, Business Chemistry can be defined as a combined study program of the two disciplines chemistry and business. Competencies in the subjects chemistry and business are developed either in a parallel or in a consecutive study program. Depending on the universities and the accessible resources at the time of implementation, the courses and specialization offers can differ. Therefore, at some universities the focus lies on developing general competencies in the field of business, whereas other universities especially focus on the courses at the interface of the two subjects such as innovation management. The chemical part of Business Chemistry is very similar at the respective universities - building competencies in the research fields inorganic, organic, and physical chemistry as well as providing analytical skills.

The initial demand for this combination came not only from industry, but also from the necessity to increase the attractiveness of chemistry as a course of study. In addition, it is quite common in the German area, in contrast to the Anglo-American region, to combine technical and natural science study programs with a business component, i.e., the study programs industrial/business engineering and business informatics. This is also one reason for the different foci of Business Chemistry at the respective universities as mentioned above. The chemical industry, with its practical view and knowledge about common career paths, has demonstrated that even though many chemists initially start in the lab, they often end up in management positions at the end of their careers. Because of this, the Business Chemistry program aims to educate students in both disciplines. Furthermore, chemical companies benefit greatly from employees having expertise in both fields and understanding the chemical processes of production. Business Chemists have the capability to look from a different perspective on business processes and value creation, which ultimately benefits the company by questioning the status quo and mediating between the business and chemical perspectives. Furthermore, the development of academic education changed in the last years. The demand for interdisciplinarity has increased, which in the end leads to the introduction of plenty of combined study programs beside Business Chemistry. The idea for Business Chemistry originates from the decreasing interest in studying chemistry in the 1990s. The path of a traditional chemist is relatively inflexible and typically ends with a PhD. With the introduction of Business Chemistry, the universities offered potential students a new career perspective, building competencies in two different research fields. Due to the two-sided education, students are more flexible in choosing their individual career path – by having the chance to end their study with a bachelor or master degree and directly enter the workforce.

In figure 1, an overview is given about the important milestones of the development of Business Chemistry. Starting with the introduction of the first course of study in the 1990s, followed by the restructuring from diploma to the bachelor/master program in 2000s and ending with the reaccreditation of the course in 2010s.

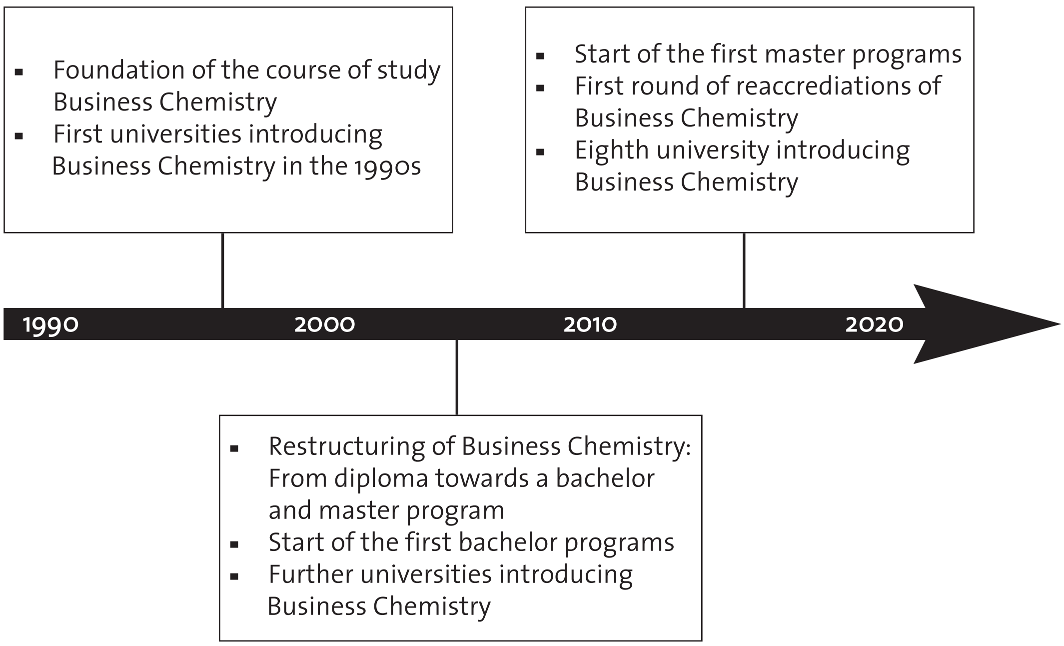
The article does not aim to present an overall picture of Business Chemistry, but it should provide our readers with different perspectives and understandings of Business Chemistry as a course of study at the respective universities. We invited persons from German and Swiss universities, who paved the way for implementing Business Chemistry, to comment on the benefits, challenges and chances of this implementation. The commentaries are presented in chronological order of the implementation – starting with Düsseldorf as one of the first institutes and ending with Regensburg recently introducing Business Chemistry as a course of study.

From Kaiserslautern to Düsseldorf

Prof. Dr. Walter Frank, Chair for Materials and Structural Research, Institute of Inorganic and Structural Research, Heinrich-Heine University in Düsseldorf

One topic of discussion from the Conference of Departments of Chemistry (KDC)[1] in the mid-1990s was the intensive examination of new concepts for specialization in the classical diploma program of chemistry. The result was the development of the Würzburger model (also referred to as 6+4 model), which offered a new specialization type of study by combining six terms of chemistry with

Figure 1 Milestones of the development of Business Chemistry as a course of study (source: own representation).



1 Association of Chemistry Departments from German Universities and technical universities, as well as the German Chemical Society (GDCh)

four terms of business economics – from then on called Business Chemistry.

First initiatives for developing programs according to the new concept of business chemistry started at the universities of Kaiserslautern, Düsseldorf, Münster, Clausthal (TU), Kiel and Ulm. Almost all of these places are still part of the list of universities with Business Chemistry programs today.

After intensive negotiations between the departments of chemistry and business engineering, highly complicated by the conditio sine qua non that a study program in business engineering with specialization in chemistry had to start at the same time, the first study program of Business Chemistry started in winter term 1997/98 at the University of Kaiserslautern (today Technical University of Kaiserslautern) according to the 6+4 model, with some higher-term students transferring from the diploma chemistry program. As the author, teaching at that time in Kaiserslautern, remembers well, a young lady from this small group of students received the first diploma in Business Chemistry ever and immediately found her way to a well-known chemical company in Ludwigshafen.

At that time, as a common project from the institute of organic and macromolecular chemistry and the faculty of business sciences, intensive preparations were made to introduce a new study program for business chemistry at the Heinrich Heine University in Düsseldorf, as well. In winter term 1999/2000 the new study program was introduced, welcoming a first group of about 30 first-term students with support of a well-known Düsseldorfer company.

Compared to the Business Chemistry programs of other universities, at the Heinrich Heine University, it has always, from the beginning of program development, been of great interest to achieve the best possible synthesis of the two important subjects, chemistry and business economics, from the first day of study on, and also to achieve a synthesis of the very different subject cultures, as well. This 'parallel combined model', which can be seen as an 'interface' between two disciplines, has gained growing popularity at Heine University since 1999. It was also prototypic for some other universities in further developing their business chemistry programs. Nowadays, the 'parallel combined model' in Düsseldorf combines a seven-term bachelor and a three-term master program, both in 'parallel mode'. The number of graduates is highly convincing and they have achieved a high level of recognition in chemical industry, but also in other commercial sectors. The Business Chemistry program in Düsseldorf has therefore already been a story of great success for 17 years now.

Münster: The next step

Prof. Dr. Jens Leker, Institute of Business Administration at the department chemistry and pharmacy and Chair for Business Chemistry, Westfälische Wilhelms-University in Münster

The idea to establish Business Chemistry as a subject at the University of Münster was born in 1998. The first discussions between the university and Degussa-Hüls AG, as an initiator and potential sponsor, led to the decision for implementation. Following these initial discussions, the “Professorship of business in natural science with focus on chemistry” was established as an endowed chair in 1999. Subsequently, the “Institute for business administration at the department of chemistry and pharmacy” was founded in 2000. The leadership of the institute is characterized by its professorship, which is primarily a member of the department of chemistry and pharmacy, but also, through a cooperation, has a secondary membership to the department of economics. The initial endowment was the basis for the foundation of the institute and therefore for the affiliation to the university’s budget. The institute had the responsibility to offer specific lectures for management qualifications in natural science courses as well as to design and supervise the course of study Business Chemistry from scratch.

As already mentioned in the previous commentaries, Business Chemistry can be designed in two ways – a parallel or a consecutive study program. In Münster, we offer a master course of study in business chemistry for students with a bachelor degree in natural science. This allows students, who initially started to study chemistry, a reorientation after their bachelor degree without losing their time and chemical knowledge. The master course Business Chemistry is designed to provide the students with an understanding of fundamental economic concepts as well as in-depth chemistry knowledge. Furthermore, knowledge and capabilities in the field of technology and innovation management are taught. By this approach, the business chemistry students are prepared for their future function as problem-mediator and -solver in research-intensive industries. The master degree in business chemistry is in most cases received following a practice-oriented master thesis about modern economic concepts for problem solving applied in the chemical and pharmaceutical industry. Moreover, the institute offers the possibility to do a PhD in this new interdisciplinary research field. Even though most of the students directly enter the workforce following the completion of their

M.Sc., 36 PhDs have successfully received their degree in the last 15 years, which further serves to promote Business Chemistry in the academic world.

Kiel's Business Chemistry model

Prof. Dr. Ulrich Lüning, Chair for Organic Chemistry, Otto Diels-Institute of Organic Chemistry, Christian-Albrechts-University zu Kiel

At the end 1990s, the Kiel diploma study program was reformed and the main study course was divided into two stages so that after the pre-diploma (four semesters), four half-semester modules had to be completed in the fifth and sixth semester. For the chemists, these modules were practical trainings in Inorganic, Organic and Physical Chemistry as well as an additional subject to be chosen by each student. For the newly designed study program Business Chemistry, nearly the same structure was used, but instead of the chosen subject in the last module, a chemical thesis is completed. In this manner, a six-semester basic chemistry study course corresponding to today's bachelor studies was completed. In the following four semesters, the prospective business chemists studied economic subjects and completed their business chemistry studies with their diploma thesis in the tenth semester.

Only after the pre-diploma did the students need to decide which degree they wanted to obtain, which was the main advantage of this system. Nearly all courses were completed together with the 'thoroughbred'-students of each subject by this successive structure of first studying six semesters of chemistry followed by four semesters of economic sciences. The business chemistry students' training level, professional discussion and language did not differ from those of the single subject students. But unfortunately, there were also disadvantages in these successive studies. When the students completed their studies, their last contact with chemistry was two years ago. Furthermore, the students had either contact to chemistry or to economic sciences . So they learned about both topics and their languages very well but not parallel at the same time.

When the change to the bachelor-/master-system had to take place, out of this struggle an opportunity was realized to alter the studies' structure. Now, the prospective business chemists study either together with chemists or the economists in their disciplines so they learn about their thinking and their language in close contact. But now, both studies happen in parallel, taking place at the same time. Thus, the students learn and practice from the beginning to deal with natural sciences as well as with business.

Where is the combining element? In the bachelor studies, there is a compulsory business internship which needs to last at least ten weeks. During this time, attention is paid to the presence of chemical- as well as business-related aspects. This internship is the reason for the bachelor studies' duration of seven semesters. In the master studies, chemical as well as economic topics are deepened. In the third master semester, in total the tenth semester, the six-month Master thesis is performed which is most usually completed in a chemical company. Hereby, knowledge which was gained in both disciplines is directly used for the studies' completion. Some graduates even get to know their first employer through their work in the economy.

After nearly twenty years of Business Chemistry in Kiel, the Business Chemistry study program has clearly found its place at the Christian-Albrechts-University. There is a high demand for this study program, which makes a Numerus clausus necessary. The graduates are requested in all parts of the chemical industry and in the related economy.

Business Chemistry in the field of tension within differentiating interests - a subject shapes itself

Prof. Dr. Jens Hartung, Chair of Organic Chemistry, Department of Organic Chemistry, Technical University of Kaiserslautern
Dr. Irina Kempter, Department of Organic Chemistry, Technical University of Kaiserslautern

Kaiserslautern, as the origin of Business Chemistry, went through a similar process compared to Kiel, with all the advantages and disadvantages mentioned above.

The Bologna-Reform offered the chance to enlarge the basis of the diploma Business Chemistry study program. Graduates of the bachelor chemistry study program could have gained further qualifications in the master Business Chemistry study program. Unfortunately, it was not possible to realize the required structures in practice. In 2013, two new study programs received the official seal of the Accreditation Council: a bachelor study program with specialization in economic sciences and a master study program 'Business Chemistry'.

In the bachelor study program, chemical issues and themes are predominant with a curriculum share of about 80%. The standards of the chemical education are orientated at the bachelor chemistry study program. The curriculum of economic sciences consists of the mandatory modules 'Basics of Business Administration', 'Basics of Accounting', and 'Financial Management'. In addition, there is a choice of four out of the following modules: Production, Marketing, Investments and Financing, Labor Organization, Strategic Management, Operations Research and Business Informatics. The teaching of the economic part covers 20% of the curriculum. By the introduction of newly designed integrated courses in chemistry, space for additional economic sciences courses could be created. The students gain analytical competencies within a lecture series, in which lecturers and professors from Physical Chemistry, Inorganic Chemistry and Organic Chemistry work together. In the further practical advanced education, the lecturers and tutors follow the same process with an Integrated Practical Synthesis training in which especially working techniques are emphasized and taught. The study structure leads to a more intensive combination of chemistry and economic sciences and clearly differentiates itself from the study program 'Business Engineer with specialization in chemistry'.

Graduates of the bachelor study programs ‚Chemistry with specialization in economic sciences' and 'Business Chemistry', if they come from other universities, have the opportunity to finish the four-semester master study program 'Business Chemistry' in order to choose an ambitious and challenging profession later on. The Departments of Chemistry and Economic Sciences share the same amount of course contents in the curriculum of the master study program. The students may choose their focus according to their preferences and their abilities. From the second semester on, the students get the opportunity to receive insights in professional fields at the interface between natural and economic sciences within research projects.

The study program's guiding principle, realizing intellectual added value by parallel confrontation with chemical and economic topics, supports the newly-designed module 'Business Chemistry', to which high-level industry representatives could be attracted. In the module 'Key Performance Indicators', the students learn to reflect and to realize natural science aspects of the active ingredients synthesis within an economic context. Therefore, company foundation, company development, investments and market domination are essential. 'Key Performance Indicators' represents an interactive innovative interface between the different specializations and offers the students an ambitious confrontation with possible professional fields.

A clearly structured study program was developed within the last two decades. By networking within the specialist group, a regular exchange with representatives from all other German and Swiss Business Chemistry locations takes place, ensuring standards which are much appreciated by the economy. In comparison to other universities the environment of the Technical University Kaiserslautern is highly appreciated by students and teachers.

Business Chemistry at University of Zurich: Fit for Chemical Industry Careers

Prof. Dr. Stefan Seeger, Chair of Physical Chemistry, Department of Chemistry, University of Zurich

The chemical and pharmaceutical industry is one of the key factors in the Swiss economy. In the perception of the Swiss population, the combination of chemistry and business is therefore a natural and highly valuable composition of disciplines. Major companies, e.g. Roche and Novartis are global players in the pharmaceutical business, while Clariant, Syngenta and Sika are examples of global market leaders in chemical industries, respectively. Furthermore, there are many large firms in the fine chemical industry and a high number of SMEs (small and medium-sized entreprises). The Swiss chemical and pharmaceutical industry is one of the most important segments in the Swiss economy.

The interdependency between different disciplines has grown enormously and is supposed to grow further and even faster. The industry has always faced tremendous changes and constantly will, e.g. due to the approaching "Industry 4.0" challenge. However, the labor force's background is largely the same as decades ago: Economical background is provided by business faculties of universities to business students, molecular science knowledge is given by faculties usually called "Faculties of Science" to chemistry students and other scientists, and practical knowledge is offered later in companies' advanced training courses. Besides updating the technical content of the programs, this principle is carved in stone in some cases until today. However, a program established in Switzerland exclusively at University of Zurich brings together disciplines for the first time, which is necessary for a successful execution of tasks in modern chemical and pharmaceutical companies.

The students experience the atmosphere in the business faculty together with the business students and in chemistry from the first day with their science colleagues. This concept enables them to communicate with chemists and business people during their studies and later in companies equally well. There are no linguistic or even psychological barriers. The bachelor program includes a bachelor thesis where the students work for the first time on a project at the interface of chemistry and business -guided by an experienced supervisor. This may include even an experimental laboratory component; however, this is not mandatory. Market studies, profitability calculations and similar tasks are typical. The Master program at University of Zürich includes 4 modules provided in close collaboration with chemical and pharmaceutical industry and is exclusively application oriented. Subjects are project management, intellectual property, marketing in chemical industry, emerging markets, logistics, and more. Further, the students collect credits by industrial internships and even the Master thesis is often performed in or in collaboration with companies. Using these instruments, the students experience the industrial world at an early stage during their university studies, learn the challenges they have to expect during their career and have the opportunity to build up a network beyond academic institutions.

Finally, the question remains, if this concept far from traditional university-based training withstands a proof in the real world. The answer is an explicit YES. The students enjoy the time at the university, and the industrial responsible persons love it as well: many companies have hired more than one of the graduates and value the program as a smart recipe of business and chemistry. And the chance to find a position in pharmaceutical, chemical and related industries or consulting business is very high: more than 80% of the graduates enter the final exam already with a signed labor contract in their pants pocket.

