D3.2 Analysis of the developmental needs of the engineer of the future

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Anonymous list of 12 interviewees

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CONTENT

1. EXECUTIVE SUMMARY

The goal of this deliverable 3.2 is to analyze the developmental needs of the engineer of the future. Therefore the Grant Agreement suggests a multi-perspective need analysis in doing semi-structured interviews and moderated workshops with focus groups and experts. In doing so, this deliverable sets up a theoretical framework of competences of a future engineer and summarizes the debate on future skills.

The main part consists of conducted, analyzed and evaluated interviews with industry and engineer experts, working in the automotive sector. The interview guideline was designed on basis of the theoretical competence framework and future scenarios in the German automotive industry. Together with the experts the different competence areas of a future engineer are discussed on derived from their professional biography and also future derivatives and reflections. Key results show that technical and digitals skills, i.e. the ability to analyze data, are in high demand. Next social and personal competences, i.e. the ability to adapt to changing economic and social conditions in the form of agile work changing the engineering profession. The main findings of the work include a proposal to conceptualize competences of an engineer from an educational perspective, results and findings of the experts regarding their future job profiles and an exemplary approach to identify needs and develop upskilling programs for the target group.

Work package 3 of BoostEuroTeQ is designed as a triad. After analyzing the market and clarify the initial situation of professional development programs for European engineers (D3.1), the present multi-perspective need-analysis of the engineer of the future is being done (D3.2). After that, a program development is planned to develop tailor-made formats for the upskilling of professional engineers (D3.3). Thereby the “Boost” project supports the superior project EuroTeQ. The present deliverable (D3.2) especially aims at broadening the process of work package 4.3 in EuroTeQ. The latter is designed to define the “EuroTeQ professional” based on the results from D3.2 BoostEuroTeQ, D2.9 EuroTeQ (Continuing education stream) and the mapping results of EuroTeQ D4.2 (Catalogue of engineer competences).[1]

[1] Cf. Action Plan D4.3 EuroTeQ Professional, 30.06.2021.

2. THEORETICAL APPROACH, METHOD AND EXPECTED OUTCOME

In the scope of the tasks of Work Package 3, Deliverable 3.2 aims at an analysis of the developmental needs of the engineer of the future by taking into account the opinions of several experts (M12). This demand can be identified by executing a multi-perspective need-analysis in the form of semi-structured interviews and moderated workshops with focus groups and experts (c.f. Grant Agreement p. 33).

2.1 Context of the deliverable and defining the subject

While trying to sharpen this broad task, different open points had to be clarified before. The engineering discipline displays various aspects and specializations in fields of expertise, namely mechanical engineering, electrical engineering, physics engineering, civil engineering, IT engineering, energy engineering, environmental engineering etc. (c.f. EuroTeQ D. 4.1, 4.2, 4.3). The multiplicity of specialization fields is too diverse to analyze within the time frame and capacities of this work package and requires a limitation of the fields under consideration. With the digital transformation taking place in every aspect of our current work environments, it also affects numerous parts of engineering disciplines. This transformation is influenced by many factors and parameters, e.g. economic, sociocultural, technological and political ones.

Following a pragmatic approach to limit the field of engineering disciplines, the present deliverable focuses on the group of mechanical and electrical engineers, who have been working in the automotive industry sector for many years. Which reasons can be cited for this decision? From the TUM perspective, esp. Bavaria and Baden-Württemberg, are riddled with big OEM (Original equipment manufacturer) and the attendant supplier network which opens a span from big to small and medium enterprises. Especially the automotive industry is heavily influenced by an ongoing change because the mobility of the future is demanded to be sustainable, efficient, multimodal, digitalized and user-centric.[2] Therefore new skills and know-how of engineers in that field are required as soon as possible in order to compete with global market standards. Due to the geographical location and regional involvement, the TUM is equipped with a good network in this sector. When building on this deliverable and extending its findings to the regional specificities of the partner universities, examining additional corporate partners from the automotive industry in Czech (CTU) and France (L'X) as well as the field of environmental engineering in Denmark (DTU) would be promising next steps.

