Journal of Business Chemistry

Practitioner's Section

Novel approaches in professional education to foster innovation in the chemical industry

Dorit Lehr* and Christoph Auch**

* Center for Industry and Sustainability at the Provadis School of International Management and Technology, Industriepark Höchst, Gebäude B835, 65926 Frankfurt am Main, Dorit.Lehr@provadis-hochschule.de

** Professional Educational Lead Europe at Climate-KIC, Industriepark Höchst, Gebäude B835, 65926 Frankfurt am Main, Christoph.Auch@climate-kic.org, www.climate-kic.org

Fostering innovation in the chemical industry demands a new approach to the competencies required by employees. To succeed in innovation processes, competencies are needed that transcend the mere scientific knowledge in chemistry: skills are needed to work in teams in a transdisciplinary manner in order to generate new ideas. Moreover, these skills will enable employees to exploit innovations that exist at the interface with other disciplines and industries. However, how can such competencies be trained and fostered? This article addresses competencies that are crucial to cross-industry and interdisciplinary innovation processes. Furthermore, it outlines principles for developing competencies through professional educational activities and provides both practical examples and domains for further research.

1 The chemical industry and the need for cross industry innovation

Observers have remarked that the chemical industry and chemical science is presently in a phase of transition: For decades, discoveries in chemistry inspired both the industrial world as well as academia. However, since the 1990s, there has been a focus on process improvement in the chemical industry and relatively few fundamentally new products have been introduced to the market. Today, innovations are more likely to originate instead from related fields such as biotechnology or partnerships with other disciplines (Whitesides, 2015; Chandler, 2005, p. 35).

According to an expert survey, the long-term success of a company is dependent, among other factors, on its ability to anticipate new (mega-)trends and explore opportunities early in the process through innovation (Utikal and Leker, 2015). The current paradigm in the chemical industry is, however, focusing on running the existing business effectively. It is about exploiting the opportunities which are provided in the current state of doing business rather than exploring new opportunities. Gathering these "low hanging fruits" will likely result in improvements to the system and increased earnings in the short run – though these small steps may not suffice in order to succeed in the long-term. Whitesides (2015) argues instead that chemistry must undergo a radical shift away from studying "atoms, molecules, and reactions" to dealing with complex systems that involve molecules, in any form – in material science, biology, geology or indeed city management. Research in the field of chemistry should therefore reframe its focus and work on systems in an integrated manner together with other disciplines. Innovations in chemistry should go hand in hand with innovations in other disciplines and should thereby focus more on societal problems. Exemplary new research questions may address such questions as "How does the brain think?" or "Water, and its unique role in life and society" (Whitesides, 2015). Research and innovation in chemistry thereby requires a completely new perspective.