Application-orientated Business Chemistry – the model of the Fresenius University of Applied Science

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Prof. Dr. Leo Gros, university council, Fresenius University of Applied Science in Idstein
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The Fresenius University of Applied Science based in Idstein (Hesse) is the only University of Applied Science (HAW) in the German-speaking area which offers both a bachelor and a master study program for Business Chemistry. The focus of Business Chemistry is on the practical and application orientation. This is emphasized by the University's mission statement: 'Learning and researching with a practical orientation, living internationality, demanding and encouraging students'. With the introduction of the study program reform based on the Bologna Process and the conversion to the bachelor-master system, in 2008 the bachelor program and in 2013 the master program 'Business Chemistry' were developed.

The bachelor program is designed as a six-semester full-time study program (180 ECTS credit points) following a consecutive model. In the first four semesters, the students gain basic knowledge in chemistry, physics and mathematics. In the fifth semester, the students extend their qualification profiles with selected courses of economics and the addition of an application-orientated case study at the interface between chemistry and business administration. Since 2015, we perform this case study within the project Student2start-up in cooperation with the Wissensfabrik Deutschland e.V. (Think Tank Germany). The exchange with companies in practice is continued in the last semester when the students execute their own project at a cooperation partner from the chemical industry within their Bachelor Thesis.

An essential distinguishing feature of this study program in comparison to usual business engineer study programs as they are offered at universities is the program structure: chemistry and economic-related courses are not taught in parallel in the first semesters. In fact, the prospective business chemists spend the first two years together with the students of 'General Chemistry'. Two advantages are realized: by the full-time participation with natural sciences and chemistry, the students gain skills like pure chemists. Moreover, in the fourth semester they may decide if they want to continue in the eight-semester bachelor program 'General Chemistry' or if they want to choose the business-related courses in the fifth semester. Actually, several students make use of their opportunity to change the study program every year. Even some students of the study program 'General Chemistry' become business chemistry students in the fifth semester. Until the end of the fourth semester, the students have learned about the specifications and professional opportunities of both study programs and have exchanged experiences with students from higher semesters as well as alumni and professors and tutors.

The master study program is designed as a five-semester part-time study program (120 ECTS credit points). Since the focus is especially set at the business-related courses, the students get the opportunity to transpose their knowledge gained at university parallel to their professional activity in practice by the part-time structure.

We have gained several positive experiences with the study program 'Business Chemistry' in the last ten years. Since 20 student places at maximum are offered in the bachelor as well as in the master study program each year, the study groups are relatively small. Since about 70 per cent of the bachelor study program's graduates decide for a profession in the chemical industry after their completion and do not change to a consecutive full-time master study program, the summary for the bachelor study program is very positive up to now.

All students who finished the master study program decided for a professional career in the industry up to now. The Fresenius University of Applied Sciences does not offer a PhD after the successful completion of the Master Thesis.

In the future, we will further concentrate and sharpen the focus on practical and application orientation within the study program. We face a great challenge to sustain, support and improve the well-known chemical industry's innovation strength. In order to realize more start-ups in the chemical industry, more founders are necessary. Therefore, our goal is to educate students in chemistry and business administration , so that they are capable to see employment and entrepreneurship as two options for their life they can profoundly and consciously decide upon.

By combining the curriculum adjusted towards the entrepreneur and the program 'Idea2Business' we follow the aim to provide an enormous contribution to the foundations' dynamics out of the chemical industry and to realize more foundations.

Chemistry and Management at Ulm University – excitement about the future

Prof. Dr. Michael Hiete, Institute of Theoretical Chemistry and Chair of Business Chemistry, University of Ulm

Ulm University, which had its 50th anniversary last year, looks back at a history of more than 15 years in the consecutive program in chemistry and management. Founded in 2001 and supported with high enthusiasm over the years by Prof Gerhard Maas, the program steadily evolved and Ulm University has become, with more than 200 students, the second largest well-known site for these studies in Germany.

The spectrum of challenges and opportunities modern chemistry is faced with ranges from electrochemical energy conversion and storage to digitalization. Experts are needed to assess products and processes and to manage innovations. Therefore, knowledge and methods from both disciplines - chemistry and management - are necessary, as only a thorough understanding of the solutions chemistry can offer, combined with knowledge of assessment and planning methods, will allow successful management of processes, products, and companies.

The program in chemistry and management at Ulm University has strongly evolved over the past years, especially with the latest major reform dating from 2017. Surprisingly, each reform strengthened the role of management science in the program. As students starting their studies often do so without having a complete overlook of their choice of study program and are torn between starting a program in pure chemistry or in chemistry and management, the reform of 2017 offers to set foci in the last year of the bachelor program with varying shares of chemistry and management. This allows students, for example, to focus on topics at the interface between chemistry and management but also alternatively on chemistry, offering them the possibility to continue in the master program with chemistry. In addition, it has become also possible to integrate courses in chemical engineering. Set in stone, however, is the idea of starting with courses in both chemistry and management already in the first semester as this is thought to foster the thinking and understanding in and familiarity with the two disciplines right from the beginning.

A pivotal change for chemistry and management at Ulm University came along with the appointment of a professor for Business Chemistry in 2016, making Ulm University besides University of Münster the second university with a professorship specifically dedicated to chemistry and management. This appointment not only enriched the range of topics in research and education, it also allows a better integration of the two disciplines which in the past existed side by side demanding high integration efforts from the students. It is our hope that courses supporting interlinked thinking and dealing with problems at the interface stimulate and motivate students. The new professorship also enriched research and teaching by bringing in new areas, for example operations and especially sustainability management. In the past, chemistry was often associated with negative attributes, but today chemistry must be seen as key for a number of sustainable development goals addressed inter alia in sustainable chemistry. Sustainability has become a must-have for companies.

Motives for studying chemistry and management differ, but our experience shows that students appreciate not only excellent job opportunities and the challenge to work at the interface between two worlds, but also some more obvious advantages; for example, that a PhD is - unlike in chemistry - not regarded as compulsory. We observe also other differences such as the fact that students in chemistry and management tend to prefer chemical sub-disciplines for their bachelor theses without typical lab work and often go abroad for their internships in industry.

Though rewarding, interlinking the two disciplines remains demanding. At Ulm University, the new situation created an enormous atmosphere of departure also reflected by many activities of the students. Summing up, Ulm University's chemistry and management program has grown and looks with optimism to the future. It is now time for the students to build more self-confidence from related disciplines such as business and industrial engineering.

Bachelor Business Chemistry in Regensburg: Expansion towards the South-East of the Country

Prof. Dr. Joachim Wegener, Institute of Analytic Chemistry, Chemo- and Bio-Sensors, Faculty of chemistry and pharmacy, University of Regensburg
Dr. Claudia Wanninger-Weiß, Faculty of chemistry and pharmacy, University of Regensburg

The University of Regensburg has been celebrating its 50th anniversary in 2017 and is proud of having grown to a total of 21,000 students over the years. The Faculty of Economics was one of the founding faculties, whereas chemistry, as part of the Faculty of Natural Sciences, joined one year later. Nowadays, chemistry and economics host about 4,000 students in several study programs covering bachelor's, master's and teaching degrees. Just in time for the anniversary, the two faculties decided to team up and develop a study program together. This decision was motivated by two reasons: (i) the growing interest of chemistry students in extra education in business administration as a side dish to their main course chemistry and (ii) our understanding that many students with an interest in chemistry do not intend to follow a strictly scientific path, but want to prepare themselves for a career in the chemical industry. Following the initiatives of other universities across the country, the BSc Business Chemistry at the University of Regensburg was born and started in the current winter term 2017/2018 with 50 students - one for every year of the university's existence. We certainly hope that the number of students will never fall behind the age of the university in the future.

The number of students in this first round of BSc Business Chemistry in Regensburg was surprisingly high given the fact that the time for advertising and marketing the new study program was just a few months. But it confirmed our notion that there is a considerable demand for this kind of interdisciplinary and tailored education in particular as no other university in Bavaria or the eastern side of Germany provides a similar offer. So far, there is no indication that this extra study program has led to cannibalism with respect to other chemistry programs as the number of enrolled students in those programs remained stable. The years to come will prove this right or wrong. Study programs in business administration are overbooked anyway in Regensburg as in most universities nationwide.

The curriculum of the BSc Business Chemistry is organized such that chemistry and business administration are taught in parallel from the first semester with special emphasis on business chemistry towards the end. The final connecting part of the curriculum is covered by colleagues from industry, who will share their experience and daily routines with our students. Moreover, the curriculum BSc Business Chemistry is designed such that students who recognize their true passion or a particular talent for straight chemistry or business administration along the way will get a chance to continue their bachelor's studies by entering the MSc Chemistry or the MSc Business Administration programs after fulfilling some extra requirements. It was our intention to make the study program as permeable as possible to all sides without relaxing academic standards.

Currently, we have very little experience with this new study program but we are very optimistic that the BSc Business Chemistry and the subsequent master's program will be attractive to young people with an interest in science and economics who are seeking a tailored education at the interface of the two disciplines.

Commentary
Motivation for innovations - experiences and reflections

Erhard Meyer-Galow*

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Motivation is a vital part of success in the chemical industry. Besides having the right knowledge and skills at hand to bring innovations on its way, there are plenty of other supporting characteristics like intuition and enthusiasm, persistence and assertiveness, integrity and team spirit as well as great commitment and entrepreneurial thinking. This statement is strengthen in the article by presenting the prize-winning innovators of the Meyer-Galow-Prize and what is needed to become a pioneer in the chemical industry.

1 Introduction

Innovations are vital for companies. They are the energy for preservation and value enhancement. Without innovation, companies approach their end. That is why almost all companies deal with the question: "How can innovation be stimulated?”

According to the second principle of thermodynamics, entropy in closed systems goes against infinity . Now, companies are open systems . They can remain in equilibrium or steady state by internal and external influences, i.e. innovations (Meyer-Galow 2017). Almost all companies try to achieve more innovations by increasing their research expenditures and efforts in the rational space of thinking, because we are conditioned to do so. The successes are often disappointing and limited because our rational thinking, which is limited to knowing, doing, managing, achieving and performing, can only lead to new ideas to a limited extent. Intuitions and inspirations are neglected as sources for new things. Mindfulness, compassion and inner growth is always a prerequisite for drawing from these sources. Intuition comes from "intueri lat.", which means "to turn inwards", for example through meditation. For this reason, this article is intended to point out the way to more intuition and inspiration as a path to more innovations[1].

In the years up to 2017, in the industry the conviction has grown that by practicing mindfulness and compassion, spaces for creativity can be created. Pioneers are the companies of the New Economy such as Google et.al.[2]. An initial spark for this movement was the book Wisdom 2.0 by Soren Gordhamer (Gordhamer 2013). Since then, conferences with this mindfulness theme have become increasingly popular. The author himself participated in the conference "Wisdom 2.0 Europe" 2014 at Google's headquarters in Dublin/Ireland and in the conference "Living with awareness, wisdom and compassion--The Power of Transformation" in San Francisco/USA in February 2018. Beside the advantage of gaining new impressions, the author furthermore received the confirmation of his own experiences and reflections. Wisdom 2.0 2018 was the premiere gathering focused on exploring the intersection of wisdom and technology with 3000 people, 30 countries and over 50 speakers.

To support the motivation for more innovations the author founded in 2012 the Meyer-Galow-Foundation for Business Chemistry, which annually awards the Meyer-Galow-Prize for Business Chemistry.

1 The author has already given a groundbreaking lecture at the Science Forum of the GDCh (Gesellschaft Deutscher Chemiker-German Chemical Society) in Bremen 2011 on the topic: "Inspirational intuition and creativity in science - we experience more than we know".
2 New economy definition: the postindustrial world economy based on internet trading and advanced technology

For a summary of the essential see box 1 :

Box 1: Meyer-Galow-Prize for Business Chemistry.

Meyer-Galow-Prize for Business Chemistry

The Foundation

In his professional life, Professor Dr. Erhard Meyer-Galow has mainly worked at the interface between chemistry and the economy. For this reason, business chemistry was and still is a central theme in his professional work.

In order to further promote business chemistry, particularly from the point of view of sustainability and the necessity of chemical products or processes of high value for our society, he founded the

"Meyer-Galow-Foundation for Business Chemistry“,

whose task is the annual awarding of the

"Meyer-Galow-Prize for Business Chemistry.“

The foundation is administered by the GDCh in accordance with the resolution of the Executive Board of the Gesellschaft Deutscher Chemiker e. V. (German Chemical Society) dated March 5, 2012. Contributions are possible and welcome.

The Board of Trustees

The work for fulfilling the foundation's purpose is carried out by an advisory board. If possible, this board of trustees should be represented alongside the founder and consists of:

- the Association of Business Chemistry (VCW) in the GDCh
- Representatives of the industry on the GDCh Executive Board
- a university teacher for business chemistry

The Prize

It is awarded to a prizewinner who has successfully launched a current innovation of chemistry in the German-speaking world - either alone or with a team. It can be a product or a process. The invention that is brought to innovation can, but does not necessarily have to, come from him or her. However, he should be the driving force for implementation in the market.

The prizewinner proves to be worthy, in particular, if he or she

- has introduced an innovation to the market that takes sustainability into account to a large extent,
- has introduced an innovation to the market that represents a special necessary value for society ("must have" and not "nice to have"!).
- is a mature personality and enjoys a high degree of human esteem among employees, colleagues, superiors and all business partners. His or her management style is characterized by a particularly high degree of empathy.

The prize is endowed with 10,000 euros.

2 Prize-winning Innovators

The innovators, who won the Meyer-Galow-Prize for Business Chemistry until 2017, and their awarded innovations are presented in table 1.

Table 1: Prize-winning Innovators.

Date	Innovator	Company	Innovation
3/2013	Susanne Röhring	Bayer Healthcare AG, Wuppertal/Germany	▪ significant contribution to the discovery, synthesis, clinical trial and market launch of the new oral anticoagulant rivaroxaban, brand name Xarelto® ▪ focussing on the essentials, intuition and enthusiasm, perseverance and assertiveness, integrity and the ability to work in a team characterize the prize-winner
2/2014	Thomas Greindl, Vice President Global Development Home Care & Formulation Technologies	BASF SE, Ludwigshafen/ Germany	▪ contribution to the innovation of sustainable products in the field of readily biodegradable complexing agents and surfactants ▪ in particular methylglycine diacetic acid, which he discovered and accompanied with great commitment and entrepreneurial thinking through all stages of development to the successful market launch
11/2014	Michael Heckmeier, Senior Vice President Liquid Crystals Research&Development	Merck KGaA, Darmstadt/Germany	▪ successful introduction of the liquid crystal technologies FFS and UB-FFS. which are produced using complex organic syntheses. ▪ successful synchronization of this longer-term chemistry with new customer specifications and short development times
11/2014	Harald Hirschmann, Associate Director Physics Research	Merck KGaA, Darmstadt/Germany	▪ special contribution of Merck physical research to the development of energy-efficient liquid crystals for smartphones and tablets ▪ new compounds were developed that meet the high customer requirements for switching time and stability
11/2014	Roman Maisch, Senior Vice President, Marketing & Sales	Merck KGaA, Darmstadt/Germany	▪ organization of a team that developed innovative product concepts for the liquid crystal technologies FFS and UB-FFS according to customer requirements ▪ effective conviction of customers that Merck should be the preferred development partner for their desired new applications
11/2014	Sang-Kyu Lee, Technical Marketing Manager	Merck KGaA, Darmstadt/Germany	▪ leadership of a global and interdisciplinary team of Merck that successfully supported FFS technology from product development to market launch ▪ responsible for connection and communications between customers in Asia and Merck in Darmstadt, Germany.

Table 1: Prize-winning Innovators (continued).

Date	Innovator	Company	Innovation
12/2015	Andreas Lutz, Associate R&D Director	DOW Automotive Adhesives, Horgen/Switzerland	▪ effective leadership of research ▪ research work in the field of structural adhesives enabling permanent and efficient joining of composite materials for the usage in particular for the implementation of innovative body concepts in automotive engineering
12/2015	Stefan Schmatloch, R&D Manager	DOW Automotive Adhesives, Horgen/Switzerland	▪ development of outstanding customer-specific solutions ▪ achievements in the field of structural adhesives enabling permanent and efficient joining of composite materials ba the usage in particular for the implementation of innovative body concepts in automotive engineering
11/2016	Thorsten Bartels, Director Performance Testing Oil Additives	EVONIK INDUSTRIES AG, Darmstadt/Germany	▪ research work in the field of fuel-saving lubricant additives ▪ realization of the production of high-performance lubricants that contribute significantly to the reduction of global carbon dioxide emissions with the help of newly developed innovative polymer architectures ▪ development and execution of the tests to evaluate the fuel-saving potential of the new additives
11/2016	Boris Eisenberg, Global Product Manager Engine Oils	EVONIK INDUSTRIES AG, Darmstadt/Germany	▪ efforts to build up an extensive product portfolio for engine oils
11/2016	Klaus Schimossek, Director Global Product Development Oil Additives	EVONIK INDUSTRIES AG, Darmstadt/Germany	▪ achievements in the development of new polymer architectures
11/2016	Torsten Stöhr, Director Strategy & Projects Oil Additives	EVONIK INDUSTRIES AG, Darmstadt/Germany	▪ special achievement in the global marketing of the new additives
11/2017	Markus Heitzmann, Drug Substance Project Leader	Boehringer Ingelheim Pharma GmbH&Co. KG, Launch&Transfer	▪ orchestration of the complex launch and transfer activities for the active ingredient Empagliflozine ▪ services to the development of a market-oriented supply for the active ingredient Empagliflozine, a novel oral antidiabetic with cardioprotective benefits helping people with Type- 2- Diabetes and cardiovascular pre-existing disease to significantly improve prognosis and reduce the risk of mortality

3 Experiences

If you filter out the skills and characteristics of the prize winners[3], you will find the following descriptions:

Focusing on the essentials, intuition and enthusiasm, persistence and assertiveness, integrity and team spirit, great commitment and entrepreneurial thinking at all stages of development through to successful market introduction, development of outstanding customer-specific solutions, orchestration of complex launch and transfer activities.