[2] Bayern innovativ (Ed.): 2030: Automobilindustrie in Bayern, https://www.bayern-innovativ.de/de/netzwerke-und-thinknet/uebersicht-mobilitaet/seite/wie-sieht-die-automobilindustrie-im-jahr-2030-aus, 12.08.2022.

2.2 Theoretical framework of future skills and competences

In posing the question to analyze the developmental needs of the engineer of the future[3], several aspects are being addressed by this question. First, in which scope and quality should a development take place, how can you sharpen the target group of an “engineer” and what is meant by the term “future”? In order to clarify this issue we focused on the target group of engineers in the automotive sector with a background in mechanical or electrical engineering and a work experience from three to 15 years. The second aspect aiming at the content range and quality of developmental needs was formulated as a theory-generating aspect in the interview (see 2.5). Third, the prevailing discourse about future skills was also examined for possible connections.

Talking about future skills one will find oneself in an interdisciplinary field, which also refers to the discipline of future studies with their educational, sociological or economical focus points. To narrow down this discourse a limitation on future skills seems profitably. Ehlers mentions future skills as

“a contribution to a decisive change of the public discussion about higher education, which we refer to as the Future Skills Turn. As a concept, Future Skills has gained an importance similar to that which emerged in the seventies of the last century from ideas such as equal opportunities or science orientation in European education. Such guiding principles usually do not appear as precisely tailored and empirically operationalized concepts, but rather as conceptual condensations of broadly diversified bundles of arguments and objectives – equally in the public, the political and the scientific discourse.”[4]

This classification demystifies the current debate on future skills in the digital transformation as unprecedented and reveals the uncertainty of people being confused and overwhelmed in the digitalization of work and the necessity to adapt. The future skills debate especially deals with higher education but deceives the fact that education always is a future-projected scenario. How else should education have an effect on children, teenagers or adults, if not aiming towards a future, where they reveal and apply their skills or knowledge into meaningful actions? Nevertheless many publications can be summarized and found under the catchphrase “future skills”. Not entering Ehlers model any further, the debate on future skills lists individual skills with regards to the perspective of the one, who claims them. Meaning, while Ehlers is mentioning a general perspective on the individual, which has to develop the ability to act in a self-organized way in relation to its environment[5], other studies focus on technical or professional skills.

[3] Cf. Grant Agreement, p. 33.
[4] Ehlers, Ulf-Daniel: Future skills turn, in: https://nextskills.org/future-skills-overview/future-skills-turn/, 08.08.2022.
[5] Cf. Ehlers: Future skills profiles, in: https://nextskills.org/future-skills-overview/future-skill-profiles/, 08.08.2022.

The miscellany “Future skills” by Spiegel et al. for example lists 30 future skills which mostly focus on meta-abilities of individuals, as for instance mentioning mindfulness, creativity or trust.[6] The World Economic Forum’s report on the future of jobs from 2020 has “tracked the labour market impact of the Fourth Industrial Revolution, identifying the potential scale of worker displacement alongside strategies for empowering job transitions from declining to emerging roles.”[7] A more action-oriented and empirical approach to scope the demand in future jobs for the economic region in Baden-Württemberg was published 2021. It examines, based on vacancies and job profiles, the key factors for this region, listing future skills cluster for the resident industry sectors, mainly mentioning technological skills, digital skills, industrial-specific skills and interdisciplinary qualifications.[8] The deduction of different advanced trainings by the DIHK, i.e. Data-Analyst, AI-Manager is what makes the study very action-oriented for further education.[9] Subsequently the Stifterverband published a series of discussion papers in cooperation with McKinsey&Company about future skills in the context of school, higher education and economy.[10] The results display future skills, which “will become more important for professional work and/or participation in society in the next five years — across all industries and branches”[11]. Inside the study digital skills, technological skills and classic skills are distinguished.[12]

What becomes apparent when looking at these different studies is that they lack a certain type of shared definition of what is defined by skills and how skills can be delimited from knowledge, competences or special qualifications. In this paper I speak about competencies as a superior concept. Based on the competencies debate from the 2000s an orientation towards competencies has taken place in almost every scientific discipline which is taught at universities.[13] Accordingly when understanding “competence as the ability to act in a self-organized way”[14], competencies act as a superior concept, integrating qualifications, knowledge and skills. To put this in order a competence “describes first and foremost how a task is completed”[15]. Qualifications are directed towards externally organized fulfilment of purposes, meaning direct job-related knowledge.[16] The term *skill* is often used in a very wide way and commonly