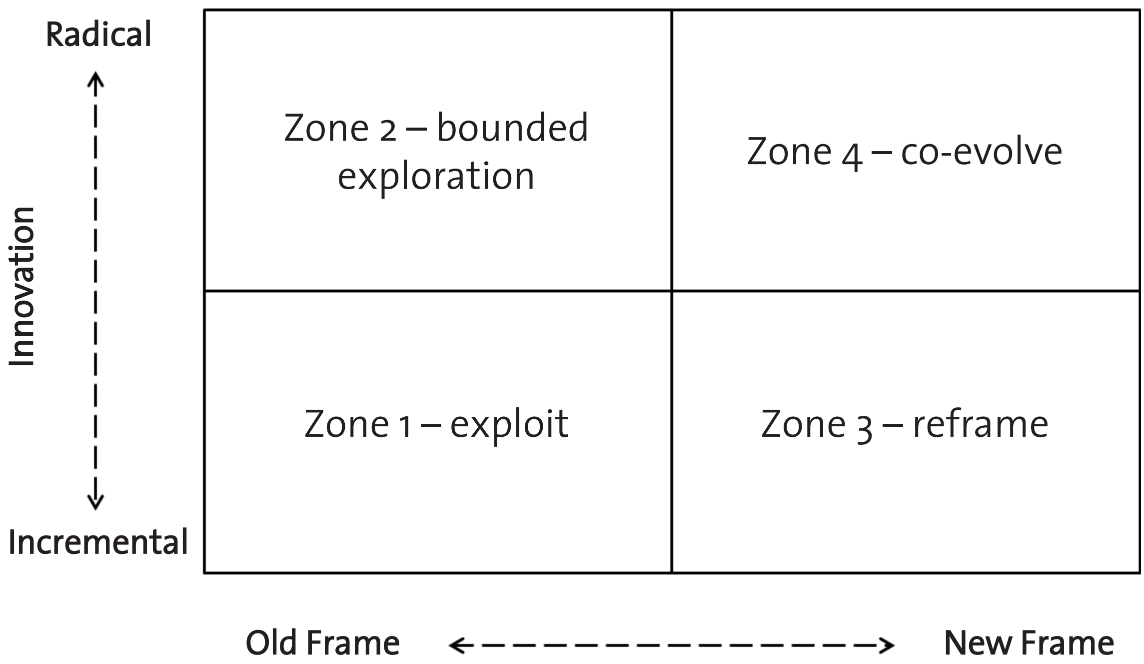
Following this line of argumentation, companies and higher education institutions should re-evaluate whether their existing framework of developing innovation is adequate. Innovation is thereby defined as a process through which a new product, service, process, position, policy or paradigm is obtained from the generation of new ideas which provide solutions to problems and needs (Matthews and Brueggemann, 2015). Evidently, processes of innovation involve many iterations and cycles between the phases of preparation, ideation, modelling and implementation. This implies that innovation does not necessarily follow a linear approach but rather adopts a trial and error pattern. The outcomes of innovation may manifest in different ways and may become disruptive to existing systems. (Bessant and Tidd, 2011) Therefore, giving room to innovation often implies abandoning existing routines and procedures in favor of new ways of operating that support creativity, flexibility and the ability to fail (Henderson and Clark, 1990; Ancona, Backman and Isaacs, 2015). But what exactly is meant by “give room to innovation”? How does innovation occur and how can innovation be fostered?

As Figure 1 shows, there are different strategies that can be employed to investigate innovation: from exploiting the current business model with incremental innovation within the existing framework, to radical innovation in a completely new system, which is related to doing something fundamentally different and working on the “edge of chaos” (Tidd and Bessant, 2013). Depending on the need for innovation and the aspiration, different routes can be taken to foster innovation.

Innovation can therefore take place in a stable and shared framework within which adaptive and incremental development takes place (Zone 1). In this zone, it is associated with refining tools and methods for its operations. Innovation can also be more radical: it involves exploring new territory, pushing the frontiers of what is known and deploying different search techniques for doing so – but this still takes place within an established framework (Zone 2). In practice this would, for example, involve research and development investments with high risk but significant opportunities. In contrast, innovation can also concern changes in the way the business architecture functions and less concerned about pushing technological frontiers with radical innovation (Zone 3). It is about exploring alternative options, introducing new elements, experimentation and open-ended enquiry. Innovations can also emerge as the product of a process of coevolution. In this space, many different elements are involved and each affects the other. Working in this zone makes considerable demands on the organizational structure as well as the people involved – it requires abandoning existing routines in favor of creativity and flexibility but also ambiguity and the ability to fail (Tidd and Bessant, 2013).

Innovation in the chemical industry has so far merely focused on exploration and exploitation of innovation in a given framework. Exploring new opportunities in the chemical industry as illustrat-

Figure 1 A map of innovation search space, adapted from: Tidd and Bessant (2013), p. 286



ed by Whitesides (2015) will likely require more radical shifts in the way innovation is framed. The ambition is therefore not only to create new products but also to shape new ecosystems, expanding the scope and playing field of chemistry (Ommen and Kuiper, 2017). There are ongoing initial attempts to reframe existing routines. The Clariant innovation center, for example, is an attempt to open up the company's innovation process to different stakeholders – from academia and other related branches – to introduce new ideas and think outside of the silos (Kottmann, 2016).