The presented research projects took up to 10 years to become successful innovations. Without enthusiasm and perseverance, it is impossible. With great discipline and diligence, the prizewinners did not let themselves be deterred from the course, even if the company did not see the project positively or even decided to end it. They just kept going. Creativity needs a corporate culture free of anxiety, but such a culture does not always exist. Successful innovators, however, cannot be stopped despite a detrimental corporate culture. They are self-confident and fearless. They do not know the fear of failure. They have acquired a high degree of resilience in their lives. The innovators demonstrate high rational thinking ability and the ability to associate knowledge with information.

Some are on a spiritual path or have had deep psychological experiences. Some are religious persons. Others take their dreams as a source very seriously.

Intuition and inspiration also play a role, but the innovators often do not consciously recognize it. Suddenly an intuition inspires them to innovate. It is not often intended to increase the flow of intuition because methods for doing so are often not known. As a consequence, it is possible to have only a few intuitions, but also possible to have more. For this reason, the following chapter describes my own experiences and reflections on how to prepare oneself to receive intuitions through internal growth and thus achieve more innovation.
Three innovators report that ideas come into play especially often in long warm showers; others experience intuition in nature; or in music; or in conversation; or on the beach during vacation ....

4 Reflections

I like to talk about the small and large "innovation funnel". Most people work with the small funnel, which contains our knowledge, our ability to think, our previous experiences, our emotions, our ability to associate, our intellect. With these tools, we try to come up with new ideas. Few intuitions flow into the small funnel, and only a few of them become inspirations that can lead to inventions, of which only a few lead to innovations. Put simply, the small innovation funnel does not catch enough intuition. You can change that. The funnel is widened when the conditions are created to develop the ability to receive more intuitions and inspirations. With inspiration I mean an inhaled intuition. If we do not inhale the intuition, to make it our own, we easily forget it.

How can this be achieved?

The thinking power of our ego-mind helps us only to a limited extent[4]. Intuition, however, offers us an inexhaustible additional reservoir and only in the equal development of our logos and our intuition as well as in the combination of both sources can we fully exploit our human potential[5].

Experience has shown that this is only possible if one creates the preconditions for intuition to flow with a certain lack of intention. That sounds very contradictory to us. But there is no other way. Only if we do not make an effort, do we experience intuition. I am aware that I am now trying to explain a little rationally that it is not rational, but can only be experienced. Well, how can you explain creativity that is not scientific to scientists? If I do this nevertheless, I try to arouse the longing to walk on a path of experience and to practice yourself daily for openness and transparence, without which the intuition cannot be experienced.

Well, I have prominent help (see box 2).

We always try to increase our ability to think, because we are trained in this way. We want to manage innovations better. Innovation management is on everyone's lips. But managing is always doing. It does not lead to many more ideas. Innovation management may make it easier to implement an invention in the marketplace, although it takes a lot of intuition to do so. But how do you get more inventions? By doing so, we could increase our creativity to an unimaginable extent.

We have often had imaginations and intuitions or inspirations, otherwise our research results would not have been possible. We have never asked ourselves where these ideas come from. Imaginations.....What came to mind from where and when? And why is that? What has been submitted to us when and by whom? Who or what is that which

3 In order to make a well-founded decision for the prize, I did not only get to know the prizewinners for a whole day on site, but I also met at least 4 applicants per year in each annual competition or 24 nominees in total since 2013
4 Ego-mind is our thinking capacity limited by our ego-consciousness
5 Logos is the rational principle that governs and develops the universe

Box 2: Prominent quotations.

Albert Einstein: "The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift."

Alexander von Humboldt: "Everywhere an early anticipating precedes knowledge."

Rupert Sheldrake: "Modern people, especially in Europe and the USA, are disaffected by the belief in such things as intuition. There is a prejudice against this form in our intellectual society. It is considered irrational and superstitious."

Hans Peter Dürr: "Everyone has intuition, but he doesn't know where it comes from. Intuition simply means that something comes from within from which the thoughts develop. Every creative scientist depends on intuition."

gives us an idea?

We have also often had "flashes of inspiration". Are those lightning bolts of our ego-mind? We are subject to a fallacy on the question of where the lightning comes from: from our mind or from the spirit. But neither is wholly true. We sometimes say "gut feeling" in relation to intuition. Intuition obviously comes from the stomach rather than the head. We could create the conditions with a mindful and meditative life that dissolves the one-sided outward orientation of our lives and leads to inner growth.

"Coincidence meets only a prepared mind and spirit," says Louis Pasteur.

Mind, reason and rational thinking have been the basis of the material world view since Rene Descartes said: "Cogito, ergo sum!" We define ourselves by our thinking. This, however, unconsciously restricts us again.

Gerd Binnig gets to the point:
"Logic alone can't get you anywhere. Life is far too complex. There's only one way. You have to follow intuition. It can help us in the complex world because it is so complex itself. We see in today's world that the overload is obvious. Individuals can't do it. There should be something like the intuition of an entire society."

Man never has time today. You could say: "He's always occupied!" He is flooded with noise. But for intuition you need silence, peace and time. We must move from the "Doing" Level to the "Being" Level. However, we are constantly disturbed in our world by our own diverse activities and by those of our fellow human beings, torn out of silence and calm. This is tragic and often limits our potential without us noticing it.

The daily task of meditation is to practice mindfulness, to walk mindfully throughout the day. Mindfulness is the gate through which man has to pass again and again. The practicing person can also practice mindfulness in the hectic pace of everyday life; the untrained person cannot. It is about practicing a mindful life, moment by moment, step by step. Then one becomes ever more present for the moment of the Here and Now (Tolle 2011). This Being in the Here and Now is the prerequisite for opening up to the flow of intuition.

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Commentary
The road ahead: Digitalization fuels innovation

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Today, chemical companies are facing an increasingly challenging environment. Markets require more holistic solutions instead of focus being solely on the development of new molecules or products. Climate change, resource scarcity, technological advances, and rising customer expectations are forcing chemical companies to adjust to new realities, with the result that many are restructuring, increasing customer focus, and, perhaps most importantly, creating distinctive capabilities that will provide a competitive advantage. These challenges, however, also offer new opportunities for growth. According to a survey by PwC, 71% of CEOs in the chemical industry believe there are more opportunities than there were three years ago, indicating that they are expecting – and gearing up for – a high pace of change.

There has been much discussion about the so-called digitally-based Fourth Industrial Revolution. With the advent of mobile super-computing, artificial intelligence, genetic and neuro-technology, dramatic change is taking place at unprecedented speed. The chemical industry is undoubtedly an important enabler of this revolution, since its contributions in the way of new chemicals, advanced materials or bio-based products to many other industries is often the starting point for developing innovative, high performance product solutions.

Sustainability issues like resource efficiency, waste avoidance, renewable energy and the circular economy, driven by dwindling resources, a growing population and a more aware middle class, are becoming increasingly important. This development requires a paradigm shift in how chemical companies operate. The traditional, incremental approaches to change no longer enable the industry to achieve time-related and technical goals due to increasing regulation, political targets, public opinion and the pace of technological development. These new requirements necessitate more holistic approaches along the whole value chain, extending beyond sectorial or geographic borders. Cooperation between international and interdisciplinary teams will be vital and might even include publicly funded consortia. Today, chemical companies operate in a tightly interconnected ecosystem of various partnerships, including academia, technology providers, start-up companies, suppliers and customers. This ecosystem of collaboration will become even more critical in developing innovative, holistic solutions in the future. Chemical companies must foster flexibility in order to complement internal capabilities with external ones. Chemical Boards and top management teams also need to overcome concerns about intellectual property, data ownership and confidentiality in order to avail the full potential of ecosystem of collaboration. This current ecosystem will increasingly lose its perceived linearity along the product value chain and will comprise a rising network of companies, countries, governments, industrial clusters, financial institutions, delivery infrastructures, logistics and information technology. Digitalization will be the glue that holds this and other ecosystems together.

Although the chemical industry might not be top of mind when the influence of digitalization is discussed, it will fundamentally alter the way it operates. The global chemical industry has reached a crossroads and the catalyst is Big Data and next generation analytics, which will impact everything from innovation and manufacturing to pricing and marketing. This change should be accepted by the industry as transformational.

Historically, chemical companies have been slow to adopt and implement the latest technologies, preferring to focus on core operational and financial improvements such as optimization of assets and yields, operational efficiency and productivity, rather than disruptive ones.

Now, however, with Big Data, real-time analytics and modelling, many chemical companies are starting to develop highly innovative holistic solutions, witnessing a new dawn of collaboration and integration across silos of all manner of internal departments and external partners. One of the most significant impacts will be how Big Data will enable companies to transform from being organizations that react to changing market demands to ones that anticipate change and help to create it. In chemical research and development, high-end technology and digitalization – including miniaturization, automation with robots and high-throughput experimentation – will create vast experimental data on a 24/7 basis. The connectivity between people and machines will increase, and there will be a transition from experimental design based on human expertise and creativity towards "in silico " predictions, analysis of data by artificial intelligence and new working hypothesis provided by cognitive systems. It will allow the identification of correlations between parameters not necessarily supported by scientific data, but rather based on the unlocked hidden information in data from customers, suppliers and other partners, which are all connected and enable real-time design of new solutions. According to the consulting firm KPMG, the traditional three pillars of a modern business — people, process and technology — should be increased to five with the addition of data and analytics.

These two new pillars will give rise to new types of job profiles and experts sought. Data scientists, digital project engineers, specialists across digital manufacturing, risk security, cloud architecture & infrastructure, control networks (SCADA), robotics and Progressive Web applications are only few examples of job positions currently offered in the chemical industry and other industries. To advance the skills needed in the chemical sector, a combination of recruiting fresh talent from outside the industry - including digitally savvy professionals - as well as recent graduates, plus updating the skills for operational staff already within the industry by targeted training on the job, special coaching and focused assignments to interdisciplinary project teams, is required. Failing to recognise the need to hire cutting edge, technology-relevant talent and benignly ignoring to promote the skills of an existing workforce are the most common pitfalls in unsuccessful transformations. In any industry, people are the most important assets, and when it comes to implementing digital transformation strategies, people are even more important. The trepidation in the chemical sector is that the skills required for this new digital age differ immensely from what has long been the traditional skillset - and they often reside with a younger generation. The required skillset of employees in the chemical industry differs, indeed. However, the traditional skillset with its basis in a sound education in chemistry or engineering sciences will still be indispensable.

Millennials dislike rigid corporate structures and want open collaboration rather than a siloed approached to working. They view the workplace as being built around tasks and projects where teams may have no formal leader, instead leaving decision making to whoever has the relevant expertise, rather than top-down decision making. From a "softer" employment perspective, the power of the chemical employer brand shouldn't be underestimated. In a study undertaken by Cone, a staggering 76% of digitally savvy millennials surveyed were seeking employers with corporate social responsibility (CSR) values that matched their own. As Bob Dudley, CEO of oil and gas major BP and a key representative of the process industry, commented: "The millennial generation don't just want career growth, they also expect to make a positive contribution to society." Therefore, it has become important for major chemical companies to communicate to millennials about how their transformational strategies will lead to a cleaner environment and innovative health solutions.

According to a study by MIT Sloan Management and Deloitte, there is some evidence to suggest that digitally maturing organizations have cultures which actively motivate employees to engage in efforts to encourage risk taking, agility, and collaboration. And, in the survey referenced earlier, Deloitte's research shows that digital technology is likely to contribute to fostering a culture where innovation is promoted.

Organizational agility and fluidity in teamworking and the ability to innovate in a rapid, iterative, "fail-fast", test-and-learn approach is seen as the way forward, rather than the old test-to-destruction method, with cascading layers of approvals.

As a case in point, Clariant, as a leading specialty chemicals company, has already made significant efforts in terms of breaking down traditional constructs, silos, old ways of working and existing structures – some of which are now part of daily work life and others as experimental tools aimed at deriving at new solutions. Interdisciplinary teams are now an integral part of our approach. Our research and development is based on four technology platforms working closely together with the business units, serving the broad range of Clariant's target market and industries. Methods incorporated, such as 'agile working', 'Design Thinking' or 'hackathons', are well understood and already established in other industry sectors - especially within IT. While our employees may originally come from more hierarchical and organizational level organizations, the key hiring prerequisite now is the right mindset in terms of openness to new ways of working together – both with internal and external partners. Cooperation within and among interdisciplinary teams and the ability to embrace different opinions will undoubtedly result in the best possible solutions.

In summary, the challenges faced by the chemicals industry are not about re-inventing chemistry. Chemistry is, and always be will be, a key and very versatile enabler for tackling future challenges across a multitude of industry sectors. The more important issue is about maximizing the synergies that chemistry has within any productive ecosystem, in conjunction with other relevant and productive disciplines. Beyond product and process innovation, this includes service and business model innovation, with digitalization driving those developments and tremendously speeding up the process.

Such demands need to be reflected in the scientific education of tomorrow's employees. Required excellence across both basic and expert knowledge - chemistry, catalysis, biotechnology, process technology and engineering science - needs to be progressed through advanced mathematical teaching methods combined with informatics. Systemic thinking and data analysis are competencies that, together with basic knowledge in economics, will complement the traditional disciplines. The establishment of interdisciplinary projects linking the boundaries of chemistry, biochemistry and physics with digital technologies can foster confidence to explore beyond one's own comfort zone and begin to act as heterogeneous teams. In this regard, the intensification of fundamental and applied science in close collaboration with the industry is of particular importance in order to be well trained for the future career challenges in the chemical industry.

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Practitioner's Section
Quo vadis Business Chemistry?

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For students of the interdisciplinary study program Business Chemistry, it seems challenging to identify career opportunities that fit their particular expertise, meaning a combination of both the chemistry and business world. This contribution's goal is to observe and describe the status-quo of Business Chemistry in the DACH-region. In an online survey, 112 employed or self-employed graduates of Business Chemistry were asked about their qualification acquired during their studies and their first working positions. The results showed that most graduates did internships and studied abroad before starting their first job. Over half of the graduates stated to have found a first job after graduation within less than four months. Half of them started working in the chemical industry, the other half in related industries. They entered in various functions ranging from accounting to sustainability management. These results serve as orientation for students, employers and universities when evaluating qualification and potential career opportunities of Business Chemistry graduates.

1 Introduction

What happens after a student tells someone that he or she studies Business Chemistry? Nearly everyone who studies or studied Business Chemistry at some point experienced this reaction: The other person asks: "What is Business Chemistry and where will you end up working?"

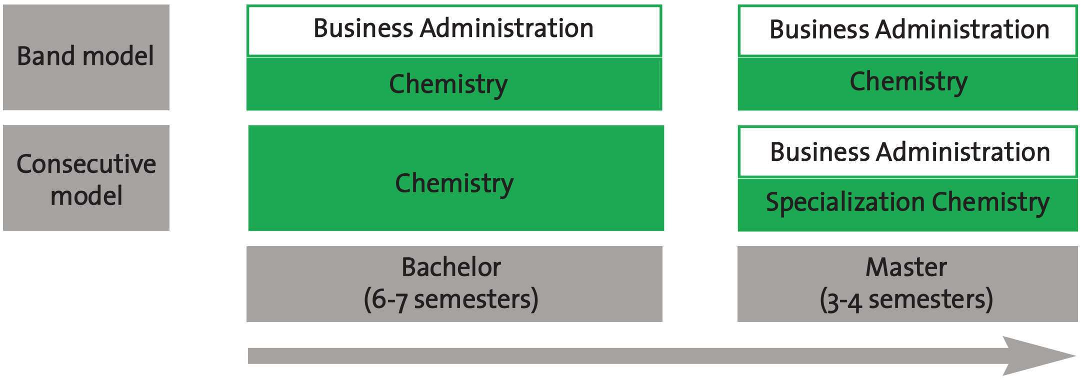
Business Chemistry (German: Wirtschaftschemie) is an innovative study program which combines business skills and science competences. The interdisciplinary aspect is the main goal of the study program and fits the gap between market and sciences in the chemical and related industries. Although the possibility to study Business Chemistry started in the 90s, no universal definition of Business Chemistry can be found online or in books.

The study program Business Chemistry is offered at the following universities: Christian-Albrechts-Universität zu Kiel, Heinrich Heine Universität Düsseldorf, Hochschule Fresenius Idstein, Technische Universität Kaiserlautern, Technische Universität München, Universiteit Leiden (NL), Universität Ulm, Universität Zürich (CH), and Westfälische Wilhelms-Universität Münster. The program may be called differently but it always combines chemistry and business studies. There are different models depending on each university (see figure 1). Some of them offer the band model where chemistry and business studies are taught at the same time. Others offer a consecutive approach where the focus during the Bachelor is on chemistry and the Master focuses on business studies and a specialization in chemistry.[1]

Competences, sectors, and functions of chemists as well as of graduates with business background are broadly known; but how can this be translated to the working environment of a business chemist? The combination of the two worlds is a typical problem young business chemists face when applying for jobs and trying to prove to an employer the advantages of their education and background. The employer faces this problem from a different angle: Even if the employer has heard about business chemists before, in which functions could their interdisciplinary skills be applied?

1 A comparison between the programs from different universities will be soon available on www.juwichem.de.

Figure 1 Schematic comparison of band and consecutive model of Business Chemistry. Based on GDCh, 2018.



As Junge WirtschaftschemikerInnen (*JuWiChem*[2] - Young Business Chemists), we want to shed light on this area. We built a network of students and graduates with interest in the two fields of chemistry and business, which aims at representing the interest of students and graduates within the *VCW*[3]. Additionally, we want to demonstrate the broad possibilities with regard to jobs and further education for our target group and strengthen the positioning of Business Chemistry programs within the DACH[4] -region.