[6] Spiegel/Pechstein/von Hattburg/Grüneberg (Eds.): Future skills. 30 zukunftsentscheidende Kompetenzen und wie wir sie lernen können. Munich 2021. p. 6-9.
[7] WEF: The Future of Jobs Report 2020, https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf, p. 8.
[8] AgenturQ: Future skills: Welche Kompetenzen für den Standort Baden-Württemberg heute und in Zukunft erfolgskritisch sind. 2021, in: https://www.agenturq.de/wp-content/uploads/2021/10/2109091_Broschu%CC%88re-Future-Skills_FINAL.pdf, 09.08.2022.
[9] The DIHK is offering various certificate programs, see https://www.dihk-bildungs-gmbh.de/.
[10] Cf. https://www.stifterverband.org/future-skills.
[11] Kirchherr/Klier/Lehmann-Brauns/Winde (Eds.): Future skills: which skills are lacking in Germany. 2018, https://www.future-skills.net/which-skills-are-lacking-in-germany, 09.08.2022, p. 4.
[12] Cf. ib. p. 5.
[13] Cf. Erpenbeck/Rosenstiel/Grote/Sauter (Eds.): Handbuch Kompetenzmessung. Erkennen, verstehen und bewerten von Kompetenzen in der betrieblichen, pädagogischen und psychologischen Praxis. Stuttgart 2017³, p. XII-XVI.
[14] Ib. p. XVI. [translated by the author].
[15] Ib. p. XIX.
[16] Cf. ib. p. XVII.

distinguished in “soft” and “hard” skills.[17] In the same way “future skills” seem to be a smorgasbord of economic or societal predicted future scenarios.

For the purpose of analyzing and identifying “future needs”[18] of engineers, I would suggest speaking of competences and qualifications, which are needed in the near, mid and longer future (five, ten and fifteen years) and shape the competence profile of engineers. A differentiated proposal is given by Erpenbeck and was refined by Pittich[19] for technical professions and craftsmen in order to investigate different competencies in the field. In this model he lists different areas of competences:

1. **Technical-methodological competences**, which are defined as the disposition of a person “to act in a mentally and physically self-organized way when solving factual-objective problems.”[20]
2. **Social-communicational competences**, which are defined as the disposition of a person “to act communicatively and cooperatively”.[21]
3. **Personal competences**, which are defined as “the disposition of a person to act actively and holistically in a self-organized manner and to direct this action to implement intentions, projects and plans”[22].
4. **Action and implementation oriented competences**, which are defined as the disposition of a person “to act actively and holistically in a self-organized way and to direct this towards the implementation of intentions, projects and plans.”[23] This dynamic competence area has not been incorporated into the competence framework for the conducted interviews, because the interview method does not allow the interviewer to observe actions during work life.

For the aim of the present deliverable, these theoretical competence areas need to be operationalized to deduce questions for experts. As the model does not specify the competence areas any further, I will combine these competence areas with another competence framework, which is focusing more on people’s behavior. This **SHL competency framework** was developed based on practical demands and a more structured, evidence-based approach and therefore delivers the missing aspects of the competence area model. In the SHL model individual behavior can be categorized into the given **“big eight competencies”** with their subordinate competency dimensions. Another advantage of the SHL

[17] Cf. ib. p. XVIII.
[18] Cf. Grant Agreement p. 33.
[19] Pittich, Daniel: Dispositional approaches for measuring professional competence, in: Journal of Technical education, Vol. 2 No. 2 (2014), p. 102-103, https://www.journal-of-technical-education.de/index.php/joted/issue/view/4; Pittich, Daniel: Kompetenz als Zielperspektive technischer Bildung, in: Zinn/Tenberg/Pittich (Eds.): Technikdidaktik. Eine interdisziplinäre Bestandsaufnahme. Stuttgart 2018, p. 101-114, p. 108-109.
[20] Erpenbeck et. al., p. XXV.
[21] Ib. XXV [translated by the author].
[22] “These dispositions thus capture the ability to use one's own emotions, motivations, abilities and experiences and all other competences - personal, professional-methodical and social-communicative - into one's own volitional drives and to and to realise actions successfully.” Ib. [translated by the author].
[23] Ib.