2 Competencies for cross-industry innovation

Optimizing the ongoing business – while at the same time creating the opportunities for innovation - is the central challenge in the chemical industry in the future (Utikal and Woth, 2017). Versatile and resilient organizations, with employees mastering the challenges of adapting to trends as well as shaping them, are key to securing business success in the long term.

Much of the literature on managing innovation focuses on an adequate organizational structure to foster innovation, but innovative organizations imply more than a structure: they constitute an integrated set of components that work together to create and reinforce the kind of environment which enables innovation to flourish (Tidd and Bessant, 2013). Individuals play a key role and we argue that education is an important pillar to prepare and coach individuals to help guide the innovation process.

Competencies promoting innovation – such as creativity and transdisciplinary communication – do not usually form part of formal education (European Commission, 2016). Competencies have often been assumed to be a given and the focus in education was rather to train students to become experts in a certain field. This particularly holds true in the case of chemistry, where the prevailing idea is that a successful employee needs to understand the discipline in depth (Utikal, 2015). However, being solely an expert may no longer suffice in order to fulfill the requirements of the future job market (Economist, 2017). In view of the need of the chemical industry to transform and foster new innovation, the question regarding how to use scientific knowledge is becoming increasingly important. This requires competencies which transgress pure knowledge but require multidisciplinary perspectives. Innovation experts are not only experts in a given area, but also in the processes of designing and implementing changes. Their success comes from their ability to see new connections and opportunities and from envisioning new realities (Bezarra, 2005). These descriptions already demonstrate the need for certain competencies in order to drive innovation. Individual competencies are thereby defined by Matthews and Brueggemann (2015, p.10) as "the combination of learnable behaviors that encompass attitudes (wanting to do), skills (how to do), knowledge (what to do), practical experiences (proven learning), and natural talents of a person in order to effectively accomplish an explicit goal within a specific context." These generic competencies can be further specified by describing competencies which are in particular relevant to promote innovation. We therefore have to first understand how the innovation process itself is organized. In essence, the process is described by Tidd and Bessant (2013) in these four steps:

1) Search - how can we find opportunities for innovation?
2) Select - what are we going to do - and why?
3) Implement – how are we going to make it happen?
4) Capture – how are we going to get the benefits from it?