In order to do so, this article is one of the first steps to give an overview about common qualifications of business chemists and the positions in which they are employed after finishing their studies. The positions in which business chemists could work are only barely mentioned on some websites of the universities offering a Business Chemistry program.[5] Beyond these websites, there is no data available. Hence, *JuWiChem* have decided to investigate: What does the career of a business chemist look like? To be more precise:

- Which additional qualifications of a Business Chemistry education are common and how are they achieved?
- How and where do business chemists start their first job?
- Which elements of education are relevant for daily working life?

The research design and the methodology are presented in chapter 2. The target group as well as the set-up of the conducted online survey are outlined. Chapter 3 introduces the results of the survey, divided with respect to the three guiding questions. Chapter 4 discusses the results. Finally, chapter 5 presents the conclusions and reflects on limitations.

2 Research design and methodology

The basis of the investigation is an online survey conducted among the broader *JuWiChem* network. In this article we only consider participants who shared information about their education and their first job after graduating.[6] In order to answer the guiding questions, a survey questionnaire was developed. As there is little research conducted in this field, a descriptive design was chosen. The target group of this survey were students and graduates of Business Chemistry and practicing business chemists independent of their education. As the program Business Chemistry exists at universities of the DACH-region, the questions were posed in German. Participants were contacted through the network of the *VCW* and of our cooperation partners *Gesellschaft Düsseldorfer Wirtschaftschemiker e.V.*, *WiChem Forum Zürich*, *WiChem Kiel e.V.*, *Wirtschaftschemiker der Universität Münster e.V.*, and social media such as Facebook, Xing, and LinkedIn.

The survey consists of three parts: general questions, questions pertaining to the period of education, and questions pertaining to the period of work. The education part focused especially on experi-

2 JuWiChem belongs to the VCW (Vereinigung für Chemie und Wirtschaft). Changes within the member's structure showed that especially the position of students and graduates within the VCW is underrepresented. In order to strengthen their voice within the VCW, JuWiChem was founded in 2015.
3 The VCW is a working group within the GDCh (Gesellschaft Deutscher Chemiker). The GDCh has members from academe, education, industry and other areas and supports chemistry in teaching, research and application and promotes the understanding of chemistry in the public domain.
4 DACH-Region includes Germany (D), Austria (A) and Switzerland (CH).
5 https://www.studium.uni-kiel.de/de/studienangebot/studienfaecher/wirtschaftschemie-ba, http://www.uni-muenster.de/Chemie/studium/wirtschaftschemie/mscwirtschaftschemie.html, http://www.uni-duesseldorf.de/home/studium-und-lehre-an-der-hhu/studium/alle-studiengaenge-von-a-z/studiengang-informationen/studiengaenge/wirtschaftschemie-1.html
6 Although the survey also considered current students this article focuses on graduates and their career experience.

ences abroad and professional experiences, e.g. internships. For the work part, we focused on the first jobs and the involvement as business chemist. Open and closed questions of qualitative and quantitative nature were asked.

The survey results were quantitatively analyzed using MS Excel. The definition of business chemists is based on the understanding of *JuWiChem* and narrowed down to a focus group. In the next chapter the results will be presented.

3 Results

Out of the 213 participants of the survey, 117 studied Business Chemistry (see figure 2). Graduates from other disciplines, e.g. chemistry, also consider themselves as business chemists based on their work activity. For this article, we only consider a focus group of 130 participants who graduated in Business Chemistry (either a B.Sc. or a M.Sc. degree[7]), in a combination of chemistry and Business Chemistry as well as in industrial engineering with focus on chemistry (Wirtschaftsingenieurwesen mit Schwerpunkt Chemie).

Figure 3 shows that from these 130 participants three participants were on job search at the time of the survey and 15 were doing their PhD. For this article a PhD is regarded as additional education, not as a first job. Therefore, only the answers of 112 industry employed or self-employed business chemists are taken into consideration.

In the DACH-region, 79% of the business chemists that participated in this survey graduated with a Master of Science from various universities. 17% of the graduates left university with a PhD and the remaining 4% with a Bachelor of Science. The universities that the participants attended include Chemieschule Fresenius Wiesbaden, Christian-Albrechts-Universität zu Kiel, FernUni Hagen, Heinrich Heine Universität Düsseldorf, Hochschule Fresenius Idstein, Technische Universität Kaiserlautern, Technische Universität Berlin, Universität

Figure 2 Distribution of programs studied by participants (n=213).

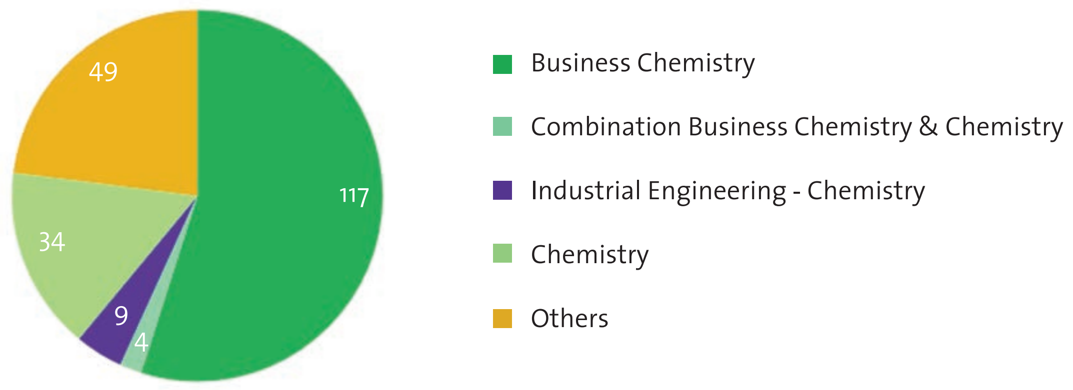
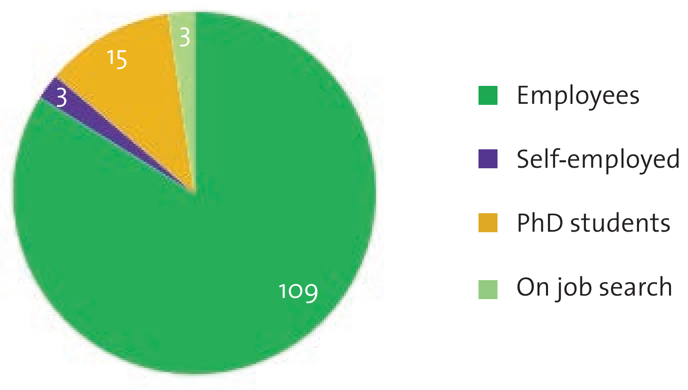


Figure 3 Distribution of employment status of the participants studying Business Chemistry, a combination or industrial engineering - chemistry (n=130).



7 For clarity reasons in this article we will only talk about the Bachelor or B.Sc. which includes the former Vordiplom and Master or M.Sc. which includes the Diploma.

Frankfurt, Universität Ulm, Universität Zürich, and Westfälische Wilhelms-Universität Münster. In the following we will take a closer look at what had not been investigated before: the nature and role of internships as well as studies abroad and the job entry of business chemists.

3.1 Common additional qualifications of a Business Chemistry education

As figure 4 illustrates, 86% of business chemists gained practical experiences through internships[8]. On average, each graduate conducted two internships.[9] 88% of the internships took place while students still studied (see figure 5). Out of the 96 participants, 44 reported to have done at least one internship during their Bachelor studies, 81 during their Master studies, and three during their PhD studies. This shows half of the graduates did an internship during their Bachelor, while 72% conducted at least one internship during their Master studies.

The graduates conducted most of their internships (56%) within the chemical sector as table 1 shows. Other internships were conducted in the consulting sector and related industries such as pharmaceutical, energy, water and environment. Within these sectors, the graduates worked in different functions. The top 10 functions by descending frequency are illustrated in figure 6: Marketing, R&D, business development, and innovation management are the most popular areas chosen for an internship followed by controlling, sales, market research, procurement, quality, and accounting. Other data of the survey shows that, if the number of internships is analyzed in relation to the company size, on average every third internship is conducted in companies with less than 1,000 employees.

Half of the Business Chemistry graduates (n=112) gained experiences abroad during their studies.[11] Figure 7 shows that 6 out of these 56 graduates stayed 1-3 months abroad. 38 graduates stayed for 4-6 months, eight 7-12 months, and four 13-24 months. According to our survey data, Master graduates tend to spend a long time abroad, typically 4-6 months.

The data in figure 8 suggests that it is most common to study a semester abroad and/or write a thesis at a foreign university. 49% of the graduates that stayed abroad either took classes or wrote a thesis or even did both. Internships abroad are also popular amongst business chemists. Only 13% of the 56 graduates conducted a research project abroad. 7% did a combination of at least two of these options during the course of their studies.

3.2 Job entry for business chemists

After graduating with either a B.Sc., M.Sc. or a PhD, the 112 participants went directly into employment or self-employment (see figure 3). Figure 9 shows that after their graduation, 57 participants found their first job in less than four months. The data does not show a significant relationship between the time of unemployment and the year of graduation. Reasons for different durations, e.g. traveling between graduation and job start, were

Figure 4 Breakdown of number of participants to have no or have minimum done one internship (n=112).

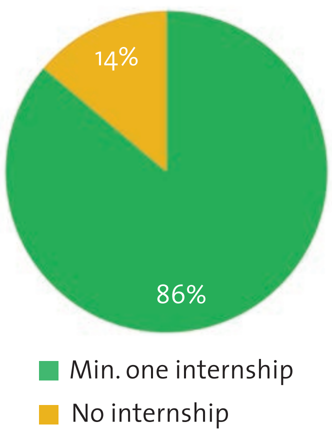


Table 1 Distribution of sectors of internships named by participants in absolute value and in % (n=146). Multiple referencing was possible.

Sectors of internships	Number of sectors abs.	in %
Chemistry	82	56
Consulting	25	17
Pharma	11	8
Energy, environment	8	5
Others[10]	20	14

8 In our understanding internships only include internships and working student activities related to Business Chemistry.
9 All 112 participants conducted 226 internships, resulting in two on average.
10 Others include public service, banking and financial services, automotive, logistics and distribution as well as internet and IT sector.
11 Only stays abroad with regards to their education are considered.

Figure 5 Distribution of internships' point in time during the studies (n=96, number of participants that did at least one internship).

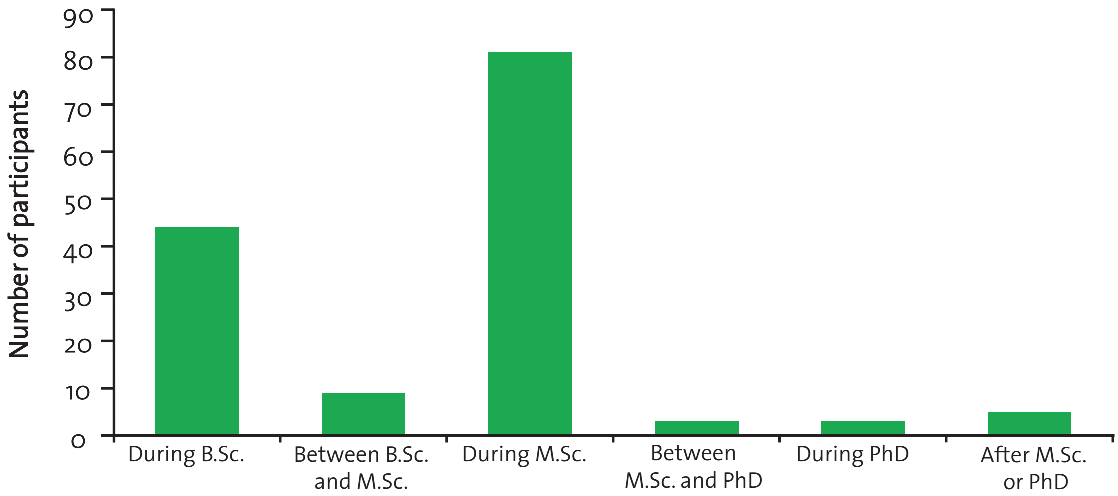


Figure 6 Distribution of top 10 functions of internships named by participants (for all functions n=230). Multiple referencing was possible.

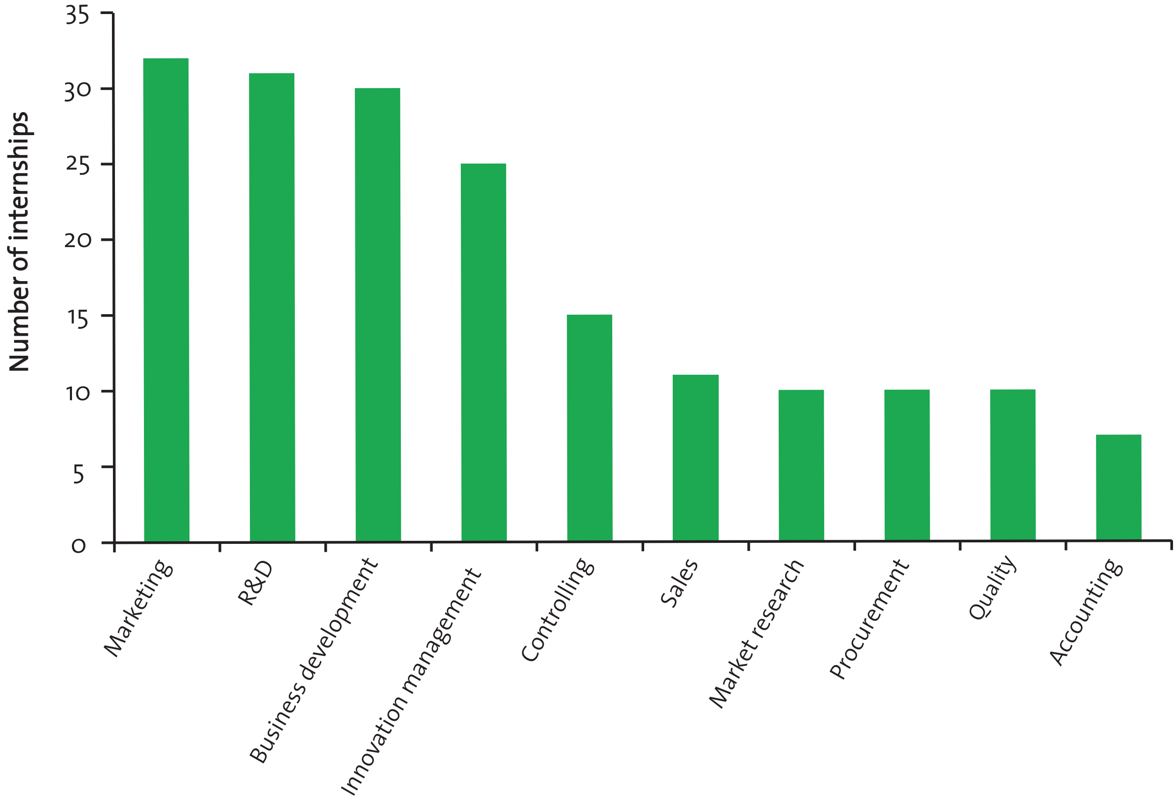


Figure 7 Distribution of duration of stays abroad by number of participants that stayed abroad (n=56).

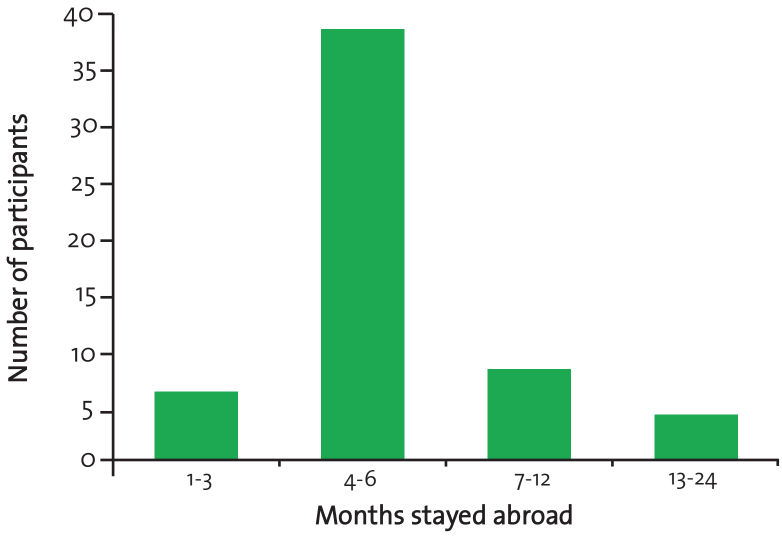
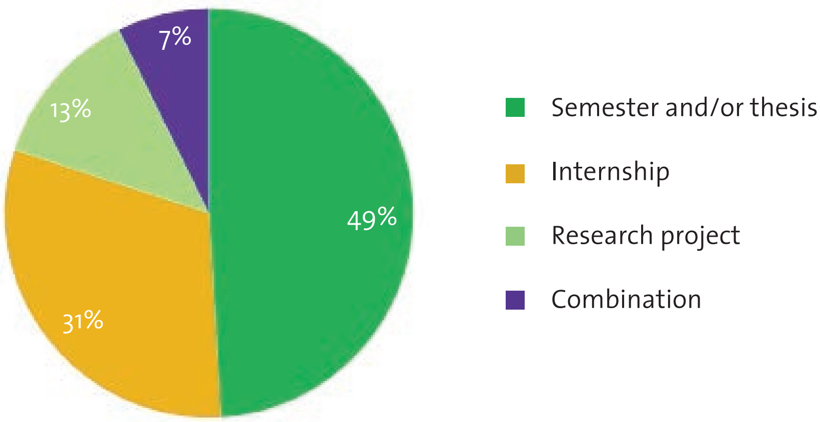


Figure 8 Distribution of reasons for stays abroad by number of participants stayed abroad (n=56).



not investigated.