model is the widespread application in industry sectors.[24] The following illustration shows a synopsis of the SHL framework (big eight competencies) by Bartram and the competence area model of Erpenbeck/Pittich. The SHL framework helps to operationalize the corresponding competence areas from the Erpenbeck/Pittich model. Additionally, the technical-methodological competences of the last-mentioned model were enriched by a lifelong learning aspect, namely (a) knowledge, which experts learned from their studies and consider as important for today's work, (b) further knowledge, which experts gained during their professional activities and (c) a knowledge gap, which might been vital knowledge right now with a future oriented perspective. Additionally, the area of personal competences is enlarged with an aspect of intrinsic motivation by the author in order to reify the above-mentioned definition. The addition was done by the author of this paper considering the fact that intrinsic motivation is not defined as a competence by literature but seems as a logical extension of this competence area.[25]

[24] Prifti, Loina: Professional qualification in „Industrie 4.0: Building a Competency Model and Competency-Based Curriculum. 2019, http://nbn-resolving.de/urn/resolver.pl?urn:nbn:de:bvb:91-diss-20190215-1447234-1-0, 11.08.2022. p. 57-62.

[25] Cf. Deci, Edward L./Ryan, Richard M. (Eds.): Intrinsic motivation and self-determination in Human Behavior. New York 1985.