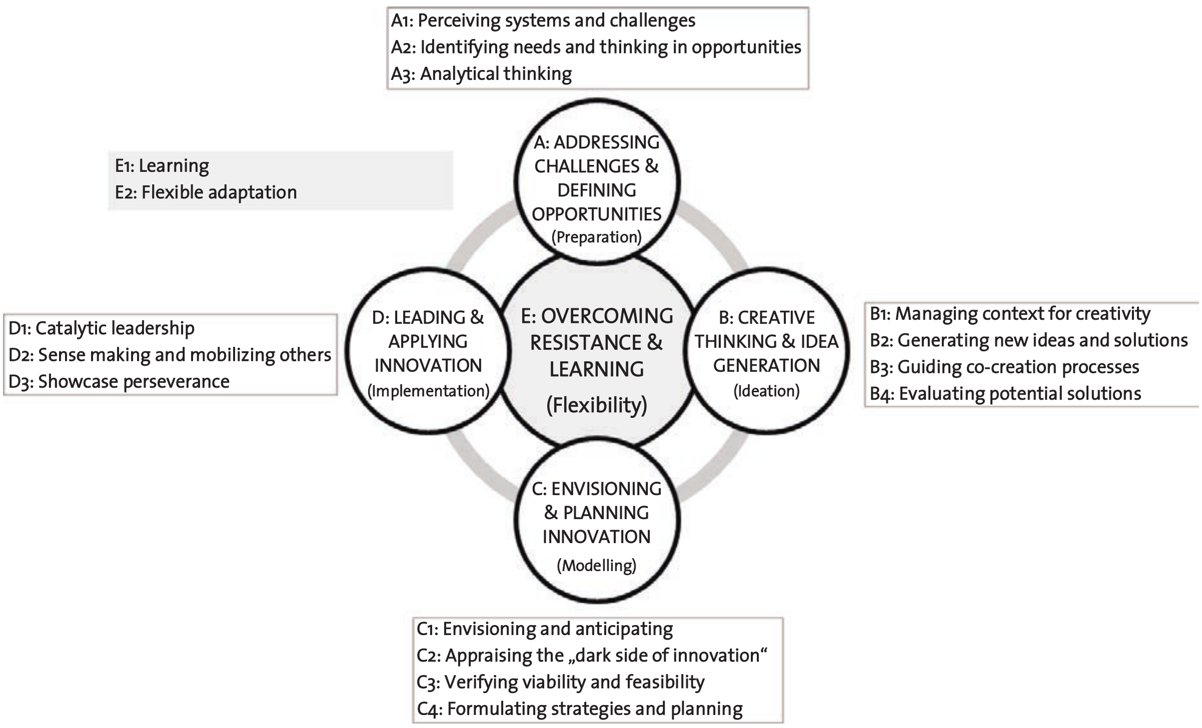
A European education project – Climate KIC's Certified Professional Program, funded by the European Institute of Innovation and Technology (EIT) - has used these four stages as an orientation to further define their competency framework in order to promote innovation. The development of the competency framework thereby followed a rigid process: based on a literature review, bottom-up research, and taking into account the Universal Competency Framework (CEB Talent Assessment, 2013) as well as general expert feedback, a first draft of the framework has been developed. The first framework was then evaluated again by experts and feedback was integrated into a second draft which has been applied in a practical test with around 50 candidates and assessors.

At the core of the framework are five working areas which are key to promoting innovation: Addressing Challenges, Creativity, Envisioning & Planning, Leading Innovation, Flexibility & Learning[1] (see figure 2). All working areas are underpinned by certain core competencies - competencies that may also be useful for employees in the chemical industry in view of the need to foster innovation.

Addressing Challenges requires recognizing that existing solutions do not always lead to the best possible results. The need to de- or reframe given

[1] See www.certifiedprofessional.eu for the general framework and further details

Figure 2 Climate KIC's Certified Professional Competency Framework for Innovation



solutions, and to constantly search for improvement, is fundamental to developing new innovations. Applying systems thinking, recognizing patterns, and thinking in options aids in identifying problems. In-depth analysis leads to a thorough understanding of the roots of these problems and allows the drawing of hypotheses. Whiteside (2015), in his article, for example, has thoroughly analyzed the chemical industry and reached the conclusion that the chemical industry is concluding an era of exceptional growth. Opportunities still appear but are broader in scope and greater in complexity. He identifies new core problems that focus on whole systems, overcoming the old paradigm in chemistry of focusing research solely on molecules. This analysis can then serve to guide further innovation in the chemical industry.

Creativity is per definition key to innovation processes and idea generation can be seen as one of the core segments of the innovation process. It is important to mention that creativity can be an individual or a group task with regard to co-generation. Consequently, the context (environment) plays an important role as it may hamper or support creativity. In fact, innovation is regularly an insightful and co-creative process. This underlines the importance of incubation as well as sharing and discussing ideas. Evaluating and synthesizing potential alternatives helps to identify which idea to expand upon.

In view of the high relevance of patents, innovation has usually been forced to take place in a closed setting. However there are initial examples now, in which the structure for innovation is opening up: for example Clariant has developed an Open Innovation Initiative jointly with the University of St. Gallen and Stanford University, with the objective of actively and strategically integrating external knowledge into the company. External partners, start-ups or universities are invited to contribute ideas and solutions to "Open Innovation" focus fields. This often results in the development of project-related, long-term partnerships. In return, Clariant offers partners access to financing opportunities, marketing, infrastructure and practical know-how (Kottmann, 2016).