As shown in table 2, the distribution of industry sectors in which Business Chemistry graduates start their first jobs is similar to the sectors in which they did internships: Half of the graduates start in the chemical sector, 17% start in consulting, 12% in the pharma sectors. The remaining quarter of business chemists starts in sectors like public service, energy and environment, logistics, automotive, and banking, as well as IT. In some cases the graduates started in the same sector in which they interned.

According to the survey results in figure 10, mostly out of all functions business chemists start their career in sales. This corresponds to 13% of the surveyed graduated business chemists. It needs to be taken into consideration that multiple-referencing of functions was possible since not every company has clearly distinguished functions as used here. Starting positions in business development (10%), R&D (8%), innovation management (8%), and mar-

Figure 9 Distribution of time between graduation and job start by number of participants considering only the ones who started from 2007 on (n=93).

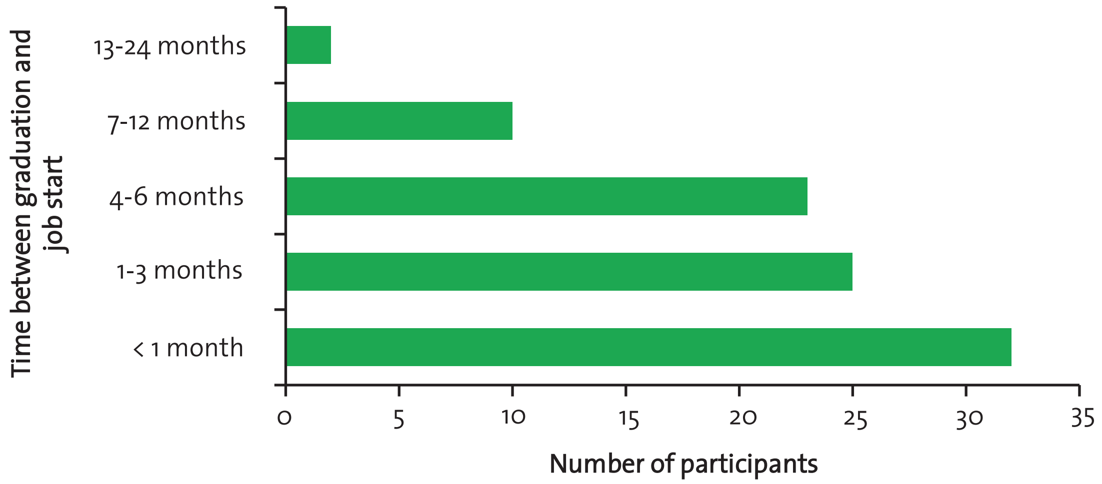


Table 2 Distribution of sectors of first job named by number of participants (n=117). Multiple referencing was possible.

Sectors of first job	Number of sectors abs.	in %
Chemistry	61	52
Consulting	20	17
Pharma	14	12
Energy, environment	7	6
Others[12]	15	13

keting (8%) are also common as they account for over eight percent each of the surveyed graduated business chemists. The remaining 43% of functions are split between 19 other functions.[13] This shows that there are some funtions that are usually taken over by business chemists. However, the functions in which they could start working remain diverse.

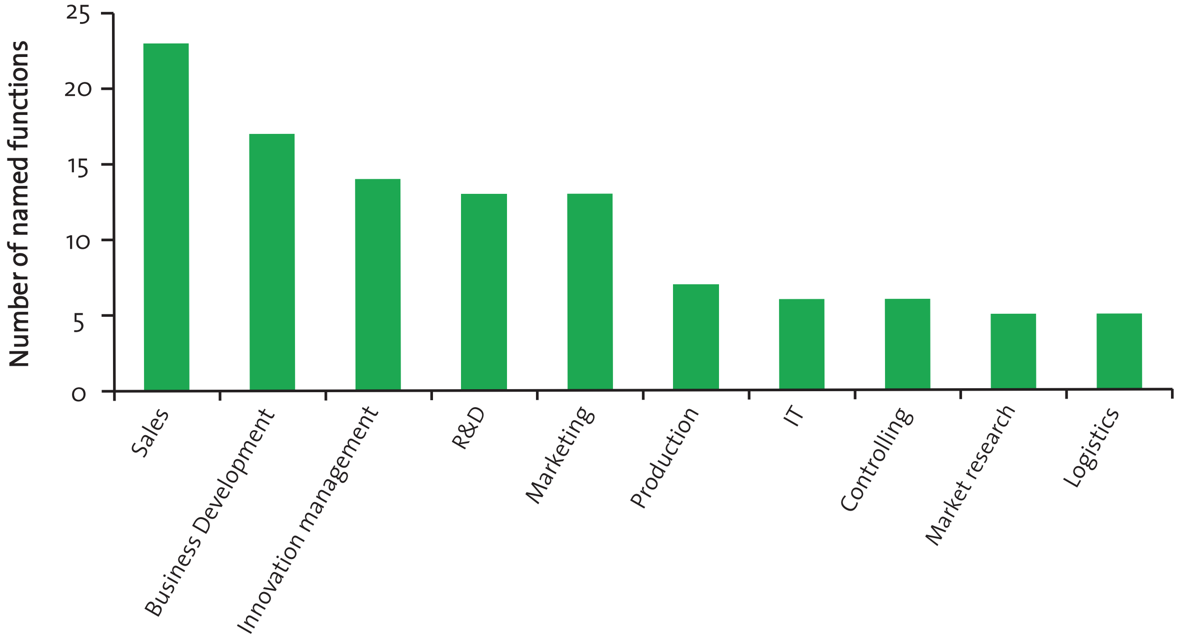
Table 3 shows the function of internship in the left column and the function of the first job in the first row. The number in the matching field shows, for example, that four participants did an internship in controlling before starting to work in accounting as their first job. Combinations with four or more matches are coloured green, combinations with two or three matches are coloured orange. When comparing the functions in which business chemists interned to the ones in which they started working later on, some patterns can be recognized (see table 3). Usually at least one business chemist that started in a certain function has interned in this function before (see bold-outlined cells within the table 3). The only exceptions are internal audit and quality; two functions in which only few business chemists did internships or started working.

The most popular functions for internships (marketing, R&D, business development, and innovation management, see figure 6) clearly have more matches to the functions where participants started to work since graduates usually did more than one internship but started working in only one job. This table clearly shows how diverse the experiences gained during internships were before starting the first job.

The number of participants stating their salary is below 100 (n=65). Therefore, the data is not representative for the initial number of 112 business chemistry graduates. It nonetheless gives an indication for graduates as well as for employers on the distribution of the starting salary[14] by degree (see figure 11). Participants with a PhD have a gross

12 Others include public service, banking and financial services, automotive, logistics and distribution as well as internet and IT sector.
13 The 19 other functions include: production, market research, IT, controlling, logistics, technical management, product management, applications engineering, procurement, inhouse consulting, sustainability management, accounting, finance, quality, administration, internal audit, human resources, savety protection, corporate communications & public affairs.
14 Only gradutes starting their first job as an employe after 2011 are taken into account. Out of this group only 65 stated their salary.

Figure 10 Distribution of top 10 functions of first job named by participants (for all functions n=150). Multiple referencing was possible.



annual salary over 60,000 € with some exceptions. Most graduates with a Masters degree earn between 40,000 and 60,000 € annually, only a few between 30,000 and 40,000 €. The few Bachelor graduates that stated their starting salary also earned a gross annual salary between 40,000 and 50,000 €. Other factors that could explain the difference in salary are sector, function, company size, and starting year.

We also investigated the companies business chemists started to work for, including company size (in number of employees). The participants that named their first employer started their first job at the following companies: A.T. Kearney, Accenture, Avery Dennison, BASF SE, BIOGRUND, BMW AG, Bosch, Brenntag GmbH, BYK-Chemie GmbH, Clariant, CONSTAB, Covestro, CTcon Management Consultants GmbH, Dow, DUPONT de NEMOURS, Dynamit Nobel AG, Evonik Industries, F. Hoffmann-La Roche AG, Freudenberg Sealing Technologies, Frigoblock, Gustav Grolman, Henkel, HP, HSBC Internationale Kapitalanlagegesellschaft mbH, Husqvarna Group, IDS Scheer AG, ifb AG, Johanna Borgers AG, Johnson & Johnson, K+S AG, KPMG AG, Merck KGaA, Mettler-Toledo GmbH, Momentive Performance Materials, MY-CHEM GmbH, Ontex Mayen GmbH, PAUL HARTMANN AG, Perkin-Elmer Bodenseewerke, PWC, Retsch GmbH, Stockmeier Chemie, Sulfurcell Solartechnik, The Boston Consulting Group, Thyssenkrupp, Warth & Klein Grant Thornton, Werner & Mertz GmbH, Westfalen AG. Figure 12 shows that more than half of the graduates start working for large companies with more than 10,000 employees. A fifth of the participants starts working for small and medium-sized enterprises (SMEs) with up to 500 employees and another fifth for bigger companies with up to 5,000 employees.

3.3 Implementation of education in everyday work

Interestingly, 45% of the graduates answered that they work in a perfect combination between chemistry and business (see figure 13). 47% do more business related work where only 8% state that their work is more chemistry related. This is also reflected by the answers given to the question asking which were the most essential topics in their education with regards to their everyday work (see table 4). Many participants stated that the combination of chemistry and business as well as understanding the mentality and the way of thinking of each discipline played an important role in their education. Some graduates stressed the importance of courses such as innovation, strategic, project and supply chain management, new business

Table 3 Matrix of function of internship versus function of first job. Multiple referencing was possible.

Function of Internship	Function of first job: Accounting	Administration	Applications engineering	Businesss development	Controlling	Finance	HR	Innovation management	Inhouse consulting	Internal audit	IT	Logistics	Marketing	Market research	Procurement	Production	Product management	Quality	R&D	Sales	Sustainability	Technology
Accounting	3			1	3	2		1								2		1	1			
Administration	1	1		1	1	1										1					1	
Application engineering			3	1				1					1						3	2		1
Business development	2	3	1	9	4	2		4			1		5	3	1	2	1	2	2	1	1	1
Controlling	4			1	5	3		1								2		1	2			
Finance	1			3	1	2								1		1		1				
HR							1															
Innovation management				7	1	1		8					6	1	1			1	4	1		
Inhouse consulting				1	1	1			2				2		1				1			
Internal audit	1			1	1	2													1			
IT	1	1		3	2	1		3			1		1	1		1			1	1		
Logistics		1						3				1		1					2			
Marketing	1		1	5	1			3	1				7	2			1	1	3	1		1
Market research				1				1	1				3	3		1		1	1	1		
Procurement		1		1	1			3					3		1							
Production	2			2	1	1		2				1		1	2	2		2	2			
Product management			1	1	1		2						1				1	1	2			
Quality				1				1												1		
R&D			1	3	2			2				1	4	1				1	7	2		1
Sales		1	3	5	1			2					9	3	3	1		2	5	7		1
Sustainability		2						1							1				1		3	
Technology			1										3	1					3	1		1

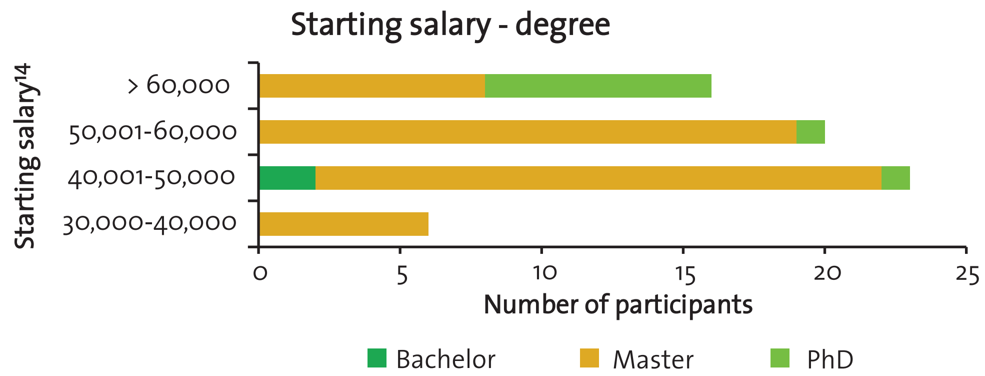
development or marketing (see table 4).

Within academic education, the graduates mostly miss the practical orientation during their studies (see table 4). Additionally, project, strategic and quality management, marketing, statistics as well as corporate finance lacked during education with regards to their everyday work. Certainly this depends on graduation year and the university visited since offered courses vary.

4 Discussion

It is impressive to see that apart from actual business chemistry graduates, a large number of people with a different study program, such as chemistry or something else, consider themselves to be business chemists (see figure 2). It also would have been interesting to see what their education looked like in comparison to the ones that explic-

Figure 11 Distribution of starting salary[14] in EUR by degree and number of participants (n=65).



itly studied Business Chemistry. However, this exceeds the frame of this article and can be investigated within another setting.

The results of our survey show that the most common degree for business chemists is the Master of Science[15]. 80% of business chemists graduate with a M.Sc. and start working, compared to only 9% of chemistry students doing the same (GDCh, 2017). This comparison underlines that industry and other future employers are willing to employ Business Chemistry graduates without a PhD. Finishing with a Bachelor of Science is less common for business chemists than finishing with a PhD. However, it is possible that the number of Bachelor graduates (4) is underrepresented in this survey as from personnel experience of the authors and *JuWiChem* members more students start working directly after their Bachelor. A future survey should investigate this aspect in more detail. Based on personal experience and empirical value, the ratio between the three different degrees sounds reasonable.

4.1 Education in Business Chemistry

What does it mean for the education at universities that 86% of the graduated business chemists did on average two internships? It proves that most graduates consider internships as part of their education as a business chemist. The results of the survey definitely show that internships as well as experience acquired abroad are common qualifications of a Business Chemistry education. Using these results, the following paragraphs examine at which point of education which type of internships are appropriate for business chemists.

Two universities offering Business Chemistry include a mandatory internship in their Bachelor program that also gives credit points towards the degree. This shows that these universities consider internships and gaining practical experience as important as other courses. Within these internships, students can learn about the importance of developing soft skills and the practical application of the concepts taught at university helping them

Figure 12 Distribution of company size of first employer (n=108).

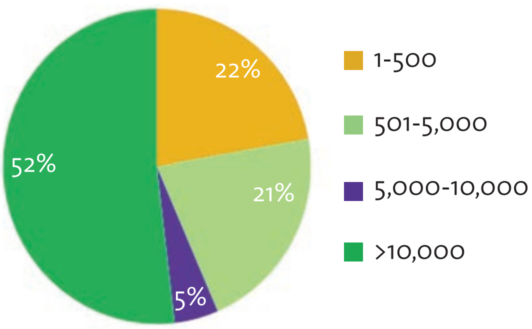
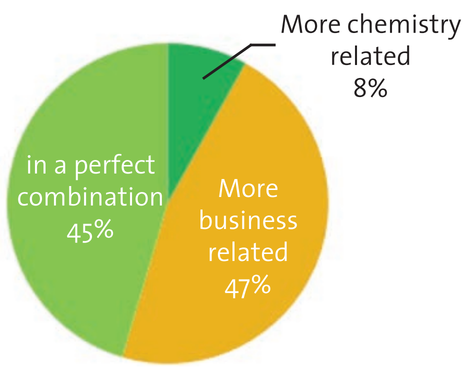


Figure 13 Distribution of daily way of working (n=99).



14 Only gradutes starting their first job as an employe after 2011 are taken into account. Out of this group only 65 stated their salary.
15 For clarity reasons in this article we will only talk about the Bachelor or B.Sc. which includes the former Vordiplom and Master or M.Sc. which includes the Diploma.

Table 4 Evaluation of programs' aspects, decreasing frequency.

Essential aspects of program	Missing aspects of program
Combination of chemistry and business	Relation to practice
Innovation management	Project management
Scientific mindset	Scale-up/Production
Business mindset	Marketing
Controlling	Statistics
Business development	Juridical aspects
Marketing	Corporate finance
PhD	Strategy
Personnel management	Quality management
Project management	
Finance management	
Change management	

to understand their relevance. In times of tightly packed and strictly timed Bachelor and Master programs, mandatory internships offer students the opportunity to reflect potential options for their future after university. Additionally, a good letter of recommendation from an internship or a number of different practical experiences on the CV may serve as valuable entry ticket into the first job.

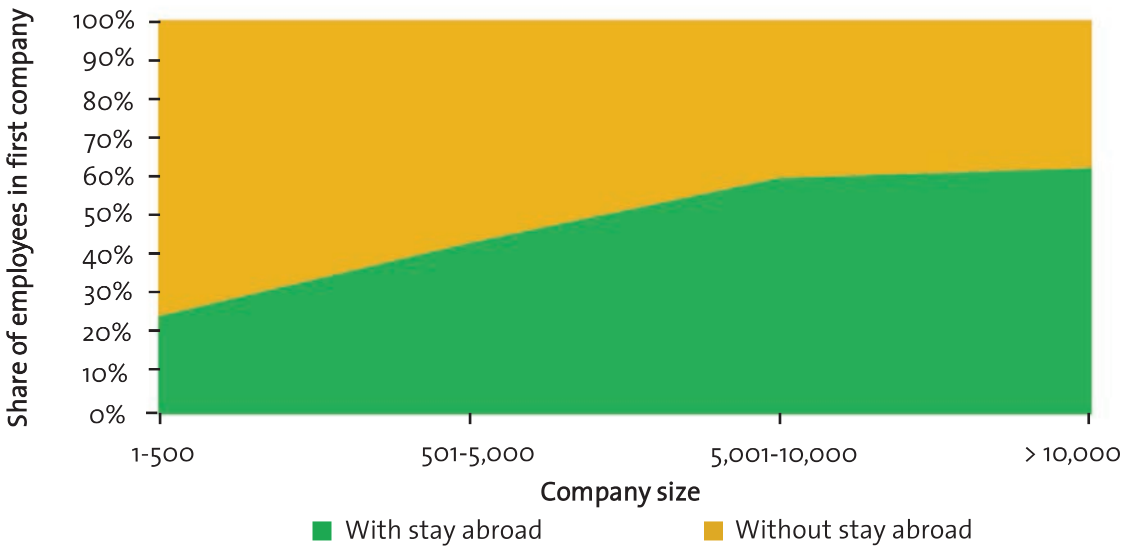
Independent of the mandatory internships in the Bachelor, 81 graduates conducted voluntary internships during the Master (see figure 5). This might be due to the fact that, especially during the Bachelor, the program conditions do not allow two to three months' time for an internship. Lab classes as well as different exam periods are conducted during the lecture-free time to stagger the regular semester and exam preparation. Towards the end of the studies, when students realize that the job start is getting closer, students appreciate gaining practical experience and finding out what their professional future could be. As the survey results underline, students do two internships on average. This shows that they want to experiment and find out in which discipline their strength and passion lies. At university, the teaching focuses on learning and understanding concepts or techniques; the research aspect is high. The theoretical background of a concept and applying the concept in practice are completely different from each other. Only from knowing theoretical concepts, one cannot tell if working with and applying it really is the right thing for oneself to do.