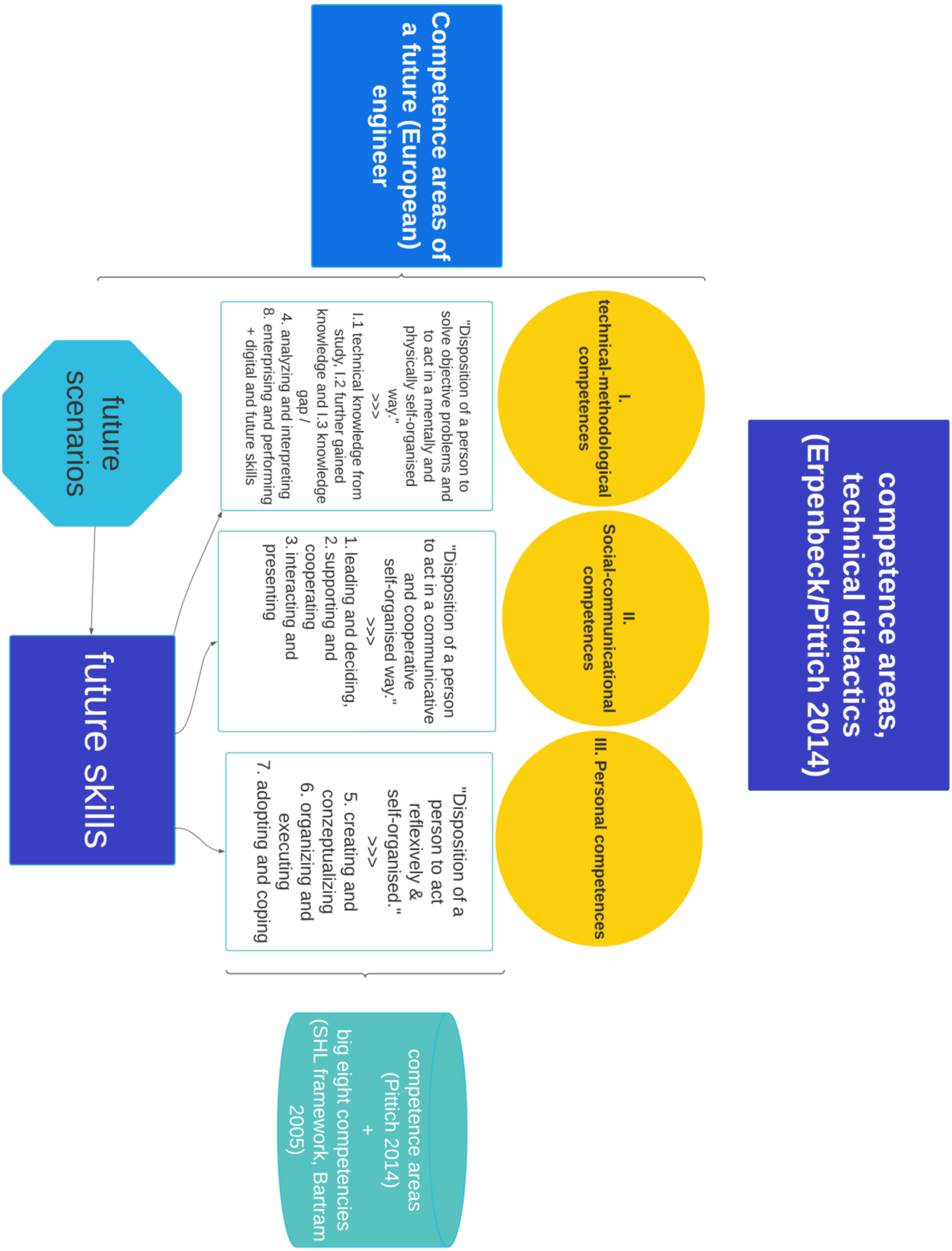


Illustration 1 and concept by Patrick Lenz (2022)

The SHL competencies are composed of eight different competency domains in brackets the matched competence areas from the Erpenbeck/Pittich model are named:

1. Leading and deciding (S),
2. Supporting and cooperating (S),
3. Interacting and presenting (S),
4. Analyzing and interpreting (T),
5. Creating and conceptualizing (P),
6. Organizing and executing (P),
7. Adapting and coping (P),
8. Enterprising and performing (T).[26]

Moreover future skills and future scenarios were derived from the future skills study of the Stifterverband and included to describe digital and technological skills, such as the ability to know web-development, smart hardware development or data analysis, besides to interact, work and collaborate digitally.[27]

Finally, to set a future scenario which could serve as a context to operate within, we originally planned to use methods so-called foresight methods. In want of time to develop a future scenario in the interviews with the experts, I referred to an already existing study describing future scenarios for the automotive industry in which our expert interview target group was working. As to that, the survey "2030 Automobilindustrie in Bayern"[28] served as a reference of future scenarios. More specifically, two possible future scenarios of the automotive industry which are most likely to happen at around 2030 where chosen and presented as a major point for discussion with the experts. The two conceived scenarios range between a progressive and moderate change seen as a chance for the automotive sector, namely diversity dilemma[29] and incremental change[30].

[26] Cf. ib., p. 59-61. Furthermore the model differentiates competency dimensions and titles on sublevels, which are not displayed here but were also incorporated in the model, esp. when matching a SHL competency with a technical competence area.
[27] Cf. Kirchherr, Klier, Lehmann-Brauns, Winde (Eds.): Future skills: which skills are lacking in Germany. 2018, https://www.future-skills.net/which-skills-are-lacking-in-germany, 09.08.2022, p. 6.
[28] Bayern innovativ (Ed.): 2030: Automobilindustrie in Bayern, https://www.bayern-innovativ.de/de/netzwerke-und-thinknet/uebersicht-mobilitaet/seite/wie-sieht-die-automobilindustrie-im-jahr-2030-aus, 12.08.2022
[29] "The demands placed on automobiles are becoming more sophisticated and mobility has become very differentiated. Depending on the occasion, different offers are used. At the same time, innovations can hardly be monetised." [translated by the author] Bayern innovativ (Ed.): 2030: Automobilindustrie in Bayern, https://www.bayern-innovativ.de/de/netzwerke-und-thinknet/uebersicht-mobilitaet/seite/wie-sieht-die-automobilindustrie-im-jahr-2030-aus, 12.08.2022, p.7.
[30] "In 2030, digitalisation in and around the car will be a key feature in industrialised countries. The traditional car manufacturers offer additional, digital business models. The use of the car moves into the centre of attention. In addition, traditional drives will be replaced by electric drives." Ib. [translated by the author].