Envisioning & Planning: In order to elevate an idea to the status of an innovation, it requires strategic vision and planning. In this respect, a reasonably elaborated idea about the future and an anticipation of the future impact of innovations are essential. Constantly questioning the nature of the demand and the added value of the innovation is crucial at this step. This includes an evaluation of viability- and feasibility issues as well as the anticipation of unintended negative side-effects of the innovation. Moreover, a strategic action plan with prioritized action steps assists in the implementation of the innovation.

Leading Innovation: As soon as an innovation attracts a certain level of attention from others, leadership qualities become an essential characteristic of an innovator. This means that resources (human, time, money, material, etc.) need to be secured and used in a strategic manner. At the same time, a trustworthy, people-oriented, inclusive working environment needs to be provided. Potential allies need to be mobilized to engage and take action and potential opponent forces need to be countered with perseverance or convinced of the advantages of the intended innovation. Companies often have a very well elaborated set of process descriptions for innovation. These mainly focus on innovations in the established fields presented in figure 1: Zone 1: exploit and Zone 2: bounded radical. However, in a company that intends to leave the established framing of the innovation field (e.g. a chemical company intending to provide broader solutions to a customer problem), employees have to handle a higher level of uncertainty and ambiguity, as information from other fields and industries have to be integrated into the established innovation processes and tools. In this situation, mobilizing support within the company and beyond is a challenging task.

Flexibility & Learning: Throughout all working areas of innovation, flexibility and the ability to continue learning are central. The innovator must learn from his/her experiences, success, and failure as well as from those of others (vicarious learning). The chemical industry often acts on the vagaries of a global market. The growth market of today can be the crisis market of tomorrow – as the example of Brazil has shown. Thus, companies in the chemical specialty sector need to re-act to global changes with increasing flexibility and speed (Kottmann, 2016). This also holds true for the individual employees who need to have the ability to share their learning with others and introduce relevant changes quickly to top management. This is especially difficult if chemical companies pursue innovation in a more radical way and reframe their existing business model, engaging in a co-evolutionary innovation process (see figure 1). They then need to integrate information from different sectors and cannot rely on the existing routines and networks in evaluating new information.

The competencies described above are often developed informally - through life and work experience. Professional education (education for practitioners with an academic background) can also play a vital role in preparing employees for their tasks and increasing employees' competencies to broaden the perspective for creating successful innovations (Utikal and Woth, 2017).

3 Professional education approaches to enhance innovation competencies

Actively striving to enhance innovation competencies requires new thinking on pedagogic approaches and a departure from the paradigm of knowledge driven education. Competencies arise not simply through transferring knowledge using a certain method. Competencies are much more closely related to the learner's inner process: the context of learning and the people with whom and from whom learning takes place. As a result, at the center of the learning process is the learner's selfhood and the development of his or her personality.

The following guiding principles are considered as being effective in developing suitable professional education programs focusing on the development of competencies.

A. **Challenge based learning:** Professional educational programs need to be demand driven. The basis for defining professional education offers are therefore innovation challenges and barriers faced and perceived by practitioners. A gap analysis between competencies requires facing the respective challenges and existing competencies of the workforce and management in a given context is the foundation for defining specific learning objectives of educational activities. The challenge is then frequently focused on a broader, more complex system which can be analyzed from multiple angles.

B. **Action / application orientation:** Participants should not only absorb knowledge, but also apply new knowledge, tools and methods to real existing problems, challenges and endeavors. The learning takes place through analyzing a situation, identifying one's own strategies and engaging in a dialogue with others about working hypotheses. It is also about allowing detours that include the counterpart's thinking, and jointly arriving at answers that are not rigidly determined in advance. A reflection phase after the exercises enables a critical evaluation of the problem solving process. Including challenges in training often creates a sense of urgency, passion and ownership, which also ensures a successful transfer of the learning to the workspace.