When it comes to analyzing the sector and function of internships, Business Chemistry graduates conduct quite diverse internships. They did not only intern in the chemical sector. Half of them conducted internships within other sectors. The same diversity can be observed with the functions the participants interned in. Most internships, except the ones in R&D, are business related (see figure 6). This is in line with the perception of business chemists that work more business related (see figure 13). For the internship it might be due to the fact that most Business Chemistry programs focus on chemistry. They are curious to get to know the practical side of business outside of the laboratory. Or maybe when internships were conducted within the chemical or a science related sector, Business Chemistry students were preferably employed for more business-related functions due to their interdisciplinary skills. Business chemists bring along a scientific background as well as business knowledge and an interdisciplinary way of thinking which makes them useful as mediators and moderators in interface positions already within their internship. This aspect will be further discussed in relation to the job start in 4.2.

Our survey shows the importance of internships during the education as it contributes to the development of practical skills. A comparison with students of other programs is difficult as no data is available. For future investigations it would be interesting to learn why students want to do internships in general and especially in which periods within their studies.

In some cases internships are done abroad. With increasing globalization, study programs become more international. 50% of graduates stayed abroad

Figure 14 Distribution of stays abroad by company size of first employer.



for educational reasons. The data suggest that it is most common to take some courses abroad or write a thesis at a foreign university. This shows that stays abroad are a regular feature of education (DAAD, 2017).[16]

Figure 14 shows that graduates with study experience abroad tend to start working in companies that have a higher number of employees. From the graduates who started working for SMEs (1-500 employees) 23% gained experience abroad during their studies. The percentage of graduates with study experience abroad increases to 60% who start in big companies (over 10,000 employees).

Independent of the company size, at least 23% of Business Chemistry graduates stayed abroad for their education. This implies that it is relevant for all industries to attract employees that have intercultural competencies. Usually SMEs are experts in certain fields and have suppliers and clients from all over the world. Therefore, international experiences are valuable in nearly all professional domains. As company size increases, the number of regional affiliates and the number of colleagues from other countries increases as well. Hence, in bigger companies the intercultural competencies are needed to communicate with not only external but also with internal stakeholders. This might be one reason for the rising trend in figure 14.

Another explanation could be the language perspective. Learning and improving language skills is also an important factor when staying abroad. As today even German companies use English as a corporate language, being fluent in English is expected from graduates. For employers this qualification can be shown not only by certificates but also by real life experiences, e.g. a stay abroad.

As far as we investigated, no Business Chemistry study program includes a stay abroad as a requirement. For business related studies, there are many programs that include international studies with at least one semester abroad. Is this necessary for Business Chemistry students as they compete with graduates from business programs? Our survey shows that despite the relationship between studying abroad and company size, not having this experience does not automatically lead to being disqualified, as graduates not having stayed abroad also start to work at large companies.

4.2 Business chemists in daily working life

Business chemists appear to need less than four months to find a job. From the data available, it was not possible to see a trend over time. Because of the economic environment, some years are known to have had freezes on recruitment. At this point, an interesting correlation between job start and membership of Business Chemistry network[17] can be observed: Most of the survey's participants were contacted through our *JuWiChem* network. 66% of the participants considered for this analysis are members of associations like *GDCh*, including *VCW*

16 The number of stay abroad for study reasons increased over the last years.

17 The Business Chemistry networks include *JuWiChem, VCW, Gesellschaft Düsseldorfer Wirtschaftschemiker e.V., WiChem Forum Zürich, WiChem Kiel e.V.* and *Wirtschaftschemiker der Universität Münster e.V.*.

and *JuWiChem*, *WiChem Kiel*, *WiChem Forum Zürich*, *WUM*, and *GDW* where creating a network and getting into contact with possible employers is very much supported. Although the data do not show a valid relationship between the membership in one of the associations and a quicker job start, our finding is supported by the fact that 42% of the participants had been somehow in contact with their future employer before. 23% of graduated business chemists started their first job with a company where they interned before. This percentage increases to 37% if Bachelor, Master, and PhD theses are also taken into account. Other contact points with the company that first employed business chemists are recruiting events and workshops as well as cooperation between company and university. Independent of these thoughts, only very few survey participants have been searching for longer than a year. This proves that the industry values business chemists and the program clearly has its specific merits.

This also demonstrates that companies are interested in getting in touch with students during their studies to recruit potential future employees. How can they find the best talents for their company? By having them work for the company beforehand, so they can learn about the company, its portfolio and processes.

Business Chemistry graduates do not only start to work within the chemistry sector, although half of the graduates start working there. Other industries also appear to be interested in their qualification. This phenomenon might be similar to the one chemists face: The basic scientific mind-set as well as the expertise in chemistry, which forms a base for many other industries, is needed by many other industries. Therefore they employ chemists and apparently also business chemists. The broad education, analytical thinking, and the mediator role qualifies business chemists as employees for many sectors.

The data analyzed prove that business chemists start working in various functions. As of their definition and their area of responsibility, marketing, business development, R&D, and innovation management are closely related to each other. Table 3 underlines this statement, as the number of matches between these four functions is high in both directions. For example, from the 25 participants that conducted an internship in innovation management, five started working in R&D, six in marketing, and ten in strategy and business development functions.[18] Of the business chemists that started working in strategy and business development, three interned in R&D before, ten in innovation management, and five in marketing. It also stands out that apparently internships in sales qualify before many other functions for the first job. Certainly a lot of personal preferences and experiences within the internships as well as the opportunities available after graduation play an important role in the relationship between functions of internship as to functions of the first job.

These functions all have one aspect in common: the scientific knowledge and the understanding of business are essential for these kind of jobs that build the interface between science and business. On the one hand they have the chemical background, the mind-set of scientists and the analytical skills. On the other hand, they bring along the business comprehension or instinct and the knowledge about concepts. Combining these interdisciplinary skills qualifies them to act as mediators between scientists and business people.

Working interdisciplinarily is often required in big companies. They have large organizational structures where many functions, e.g. marketing and R&D, need to work closely together. The marketing department knows what the consumer needs and the R&D is aware of which technologies are feasible. Usually the employees working in these two functions have different backgrounds and mindsets. In some situations communication between these two functions is difficult. At an interface of those functions, business chemists can use their skill set and make a major contribution to the company's success. The results of our analysis show that 52% of the Business Chemistry graduates start working in bigger companies with more than 10,000 employees. The other half works for smaller enterprises where business chemists can also make major contributions to the companies' success. Especially in SMEs, business chemists, with their broad education and background of two disciplines, are needed. Since they do not have many employees, the ones working there are often responsible for several tasks and functions. For the graduates, it is a great opportunity to get the insight of many different tasks and challenges in just one position.

4.3 Implementation of education in everyday work

For 45% of the participants, studying Business Chemistry was an excellent preparation for their everyday work. They stated that they work in the perfect combination of chemistry and business. They took jobs at the interface where competences of both disciplines are needed. It appears natural that also some participants state that their work is either more chemistry or more business related.

18 Please notice that multiple referencing was possible for the function of the first job. Therefore someone who worked within a company where innovation management and business development are coordinated from the same team.

However, it also depends on their personal preferences where they start working. The ones that state that they work in more business related functions even exceed in number the ones who work in perfect combination by 2% (see figure 13). Maybe working at the interface level could also be more business than science related because scientific understanding and mind-set are necessary. But when it comes to everyday work, it is often a business related task that needs to be performed. Alternatively, it is possible that companies do not know how to use business chemists correctly, as they do not work at the interface level. Another explanation might be that the participants just feel more comfortable in a more business related function. In order to better understand the distribution of the pie as shown in figure 13, a further survey should investigate why a certain answer was given.

The aspects that most participants consider essential for everyday work are the combination of business and chemistry as well as the learning and experiencing of each mind-set. The groundwork for that should be laid during their studies. This supports the thesis that business chemists are best suited to work at the interface between chemistry and business. Other participants value innovation management courses. Certainly for those who interned or started their first job in innovation management, this is true.[19] But also for others, innovation management is important as companies are looking for innovations to drive further growth. Therefore, not only the ones working in innovation management need to be aware of the concepts behind it. In addition, the ones working in R&D, where innovations have to be created, need to be aware of such concepts, e.g. the innovation funnel.

The most named missing aspect within the education is the relation of studies to work practice. This points out the importance of internships as part of the education. Project management was further named as a missing aspect within the education. At the same time some participants named project management as essential. This shows the differences in the curricula of different universities. For marketing, the same is true. It is named as an essential and as a missing aspect. The scale up or the production was also named as a missing function, which is comprehensible, as most universities do not offer special course on production processes. Courses related to this function are not taught everywhere because universities usually focus on research and not on how to make it available to customers. An exception for this is industrial engineering where process planning is part of the curriculum.

5 Conclusion

Graduates of Business Chemistry increase their qualifications during their studies. The analysis of the survey data has shown that 86% of the participants on average do two internships before starting their first job. Mostly they are matriculated during that time and almost twice as many participants did an internship within their Masters compared to the Bachelor. 50% of them stayed abroad, usually for four to six months, mostly taking courses or writing a thesis at a foreign university. After graduation, most of the participants needed less than four months to start their first job. Half of the participants started within the chemistry sector; the other half entered related sectors such as consulting, pharmaceuticals, or energy. The overall distribution of employment sectors was similar to where participants interned. The functions in which Business Chemistry graduates interned and started to work range from marketing and sales over R&D and innovation management to controlling and sustainability management with a higher frequency in business related functions. Business chemists tend to work either in a perfect equilibrium between chemistry and business related topics or in a more business related context.

The research on sectors and functions that business chemists enter after graduation confirms the range universities describe on their websites explaining the program Business Chemistry to potential students. This article also indicated the importance of internships, even though no sound relationship could be proven between contact to the employer before the job start and time between graduation and job start. This might be due to the low sampling size and many variants, e.g. university, graduation year, and field of interest. In a following survey, the reasons for conducting internships should be investigated, e.g. why timing, function and sector were chosen.

Current students and graduates can use this article for career orientation purposes. When no internship or job opening for business chemists is found, students - depending on their personal preference - can use the results to find interesting position. They can also use the answers of the graduates as inspiration for possible sectors or companies that already employed business chemists. The significantly short time to find a job may not only encourage them to pursue their studies and additional qualifications, but also to start networking and get in contact with possible future employers.

The employing companies and their managerial staff get a great overview about possible qualifications of business chemists. Depending on an

19 Only two participants out of seven who stated that innovation management is essential for their everyday work started their first job in innovation management.

applicant's personal interest and previous experiences, a business chemistry candidate might be highly qualified for an open position, even though the company was not looking for a business chemist.

Universities can learn about which of their courses have an impact on the students from the results of this article. For example, they could use the results as an impulse for a redesign of the study program. Including mandatory internships, offering more opportunities to participate in other business courses than the ones available already, or offering workshops in cooperation with companies could be measures to be taken.

Acknowledgements

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Practitioner's Section

Chemistry 4.0 - Growth through innovation in a transforming world

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A new phase of development is beginning in the German chemical industry. With "Chemistry 4.0" begins the fourth stage of development in the industry's 150-year history, which will be shaped by digitalization, the circular economy and sustainability in the coming decades. This is the conclusion of the study "Chemistry 4.0 - Growth through Innovation in a Changing World", created by the German Chemical Industry Association (VCI) with the support of Deloitte.

1 A transforming world is challenging the chemical sector

The business situation of the German chemical industry is currently very good. Following a strong upswing in 2017, the perspectives remain favorable in 2018 and the sector is heading for new records. For the first time in its history, the German chemical industry could surpass the € 200 billion mark in revenues. To be prepared for the future, the companies invest in new capacities, research and development as well as in tertiary education of high-skilled employees. But looking for the decades to come, the industry is faced with elementary strategic and structural challenges:

On the one hand, demand for chemical products in Western Europe will grow only modestly in the decades ahead, moving the focus toward markets in Asia, South America, and, eventually, Africa. Since international and local competitors are expanding their production capacities there, and additional capacities in resource-rich regions are to be expected, the whole competitive environment in the chemical industry is about to face a transformation. In addition, manufacturers in developing and resource-rich countries are expanding their scope to include specialty chemicals - which until now had often been covered by German exports. These changes mean a further increase in competitive intensity for the chemical sector in Germany, both in its European home market and in the export markets: in Europe, import pressure on base chemicals and intermediate products from resource-rich regions will go up, while in export markets, competition with local providers and other importers will intensify.

On the other hand, a paradigm change in demand structures and public preferences has already been taking place for a while and is set to continue. The desire to use resources in an efficient and environmentally friendly way has noticeable effects on energy supply and consumption habits. The trend toward the Sharing Economy illustrates this transformation. By developing strategies to serve changing customer requirements, companies make an important contribution toward reaching UN sustainability goals. Circular economies will gain in importance, and digitalization will lead to extensive changes in all sectors. These two core topics are of central importance to the trends in the chemical sector up to 2030 and beyond.

Consequently, the environment of the chemical industry in Germany is not only changing more strongly than in earlier decades. In the future, there will also be disruptive changes for which the companies need to get ready. The digitalization of agriculture, personalized medicine or autonomous driving with electrical vehicles are prominent examples of changes with considerable impact on chemical business. In view of these major challenges, considerable efforts are required to continue the industry's 150 years of success. It is obvious that process innovation and product innovation should in most cases be accompanied by new, service oriented business models in the future. Solutions for customers will increasingly be developed and marketed in cooperation with other companies, research institutes or start-ups.

The VCI/Deloitte study shows that the chemical industry in Germany is in a transition to a new development phase. After industrialization and coal chemistry (Chemistry 1.0), the emergence of petrochemistry (Chemistry 2.0) and increasing globalization and specialization (Chemistry 3.0), the industry is entering the new phase of Chemistry 4.0 in which digitalization, sustainability and circular economy play key roles. These topics are not

Table 1 Development from Chemistry 3.0 to Chemistry 4.0 (source: own representation).

	Chemistry 3.0 Globalization & Specialization	Chemistry 4.0 Digitalization & Circular Economy
Drivers for transformation	Globalization, the European internal market, growing competiton from gas-based chemistry, the influence of financial markets on corporate strategies, commodification	Digital revolution, sustainability, climate protection, closing material cycles
Raw materials	Increasing use of renewable raw materials and natural gas	Intensive use of data, recycling of carbon-containing waste, H_2 from renewable energies in combination with CO_2 used to produce base chemicals
Technology	New synthesis and production processes through biotechnology and gene technology, enlargement of individual processes	Digitalization of manufacturing processes
Research	Close cooperation between basic research in universities and application-oriented research in companies	Decentralization of R&D in customer markets, utilization of Big Data, joint development with customers
Corporate structure	Internationalization of trade and on-site production abroad, specialization and growth in SMEs, consolidation through M&A, creation of chemical parks	More flexible cooperation as part of economic networks, digital business models and consolidation
Products	Expanding product range, specialty chemicals oriented to specific customer requirements, new drugs, replacement of traditional materials with chemical products	Expanding the spectrum of value creation: chemical sector becomes a supplier of extensive and sustainable solutions for customers and the environment
Environment, Health and Safety	Environmental protection integrated into production, increasing product safety through expanded review of material properties, responsible care	With chemistry (ecology, economy and social affairs), sustainability becomes a comprehensive model and future concept for the industry

detached from each other: In particular, the interplay between digitalization and circular economy is growing in importance and contributes to achieving the UN sustainable development goals.

This study analyzes in detail this dramatic change, with the following guiding questions:

- How can the chemical industry at the location Germany expand its value creation potentials domestically while at the same time improving its international competitive position?
- How can the industry comprehensively use digitalization, identify attractive digital business models early-on and thus open up new business potentials that go beyond the production of chemical products and materials?
- How can the industry contribute to closing material cycles, minimize resource consumption and, in this manner, equally achieve social, economic and ecological goals?
- Can we improve economic framework conditions, supporting the chemical industry to remain an innovation and growth driver of the German economy and essentially contributing to the prosperity of our country?

2 Methodology

The analysis was made in a multi-stage process involving experts from VCI member companies and VCI, Deloitte, associations of suppliers and customer industries, as well as from science and politics. The study consists of four sections:

2.1 Analysis of the business environment

Major trends were identified, based on a comprehensive, artificial intelligence-supported literature analysis by the Deloitte Center for the Long View. Relying on that, an expert workshop prioritized 30 trends for further analysis. These trends are likely to have a significant influence on the chemical and pharmaceutical industry in Germany to 2030.

That was followed by 5 expert workshops and around 40 expert interviews which analyzed the developments in energy and raw material markets, pharma and health markets, business-to-consumer and business-to-business activities of the chemical industry, and special characteristics of Germany as an investment location. Each of the 30 trends was analyzed in detail and evaluated concerning the impact on the chemical industry in Germany, and whether it constitutes a chance or a risk for the chemical industry in Germany in current framework conditions.