C. **Interdisciplinary approach:** Innovations are often created at the interface of disciplines. However to be able to really work in an interdisciplinary manner, it is important to set a base for cooperation and communication: so that participants value that other people make different observations, that another way of thinking makes sense, that there are more possibilities than were previously registered. Difficulties in forming an interdisciplinary team have to be mentioned in advance of the program, as well as providing rules for handling conflicts.

D. **Modular approach, allowing contextualization:** The central question is: how do the competencies arise? What are the needs? What are the objectives? People have different levels of competencies and it is important to adapt the training content to the respective expectations of the participant.

E. **Personalized learning:** Learning formats ensure that people can shape continuous learning under their own motivation and direction. Competency based learning becomes a much more personal experience and in the design of the training formats, it has to be carefully evaluated regarding how much personal presentation and explanation, self-disclosure, trying things out, making mistakes, feedback etc. are necessary in order to initiate, practice and develop the desired competences to a genuinely sustainable degree.

F. **Renewing the role of the trainer / coach:** In a learning community, the trainer makes participants aware of their active role and then guides the collective generation of knowledge across participants so that a collaborative learning experience evolves. The trainer also helps participants in reflecting about their own learning situation and the learning challenges. Depending on the focus of the training, additionally a lecturer/content driven trainer acts as an expert in their field and provides input in the training.

G. **Make use of the knowledge triangle between education, research institutions and business:** Active cooperation between the three partners serves to create a stimulating atmosphere for innovation: education provides skills and competencies for research and innovations, research generating new knowledge for education and innovation creation, and business ensuring knowledge on market developments for education and business opportunities regarding new research.

These principles have being taken up by Climate-KIC and Provadis School of International Management and Technology AG activities in professional education. The activities aim to foster innovation relating to a low carbon and climate resilient development. The applied formats are new approaches to learning and explicitly focus on the enhancement of competencies for innovation and transformation. To ensure the success of the courses, participants are briefed beforehand about the pedagogic concept and the new learning setting. Furthermore, during the program, trainers need to announce the objective and design of upcoming learning and team challenges carefully in order to guarantee that participants can handle them in a productive manner. All formats have been applied to professional education activities with participants from the chemical industry.

The **Pioneers into Practice Program**[2] for example allows climate change professionals to work in a different work placement for four to six weeks. Thereby the participant is tested in the application of their expertise in a new working environment and concurrently receives insights from a different branch. By solving a real climate challenge in the temporary work placement institution, the participant has to work in a transdisciplinary manner. The exchange also fosters the connection between research, education and business as it is intended to place participants from research to business and vice versa. Before and during the placement the participants receive bespoke mentoring and support on transition thinking and system innovation in the area of climate change adaptation and mitigation. This program has been applied in the chemical industry as well: Here, an energy advisor has been working in the manufacture of varnishes. The participant could use his knowledge and skills to develop an energy registry in which, on the one hand, the total consumption of electricity, gas and heating oil of the manufacturer is recorded and on the other hand the energy used in the various business sectors, e.g. in the production, for the illumination or for the cooling of compressors calculated. The program thus allowed the participants to thoroughly assess a certain system of working – addressing challenges which hinder an efficient use of energy. Within four weeks of collaboration, many suggestions for improvement have been developed, which in future can significantly reduce

[2] For further information: pioneers.climate-kic.org

energy consumption in the company. New ideas from the energy advisor as well as intensive collaboration helped to identify low-hanging fruits for energy efficiency – but it also tackled more structural problems and technically challenging issues, such as the cooling of the compressors. To ensure that the ideas are also being implemented, the energy advisor also had to develop a clear vision and translate this into a detailed action plan with prioritized actions.

The **Exchange** program is also an example which puts the action and challenge based learning into focus: Participants are involved for 18 months in their respective enterprise working on a real challenge. The project "Sustainability in the Chemical Industry", for example, supported companies in the calculation of their Carbon Footprint as well as in the implementation of a climate strategy. Eleven companies, most of them SMEs, participated in the program. All companies calculated their footprint and were challenged to transform the results into entrepreneurial decision processes and to develop a climate strategy. Participants received professional mentoring through workshops and coaching to support them on their journey. Through this project, participants could apply and further enhance their competencies in promoting and implementing a certain innovation: They identified company-specific barriers that needed to be overcome to create climate friendly products and processes. Creating company internal alliances, gaining support for one's own ideas and initiating change processes have been relevant competencies that have been trained in the program.

Professional Education Training Courses on the other hand are very condensed courses, lasting for 1 to 8 days. These courses support ideation and promotion of innovations tackling the challenges of climate change. The training courses combine thematic focus areas with action based learning modules and participants work in transdisciplinary groups on case studies. Learning from peers is thereby of increasing importance. In the courses, realistic examples are applied allowing participants to use their competencies to solve the exercises, which will also help participants in their everyday contexts on the job.

The formats have been developed based on five years of experience in which the aforementioned formats have been co-created and tested with partners. More than 1000 participants from more than ten European countries joined the different formats. All courses have undergone a thorough evaluation using standardized questionnaires and open feedback sessions. The evaluation was created from the perspective of trainers/lecturers, program managers (responsible for the planning and organization of the courses) and participants. Participants particularly appreciated the action based and peer to peer learning approach as well as the experience of working in an interdisciplinary manner in teams. These principles led to an active involvement in the learning process and participants took pride in the results achieved. Trainers positively mentioned the creativity that became apparent after groups were formed and operating properly. Program managers see the challenge driven design as very rewarding, as the program reflects a "real life challenge". For them, a major challenge lies in adequately contextualizing the program. To make sure that participants fully engage in the program, the challenge needs to be linked to participants' background and professional experiences, but it has to be framed in a way that forces participants leave their established way of thinking.

The outlined examples of European professional education activities highlight current approaches to developing participants' innovation and cooperation skills. In view of the need for the chemical industry to promote cross-industry innovation, the outlined pedagogic concept is considered to be a complementary activity to the established formal education system focusing on knowledge in a single discipline. This challenges experts in one field and discipline to work in new ways and to work in a more transdisciplinary fashion.

4. Outlook and fields for further research

Broadening the competency development of the chemical industry seems necessary if innovations are increasingly tackled on a system level rather than a product and process level. The ability to identify and analyze systems is a prerequisite for identifying promising fields concerning innovation. However, to successfully transform the inventions into innovations, not only knowledge, but also skills and a proactive attitude are needed. Learning approaches that explicitly aim at knowledge development in addition to skills and attitude development are still comparatively new.

Based on the examples outlined we see the following topics as important for further research:

Effectiveness and efficiency of professional education activities:

Measuring the effectiveness of a professional educational activity is an important challenge in itself. Asking participants about their satisfaction level after the course and after a four week time span, is one of the pragmatic approaches to evaluating effectiveness. Nevertheless, competencies are not rapidly acquired, making it difficult to quantify and visualize the impact of the educational formats. Sometimes the outcome of the programs becomes apparent for the individual only in the long-term by having a better awareness of the embeddedness of individual innovation activities in a broader system and within a company's and industry's history. With regard to the efficiency of the professional education programs, the right balance between in-class and online training for adequate competency development is an ongoing issue. For higher education institutions, it will be a continuous learning process to identify the most suitable concepts and formats by which to enhance competencies.

Certification of competencies:

Europe's business world still attributes considerable importance to formal education and university degrees in its hiring and career development approaches. This may be an effective manner at times when there is little or no change. Nowadays, however, employees work longer than ever before (around 40 years if they start their professional career at the age of 23) and they do so in a dynamic environment, e.g. due to the digitalization. In this context, it is important to maintain a system for identifying and measuring competencies that are relevant to the current and future success of companies (Cedefop, 2015)

Climate-KIC, in cooperation with Provadis School of International Management and Technology AG, is tackling the challenge of defining and measuring competencies and thus aims at recognizing talent, which has so far not been captured by formal degrees (Certified Professional Program). The program assesses, in the field of transition management, innovation management and entrepreneurship, existing competencies of candidates based on their experience.