2.2 Detailed analysis of chances and risks of digitalization and circular economy

Building on the analysis of the broader environment, further detailed analysis considered the impacts and chances of digitalization and circular economy as key topics. For this purpose, two workshops each were held on digitalization and circular economy. The connection between digitalization and circular economy was addressed more profoundly, and potential roles of chemical companies in (digital) economic networks were considered.

2.3 Survey among medium-sized enterprises

The analyses were supplemented by a comprehensive survey among medium-sized chemical and pharma companies. The survey aimed at obtaining information on the preparation of companies for the digital and circular transformation, on corresponding challenges, and on expectations towards policymakers and associations. In total, 124 medium-sized enterprises from the chemical and pharma industry took part in the survey (response rate >15%).

2.4 Recommendations for action

Results of the study were summarized in a catalogue of recommendations, directed at policymakers, industry associations and chemical companies.

3. Results

3.1 Incremental innovation and disruptive changes in chemical business

Within the study, 30 trends were identified that will be of special importance to the chemical and pharmaceutical industry[1] in Germany to 2030. In the medium-term, many of the trends have considerable impacts on the companies of the chemical industry. In particular, it can be differentiated according to whether the trends in their impacts on the chemical industry need to be seen rather as incremental or disruptive.

Incremental changes are characterized by continuous innovation and improvement processes that largely take place inside existing product portfolios, process technologies and established business models. The structure of value chains remains largely unchanged. Such incremental, continuous innovation processes are part of the existing business and success models of the chemical industry

1) In the following summarized as chemical industry, comprising NACE segments 20/21.

in Germany. Also in the future, they will offer significant growth opportunities for chemical companies. The chemical industry in Germany is traditionally in a good position for coping with the challenges of incremental changes.

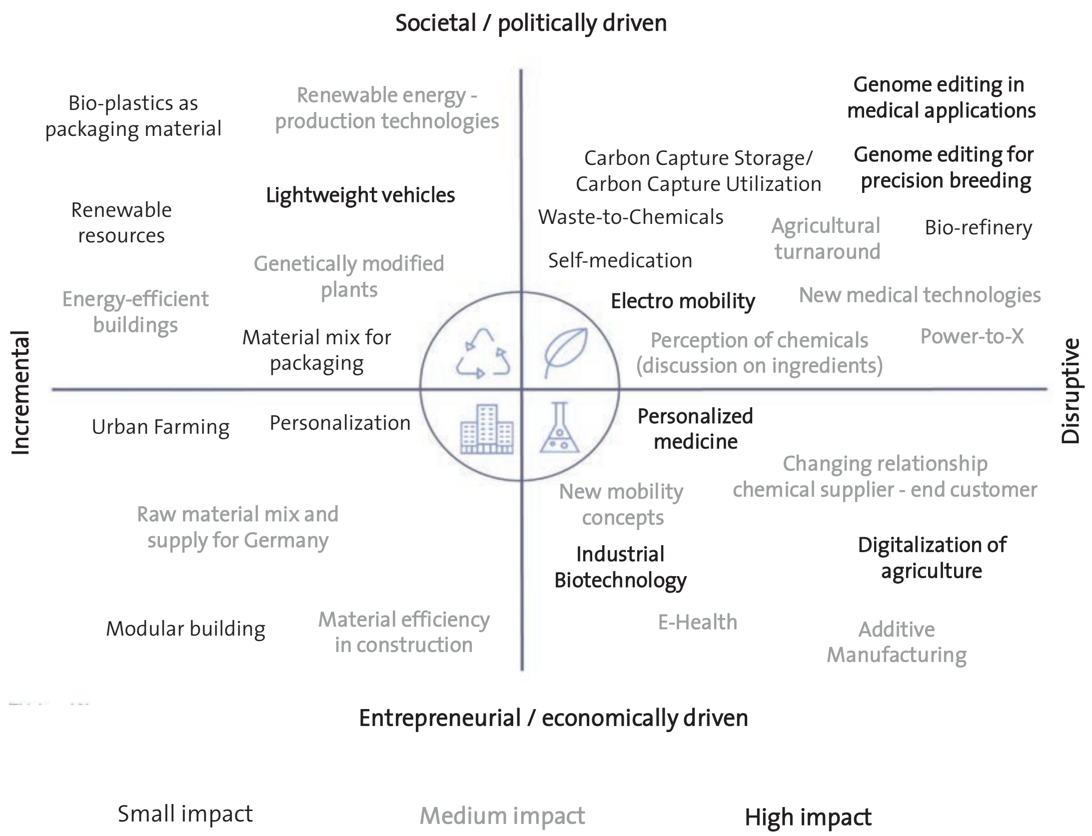
But intensifying competition in the national and international environment means an ever-faster erosion of prior competitive advantages. Also in the future, major efforts will need to be made in research and development. Here, the medium-sized chemical industry – as an innovative industry close to consumers – is an important driver. Especially this industry can and needs to deploy its strengths through cooperation across companies and sectors (see chapter "Recommendations for action to companies and their associations").

Disruptive changes in the chemical industry's environment profoundly influence product portfolios, value structures and new business models. This comprises both the chemical companies themselves and the entire structure of their customer and supplier relations. Frequently, disruptive changes are triggered by changing needs of society, regulatory changes or new technologies. On the one hand, this type of change brings changes for chemical and pharma companies in new fields of growth. On the other hand, it presents challenges for fundamentally adapting products, services and business models to the new framework conditions.

Disruptive changes come in two forms: disruptive product innovations and disruptive changes of business models.

- Disruptive product innovations describe technologies or products that are fundamentally different from existing ones. They offer great growth potential while competing with existing products. The above-described trends (e.g. in e-mobility and personalized medicine) can be subsumed here, as they can profoundly change the demand structures in the respective product segments. All the same, disruptive product innovations only have a limited impact on the structure of value chains – to the extent that products can continue to be manufactured and marketed within existing structures.
- By contrast, disruptive changes of business mod-

Figure 1 Trends in the chemical industry up to 2030 (source: own representation).



els describe a new form of service rendering where several companies bundle various products and services and jointly offer them to customers. On the one hand, this gives the opportunity to chemistry to get closer to customers and to take over a larger share of value creation. On the other hand, there is the risk of the chemical industry being reduced purely to a supplier of materials and chemicals, while new market players establish themselves between the customers and chemical companies. Here, digital business platforms and value networks are gaining in importance, and the gathering, exchange and analysis of digital mass data are becoming ever more important. In this new environment, the above-described role as a chemical supplier – with a focus on a more efficient production of innovative chemicals – can pose a risk if other non-chemical competitors build market power and control value networks.

At a second level of differentiation, a distinction is possible according to whether the above-described trends and the connected decisions largely follow economic or business management calculations or whether societal and political criteria have a dominant role for the further development. This categorization is difficult and also depends on the development of societal and political dialogues. However, a distinction according to these criteria indicates the breadh of the connected societal debate and points to the need to involve political and civil society stakeholders in the development.

According to these distinction criteria, figure 1 categorizes the 30 trends examined within this study into four different groups. This is based on a joint assessment from the viewpoint of the participants in the expert workshops where the environment analysis was performed. The typeface of the trend names reflects the magnitude of the impacts on the chemical industry in Germany to 2030.

It emerges that many innovations in important business fields of the chemical industry like the automobile, construction and packaging industries but also in production processes like industrial biotechnology will rather come about stepwise. But in fact, an unusually large share of the changes for the chemical industry, which can already be predicted for the coming years due to product and technology innovations, have a disruptive character.

A number of these developments are closely connected with the advancing digitalization of business models, as is highlighted by the examples of additive manufacturing, digitalization of agriculture and e-health. Furthermore, many developments – especially in the upper half of the graph – have an obvious reference to sustainability topics and circular economy concepts (e.g. renewable resources, renewable energies, carbon capture storage, carbon capture utilization, bio-refineries, bioplastics). Many of these trends also point to an increasing "biologization" of the chemical industry.

Thus, the analysis of developments in the chemical industry's environment reveals two thematic focal points that can be subsumed under the headings "circular economy" and "digitalization". Both topics will trigger transformation processes that will cover not only individual companies but the chemical industry and the economy as a whole. Business models and the distribution of roles in industrial networks will change considerably in the coming years.

At present, many industries are evaluating the potentials of digitalization. This tends to be linked with far-reaching changes in the structure of the industrial value chain. Therefore, digitalization is not only a trigger for fundamental change in the environment of the chemical industry. It also offers the opportunity to increase process efficiency and, above all, to open up perfectly new business and service sectors. Society and politicians demand the further development of circular economy concepts, in order to achieve sustainability goals. From the viewpoint of companies, this brings growth potentials – as products and services from chemistry can play an important role in closing the material cycles of the chemical industry's customer industries. Furthermore, this tends to influence the perception of the chemical industry: Part of the general public still has an insufficient picture of the industry as a major innovation driver and problem solver for the main sustainability topics.

So far, the interplay between circular economy concepts and digitalization has largely gone unnoticed. VCI and Deloitte's analysis have shown that there are significant parallels in the structures of digital and circular business models which result in similar requirements in the companies. Moreover, digitalization can benefit the expansion of circular economy models. In the light of these interactions, it makes sense for the study to give emphasis on both focal points and to examine them together regarding their challenges and the ensuing recommendations for action.

The cumulative occurrence of many potentially disruptive developments, especially in the fields of digitalization and circular economy, is unusual, requiring high responsiveness and ability to innovate. Many of the developments discussed in the environment analysis – particularly the intensive use of data as production input – open-up further growth potentials if the companies use the connected chances. At the same time, there are huge risks of non-chemical competitors building market power and trying to take away value creation shares from the chemical industry.

3.2 Digital transformation of the chemical sector

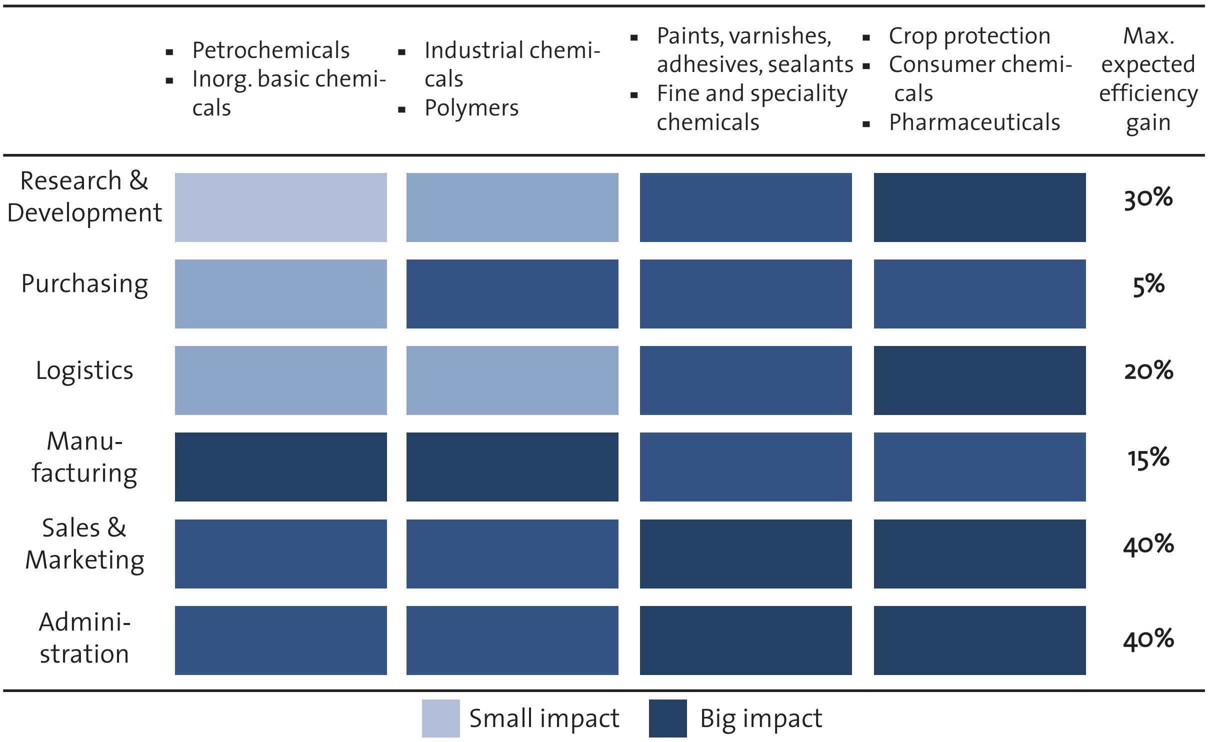
Digitalization offers an opportunity for chemical companies to collect extensive data in their own businesses, then evaluate and utilize it to improve operational processes within the company. Due to new technologies and a systematic collection of large data volumes (digital bulk data, e.g., on customer behavior and preferences, utilization of products, environmental properties of products), digitalization opens new opportunities to make further improvements in the efficiency of processes and operating models, and to develop new business models. In future, data utilization will therefore become more and more important for value creation in the chemical sector. It can be split into three categories:

Transparency and digital processes as the first category, include the collection and initial utilization of comprehensive process data within the company. These lift efficiency potentials in the context of largely unchanged manufacturing and business models. Especially in its continuous and discontinuous production processes – but also in business processes – the chemical industry is comparatively advanced in this respect. Even in an industry that is already comparatively advanced in this respect, digitalization offers new technologies for progress, for example, by further automating manufacturing processes.

Data-based operating models intensively utilize operational big data, external data (e.g., about the behavior of markets, customers, and competitors), and advanced analytical methods for smarter decision making and higher efficiency. The industry is currently driving developments in areas like predictive maintenance, networked logistics, and the application of concepts from virtual reality and advanced simulation ('in-silico') for research.

Digital business models describe value creation structures that fundamentally alter existing processes, products, or business models. What differentiates them is that products and services are digitally augmented to increase customer utility. Often this is not created by an individual company, but within digital networks in which different providers join to generate solutions for their customers. Customers are often actively involved in this process, enabling them to specify their individual requirements. The combination of digital services with

Table 2 Overview of implications of digitalization (source: own representation).



products from the chemical industry in the digitalization of agriculture, in additive manufacturing (3D printing), and in e-health concepts in the health sector are examples of current developments in this area.

The industry currently finds itself in a phase of change and development. Digital processes and data-based operating models are applied more frequently. Half of small and medium-sized chemical companies (SME) intend to invest extensively into the digitalization of their processes and business activities. Likewise, the importance of digital business models to the future viability of the German chemical industry has been recognized, and digital business models are undergoing dynamic expansion: 30% of chemical SMEs in Germany already achieve 5% of their revenue through digital business models, and a further 40% intend to introduce digital business models in future years. Over the next three to five years, chemical companies are planning to invest a total of more than a billion euros in digitalization projects and new digital business models to achieve this. Digitalization will therefore become an integral part of the business and success model of the chemical industry.

The potential for increasing efficiency through digital processes and data-based operating models differs depending on the specific segment of chemical industry. Table 2 visualizes the expected efficiency gains on the value creation process. In upstream segments of the value chain, close to raw materials and energy, efficiency gains in manufacturing come into effect, for example through remote-controlled, preventative, and proactive maintenance and the corresponding operation of plants. In downstream segments, closer to the customer, efficiency gains lie more in the improvement of sales, marketing, and administration.

3.3 The chemical industry's key role in the circular economy

The change in public preferences toward sustainable production and consumption requires the development of new products and business models. In a circular economy, the chemical sector can utilize growth potentials: for example by supporting customers in reaching their sustainability targets or extending their core business with new circular business models, such as chemical leasing. Circular economy requires rethinking: the focus here is less on volume, and more on application utility and value-based pricing.

In this study, the circular economy concept encompasses all contributions toward protecting resources (such as raw material base and ecological systems) and includes the following measures:

- Increasing resource efficiency at all levels of the value chain (suppliers, chemical industry, customers).
- Extending the lifespan of products and components, as well as reducing resource consumption in the application phase.
- As far as possible, closing cycles by reusing, recycling, energetic utilization, and biological degradation, as well as maximally efficient utilization of residual materials.

It is a task, a challenge, and an opportunity for chemical companies to take all aspects of the circular economy over the whole product life cycle into account. This begins with the production of base chemicals and extends over subsequent refining steps to the utilization phase of the (end) product. Options are avoiding waste by multiple usage, as well as higher efficiency through the utilization of byproducts, waste materials, and CO_2 as raw materials (Waste-to-Chemicals and Carbon Capture Utilization). Additional possibilities are chemical recycling (also called feedstock recycling), biodegradability as CO_2 cycle, and climate protection through "biologization of chemistry" (use of industrial biotechnology, genome editing for precision breeding, biorefineries, and the utilization of renewables as raw materials). Following this broad definition of circular economy, the chemical sector delivers an increasing quantity of examples for circular applications.