In our view, making the relevant competencies transparent is the first step in developing and managing competencies more effectively. To make this approach more powerful we encourage and further promote the discourse on developing a competency framework for innovation. A continuous discussion regarding how to integrate this standard on the job market is also necessary.

Linking professional education activities to a transparent competency framework will increase the value of professional education activities. Employees will better understand which competency they need to develop and how to do so. Employers will be able to evaluate the added value of an individual professional education measure if this measure is related the standard competency framework. Thus, finding consensus regarding relevant competencies to promote innovation will further reveal the value of professional education and facilitate in helping to professionalize lifelong learning in Europe.

References

Ancona, D., Backman, E., Isaacs, K. (2015): Two Roads to Green, in: Henderson, R., Gulati, R., Tushman, M. (ed.), *Leading Sustainable Change. An Organizational Perspective*, Oxford University Press, Oxford, pp. 225-249.

Bessant, J., Tidd, J. (2011): *Innovation and Entrepreneurship*, 2nd ed., Wiley.

Bezarra, C. (2005): Building Innovation Competencies, in: *Proceedings of the Canadian Design Engineering Network (CDEN) Conference*, Kaninaskis, Alberta, July 18-20, 2005.

CEB Talent Assessment (2013): *The Universal Competency Framework*, available at https://www.cebglobal.com/content/dam/cebglobal/us/EN/talent-management/talent-assessment/pdfs/Universal-competency-framework-white-paper.pdf, accessed 13 February 2017.

Cedefop (2015): *European guidelines for validating non-formal and informal learning*, Luxemburg.

Chandler, A. D. (2005): *Shaping the Industrial Century. The remarkable story of the evolution of the modern chemical and pharmaceutical industries*, Harvard University Press, Cambridge.

Economist (2017): Learning and earning, in: *Special Report Lifelong Education*, 12 January 2017, pp. 5-7.

European Commission (2016): *New Skills Agenda - Working together to strengthen human capital, employability and competitiveness*, available at http://ec.europa.eu/social/BlobServlet?docId=15621&langId=en, accessed 13 February 2017.

Henderson, R. M., Clark, K. (1990): Architectual Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms, *Administrative Science Quarterly,* (35), pp. 9-30.

Kottmann, H. (2016): Interview on "Managing growth and profitability in the chemical industry", in *Journal of Business Chemistry*, **13** (3), pp. 99-101.

Matthews, C., Brueggemann, R. (2015): *Innovation and Entrepreneurship: A Competency Framework*, Routlege, New York.

Ommen, F. v., Kuiper, C. (2017): Openness and managing the innovation family, in: *Perspectives* (4), pp. 30-33.

Tidd, J., Bessant, J. (2013): *Managing Innovation: Integrating Technological, Market and Organizational Change*, 5th ed., Wiley.

Utikal, H. (2015): Personalarbeit wird bunter, in: *Provadis School of International Management and Technology (ed.) Von den Megatrends zum Geschäftserfolg Was bedeuten Megatrends für das Management in der chemischen und pharmazeutischen Industrie in Deutschland*, pp. 24.

Utikal, H., Leker, J. (2015): Die Studie: Von den Megatrends zum Geschäftserfolg, in: *Provadis School of International Management and Technology (ed.) Von den Megatrends zum Geschäftserfolg - Was bedeuten Megatrends für das Management in der chemischen und pharmazeutischen Industrie in Deutschland*, pp. 5-7.

Utikal, H., Woth, J. (2017): Raus aus dem Silo, in: *Perspectives* (4), pp. 8-10.

Whitesides, G. M. (2015): Reinventing Chemistry, *Angewandte Chemie International Edition* (54), pp. 3196-3209.