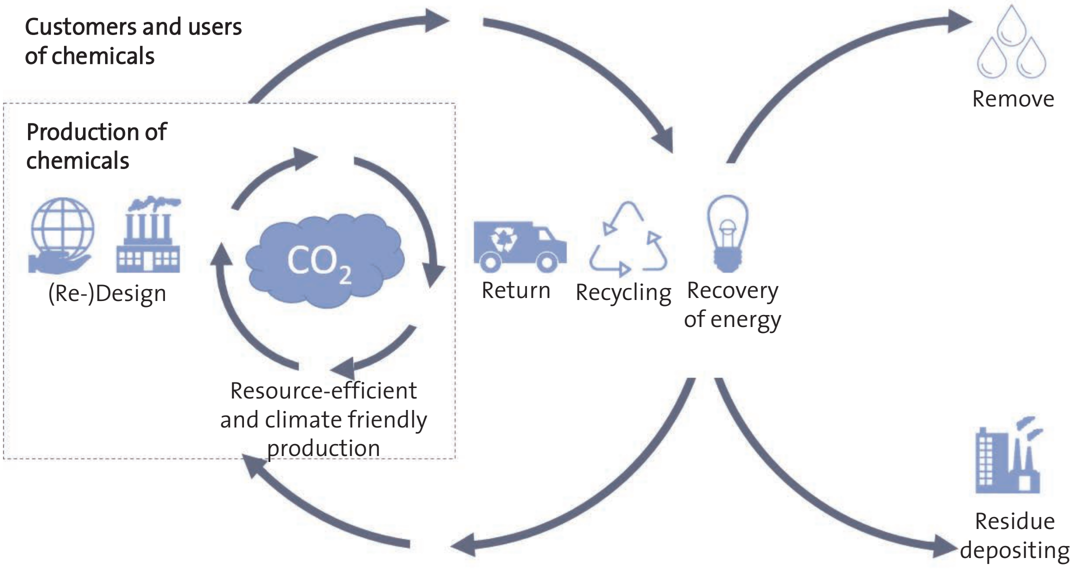
Chemical companies are actively involved in sustainability and circular economy: all of the large companies analyzed in this study regard sustainability as an important aspect of their corporate strategy, and the concept of circular economy has entered corporate strategies through the levers mentioned above. Sustainability and circular economy are also very important to small and medium-sized enterprises. Over 20% of respondents are looking closely at the effects of a circular economy on their company. Just under 40% of the companies already have a sustainability strategy, and another 25% plan to introduce one in the coming years.

At a sector level, the chemical industry in Germany has already started a number of sustainability initiatives. Of particular importance in this context is the German chemical industry's Chemie³ sustainability initiative.

3.4 Digitalization as enabler for circular business models

In all aspects of circular economy, the generation and analysis of digital mass data play an increasingly important role, as does exchanging data. Numerous technological options in the areas of

Figure 2 Seven circular economy levers ("Rs") in the chemical sector (source: own representation).



connectivity, computing, and manufacturing technology affect the interface between digitalization and circular economy. Digitalization can thus enable the development of circular business models, accelerate them, and make them more efficient. The following approaches can serve as examples:

(Re)Design: Detailed, digitally collected and evaluated utilization patterns and specific data on environmental effects enable an improved, data-supported product design to enhance product performance and durability, and utility for the customer.

Resource-efficient production: Detailed and comprehensive insights into production processes as well as the analysis of process information and process simulation enable optimized processes and plant utilization with minimal application of resources. Advanced manufacturing technologies like modular production and robotics allow an increase in efficiency and in the degree of automation.

Return: The analysis of internal and external customer data (for example from social media via 'Social Listening') enables the identification of those cases in which a take-back business model holds advantages - for both customers and chemical companies. To do so, for example the consumption of chemicals over time is analyzed in comparison with other customers and set in relationship to other available information. By using customer data, e.g., through sensors in their manufacturing plants, chemical companies can draw conclusions about their products and recognize when they need to be replaced.

Recycling: Digital traceability and innovative processes, e.g. through modern sorting technologies, create transparency about material information. Recycling is made easier by efficient harmonization of waste capture and logistics, sorting and/or treatment, and subsequent utilization.

These examples reveal that there are significant parallels in the structures of future digital and circular business models. A significant commonality between circular and digital business models is that several companies deliver an extensive range of goods and services to their customers within network-structures. Companies that want to be successful therefore must combine technical and network competencies to develop innovative solutions and successfully establish these in complex and dynamic networks in the market.

In principle, chemical companies already have a high degree of network readiness and ability, because they have been operating in a complex environment from the start: they run complex manufacturing networks at integrated production sites or chemical parks, and deal with a large number of different suppliers and customers in a broad range of customer industries. However, the opportunities inherent in digital economic networks are not yet being fully exploited by the chemical industry. To better develop these opportunities, chemical companies not only need to recognize the development and dynamics of economic networks at an early stage, but also identify the role of their own company in these structures and organize themselves strategically. For many companies, these complex economic networks with new partners from other sectors are still unknown territory, characterized by uncertainties and risks.

3.5 The transition of SMEs

Although global companies dominate in public perception, the chemical industry in Germany is predominantly medium-sized. More than 90% of the chemical companies employ less than 500 employees. With an annual turnover of around EUR 55 billion, the “Mittelstand” accounts for almost 30% of the total turnover of the sector. Small and medium-sized enterprises are successful in their strategy of developing and occupying niches and are often world market leaders in their field.
The chemical and pharmaceutical SMEs in Germany are experiencing considerable adjustment pressure. The environmental trends examined in detail as part of this study as well as the digital revolution and the transformation into a circular economy will trigger change processes in the future. The majority of companies expect strong incremental changes. Around 30% of companies even expect significant, disruptive changes in the chemical and pharmaceutical business. This includes extensive adaptation of the product portfolio, the use of new process technologies as well as changes in the value chain and business models. Only 7% of companies do not expect change for their own company as a result of digitalization and the circular economy. In one thing, the surveyed companies agree: they see in the developments mainly opportunities for their company.

In order to strengthen the future viability of the company, the chemical industry invests almost 5% of its turnover in innovation. Traditionally, product and process innovations are very important. For 43% of companies, however, new business and operating models are of high or very high importance, according to the member survey. Due to the high complexity of the changes in the environment of the chemical business, the innovative power of individual companies is often insufficient. The companies therefore rely on innovation cooperation. In their innovation projects, 75% of companies work closely with suppliers, customers, universities or research institutes.

Digitalization has reached strategic importance in the chemical and pharmaceutical SMEs. More than half of the executives participating in the VCI membership survey claim to be intensively involved in digitalization related topics. 18% of companies already have a digitalization strategy and another 32% are planning to implement one. However, the goal is not yet reached: While one in four companies is already well prepared for the digital transformation, almost 30% of the companies recognize a need for action.
Overall, digitalization will leave its mark on the chemicals business. The majority of companies see the changes largely in the context of existing product portfolios, process technologies and established business models. However, almost every third company expects disruptive changes in their own companies as a result of the digitalization and networking of the economy. At the same time, digitalization has an overall positive impact. The opportunities outweigh the risks, especially for efficiency gains, but also for the development of new markets and the establishment of innovative business models.

Digital processes and digital operating models are already part of everyday life for many medium-sized chemical and pharmaceutical companies. Around 40% of companies claim to have digitalized production and business processes comprehensively, or to make extensive use of data to optimize their business operations. For the other companies (60%), however, digital processes and data-based operating models are only partially implemented. But that is about to change, with 50% of companies planning major investments in digitalizing their processes and business processes.

On the other hand, digital business models have so far had only a minor significance in the chemical and pharmaceutical SMEs. 70% of companies say they do not have digital business models. Nevertheless, the topic of "digital business models" is on the agenda of many SMEs. Around 40% plan to introduce digital business models in the coming years.

Digitalization in small and medium-sized enterprises is hampered by high demands on data protection, but also by fears of being unable to adequately protect one's own data (data security). A shortage of IT specialists as well as a lack of IT skills among employees further inhibit the pace of digitalization. Likewise, the development is hampered by an insufficient technical infrastructure and lack of technical standards, especially at the interfaces for data exchange with partners. In contrast, rapid digitalization, according to surveyed SME, would not fail due to lack of financial resources.

Sustainability and the "circular economy" are very important for the chemical and pharmaceutical industry in Germany. More than 20% of companies report that they are working hard to understand the impact of a circular economy on their business. 45% of the companies have a managerial or governance body responsible for managing sustainability. Nearly 40% of companies already have a sustainability strategy and another 20% are planning to introduce it in the coming years. One in five companies is well prepared for the changes in a circular economy, but nearly 30% see a need for action.

For medium-sized chemical and pharmaceutical companies, circular economy primarily means resource-efficient and climate-friendly production. But "recycling" and the "design of the products for saving resources over the entire life cycle" also play a major role in the company's strategy. In contrast, the return and recycling of chemicals (chemical leasing) is not relevant for many companies because their products are not suitable for them. Many companies see potential to accelerate the expansion of circular economic models with the help of digitalization or to make them more efficient. The development is only at the beginning. Concrete projects are currently only available in about 8% of companies.

Almost all medium-sized companies are responding to increasing competitive pressure and to changing customer requirements with the tried-and-tested strategy mix: expanding innovation, promoting specialization and occupying niches, and seizing the opportunities of globalization.

Disruptive changes often require a readjustment of the corporate strategy and a review of existing business models. Only in this way can companies seize growth opportunities and remain successful in the long term. Many middle-sized companies have recognized this need for action and implemented a digitalization and sustainability strategy.

The economic policy framework conditions are rated mostly positively by the companies. However, the regulatory environment has recently deteriorated slightly. The problems with regulation are mainly in implementation and enforcement. 67% of companies rated the approval procedures as "slow and bureaucratic". Concrete support can be provided by politics and public administration, reducing bureaucracy further, making laws more cost-efficient and speeding up approval procedures.

4 Recommendations to companies and their associations

Use the chances and set strategic goals: The future importance of digital business models makes it necessary for the chemical industry in Germany to look even more intensively into identifying, assessing and introducing such models. Business models developed by networks require a comprehensive analysis of incentive structures, value contributions and remuneration structures.

Companies need to define digitalization, circular economy and innovation as elements of the corporate strategy. The interplay between digitalization and circular economy, too, needs to be seen for the business model. Furthermore, new assessment criteria have to be added to the classic performance parameters of business management. They should take into account the properties of new production and value creation structures (higher flexibility, smaller lot sizes/personalization, appraisal of existing and newly generated data).

Enhance resources: Digital and circular business models call for technical and network competencies. The chemical industry has a good starting position, as its core business is characterized by complex value creation and highly integrated (Verbund) structures and by cooperation between large businesses and medium-sized specialists. But these competencies and structures of chemistry need to be expanded and adapted, in order to overcome the remaining barriers and to fully use the chances for growth. Such change involves many risks and requires high investments in education, equipment and software.

Transform corporate culture: The successful development and scaling of new business models for digitalization and circular economy – especially at the interface between both fields – call for corporate cultures of start-up character. Innovation cycles are becoming shorter, and new products and business models need to be implemented in an agile and timely way. Important elements of the prerequisite corporate culture are transparency and openness, agility and failure tolerance as well as a culture of cooperation and communication, also across companies. In their operative activities, the companies have to cope with the potential field of tension between traditional business and new business models. Furthermore, they need to create structures that also allow them to operate in parallel within different models. This includes enabling and permitting the scaling of new business models that can be directed against the core business (“managed cannibalization”). Moreover, large parts of the chemical industry’s business model are based on protecting intellectual property: This is another potential obstacle to a fast cultural change towards openness and cooperation across companies and needs to be discussed in a frank manner. The associations should actively support the change in the industry’s culture.

Build up cooperations and platforms: Digital and circular business models require far-reaching cooperations, both within the chemical industry and across industries. Through its associations, the chemical industry can promote the development

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of platforms for knowledge exchange and initiating partnerships inside the industry, position itself as an open and attractive partner for start-ups and technology companies, and expand research collaborations. Chemical industry associations can actively support this by developing catalogues of criteria (best practice analyses, toolboxes, guidelines) for adequately assessing digital and circular business models and implementing them in the companies.

Develop new participation concepts: The speed and complexity of change can provoke rejections of these innovations. Beyond stronger communication, the associations and companies should open up their innovation development for a stronger participation of politicians and other interested groups in society. Thinking and acting in networks is necessary for the success of digitalization; this should also include the cooperation with societal stakeholders. For this purpose, companies and associations can jointly develop new participation concepts.

Figure 3 Recommended actions for companies and their associations (source: own representation).

Set strategic goals
- Anticipate disruptions
- Make digital and circular an integral part of corporate strategy
- Amend decision criteria

Seize opprtunities
- Ideate freely
- Utilize economic networks
- Establish co-operations and platforms
- Develop new concepts for participation

Enhance resources
- Company structure
- Competences
- Investments

Transform corporate culture
- Transparent and open
- Agile and tolerant
- Collaborative and communicative
- Act multi-modal

5 Conclusion

Chemical and pharmaceutical companies in Germany have shown many times that they are able to successfully master the tectonic shifts in their competitive environment; examples in the 150 year old history of industrial chemistry are changes in raw materials, relocation of growth centers to emerging economies, and the call to make business more sustainable, which has been receiving broad public support recently.

The key to the sector´s competitiveness is the innovative power held in chemical and pharmaceutical companies: new and improved molecules, production and business processes. In Europe, the sector has been characterized by globalization, specialization, and focusing on the core business since the 1980s. The industry has now reached the next level: The era Chemistry 4.0. Digitalization and circular economy are the key characteristics, and these two elements will fundamentally alter the way we work, as well as support sustainable management. Digitalizing the chemical industry offers new opportunities as well as risks. Research and development, manufacturing, and business models will be transformed. It is not easy to separate myths from real risks and opportunities, take appropriate measures, and gain a competitive advantage. This transformation offers great opportunities for the highly developed chemical industry in Germany in terms of enhancing its global competitiveness.

The chemical and pharmaceutical industry's innovative processes, products, and services make a significant contribution to sustainable development of our society. The sector will continue to be a traditional supplier of materials, while the role as a service provider will grow in importance at the same time.

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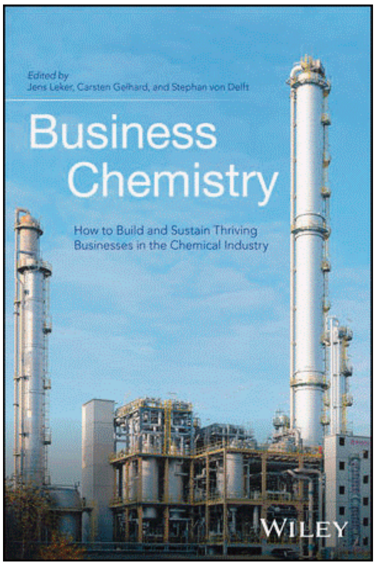
BOOK RELEASE ANNOUNCEMENT

Business Chemistry: How to Build and Sustain Thriving Businesses in the Chemical Industry

Edited by Jens Leker, Carsten Gelhard, and Stephan von Delft



Business Chemistry: How to Build and Sustain Thriving Businesses in the Chemical Industry is a concise text aimed at chemists, other natural scientists, and engineers who want to develop essential management skills. Written in an accessible style, with the needs of managers in mind, this book provides an introduction to essential management theory, models, and practical tools relevant to the chemical industry and associated branches such as pharmaceuticals and consumer goods. Drawing on first-hand management experience and in-depth research projects, the book outlines the key topics to build and sustain businesses in the chemical industry. It addresses important topics such as strategy and new business development, describes global trends that shape chemical companies, and looks at recent issues such as business model innovation.

Features of this practitioner-oriented book include:

- Eight chapters covering all the management topics relevant to chemists, other natural scientists and engineers.

- Chapters co-authored by experienced practitioners from companies such as Altana, A.T. Kearney, and Evonik Industries.

- Examples and cases from the chemical industry and associated branches throughout to illustrate the practical relevance of the topics covered.

- Contemporary issues such as business model design, customer and supplier integration, and business co-operation.

Business Chemistry: How to Build and Sustain Thriving Businesses in the Chemical Industry will be a valuable resource for scientists and engineers looking to expand their professional portfolios and enhance their value to their organizations by acquiring essential business management knowledge and skills. It will also be of interest to business students interested in a career in the chemical industry or related sectors.

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Submission guidelines

Manuscripts may be submitted for consideration as research papers, papers for the practitioner's section or as commentaries.

All submitted manuscripts should contain original research not previously published and not under consideration for publication elsewhere. Papers may come from any country but must be written in American English.

Initial Submission

Authors are required to submit manuscripts via e-mail (submit@businesschemistry.org). Please prepare the text in Microsoft Word or rtf-format. When submitting a manuscript, please include the following information:

- Information about the authors (affiliation, postal address, e-mail address)
- Tables and graphics separately in jpg-format (high quality), Microsoft Excel or Powerpoint.

Additionally, please stick to the formal requirements presented below, especially concerning citations and graphics. Manuscripts disregarding the guidelines may be returned for revision prior to any reviewing activity.

Organization of the manuscript

Manuscripts can be arranged in the following order:

- Title, author(s), and complete name(s) of institution(s), corresponding author's e-mail address
- Abstract
- Introduction
- Methods
- Results
- Discussion
- References

These guidelines are, however, flexible, especially for case studies. To structure your manuscript, please try to restrict yourself to a maximum of three levels of headlines.

References and footnotes

The authors are fully responsible for the accuracy of the references. Citations in the text contain only authors' names and date of publication [e.g. (Leker, 2001), (Bröring and Leker, 2006) or (Bröring et al., 2006) when three or more authors]. Full references have to be included at the end of the paper in alphabetical order. For more information on the reference style, please visit www.businesschemistry.org.

Tables and figures

Tables must have titles and sufficient empirical detail in a legend immediately following the title to be understandable without reference to the text. Each column in a table must have a heading, and abbreviations, when necessary, should be defined in the legend. Please number the tables. Figures should have titles and explanatory legends containing sufficient detail to make the figure easily understood. Appropriately sized numbers, letters, and symbols should be used. The abscissa and ordinate should be clearly labeled with appropriately sized type.

Revision

Revise text in Microsoft Word. Revise graphics at publication quality resolution. You may submit the revised manuscript as a single Microsoft Word document. Please send the revised manuscript via e-mail to the Editor who contacted you. You will need:

- Your submission number
- A cover letter with information for the Executive Editor and responses to raised concerns
- The revised manuscript.

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The Executive Editor responsible for your submission might ask you to change the format of your files in order to publish it. If the manuscript does not fulfill the formal requirements, the paper might be denied publication.

Comments

More information can be found on www.businesschemistry.org. If you have any further questions or comments you are welcome to contact us at contact@businesschemistry.org.

Thank you for your contribution!

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