2.3 Expert interviews: Methodological background & research interest

Individual interview dates were arranged with the experts individually via the video communications software Zoom between May and July 2022. Each interview lasted about 60 minutes and was conducted by a single interviewer and the participating expert.

How and why was an expert chosen? What can be understood as an expert? Considering Bogner et al., experts can be found in many fields besides the scientific field. This ubiquity of expertise in everyday life has led to a wide range of expertise, which needs to be specified.[31] Hence to have an expert status can be seen in a sociological perspective as an attribution based on a specific interest in knowledge.[32] Schütze described an expert already thirty years ago as persons “who have the possibility to (at least partially) assert their orientations. Experts are distinguished by the fact that they decisively determine from which perspective and with the help of which terminology certain problems are certain problems in society. It is precisely this practical relevance that makes experts interesting for many empirical research projects and research questions.”[33]

In the light of an attributing process, the knowledge one wants to acquire from an expert needs to be described. Bogner distinguishes three areas of knowledge: First, technical knowledge describes data, facts, "pertinent information" and specialist knowledge.[34] Second, process knowledge can be described as insight into courses of action, interactions, organizational processes etc. Third, interpretive knowledge describes normative dispositions, objectives or evaluations. As a consequence, knowledge is "always true" for the respondents, strengthens their subjective perspective and therefore can be used to generate contradictory, inconsistent knowledge and separate them from each other.[35] Our research interest for the interviews integrates aspects of an explorative interview method with those of a theory-generating interview. The first approach is applicable insofar as the expert is the source and central object of research and also giving information about a complementary target group.[36] The theory-generating method applies insofar as action orientations, implicit decision maxims, patterns of perception that guide action, world views, routines, etc. are our research interest. In other words, the survey is aimed at the interpretive knowledge of the interviewees.[37]

With regard to our research interest, the interviewees serve as an information source regarding an estimation of the current developments in their area of operations. These developments can, for instance, occur in fields of technology and raise the question how this technology influences the requirements and necessary skills of engineers. In our specific case, we focused on the trends and

[31] C.f. Bogner/Littig/Menz (Eds.): Interviews mit Experten. Eine praxisnahe Einführung. Wiesbaden 2014, p. 10
[32] Ib. p. 11.
[33] Ib. p. 15.
[34] Cf. ib. p. 18.
[35] Cf. ib. p. 19-20.
[36] Cf. ib. p. 23.
[37] Cf. ib. p. 25.

possible future scenarios happening in the automotive sector. Besides the digital transformation and technological development, also political, economic and socio-cultural factors influence and shape the current evolution of engineers working in the industrial (in our case, the automotive) sector.[38] Consequently, the interviewed persons act as experts with their interpretative knowledge on these ongoing developments. Coincidentally, the interviewed experts have an academic background (mostly engineering) and field of expertise within their area of operations which allowed them to act as a source for process knowledge and to give new insights about their own lifelong journey as engineers in a leading position dealing with current developments and their subjective competences in their field of operation.

In summary, our experts were supposed to act both (a) as a source on their subjective skills and knowledge and (b) a source on the current transformation with their process knowledge and interpretative knowledge on what is needed for other engineers in order to be able to keep up with current requirements and predicted future skills.

2.4 Developing the interview guideline

Based on the above mentioned model (cf. 2.2) of the competence areas of a future engineer and the research interest of the aforementioned and defined experts an interview guideline for conducting qualitative research interviews was developed. According to Bogner et. al. an expert interview is always seen as a semi-structured interview, which can be put on any phase of the research design and can serve as an explorative, systematizing or theory-generating access.[39] The questions should represent an operationalization of the above-mentioned competency framework. When conducting the interview, interviewees don't need to be asked identical questions in order to compare the interviews afterwards, as the interview is preliminary about making people talk. Accordingly, in our interviews not all questions were asked, some were kept as a backup to deep dive if necessary.[40]

Overall, the following topic blocks were included in the interview guide: First, starting with a quick introduction from the interviewer about the aim of the interview, followed by a short introduction of the interviewee, covering mostly demographic information. Second, the first big topic aimed at (I.) technical-methodological competences, the second about (II.) social-communicational competences and the third (III.) about personal competences. When taking a look at the interview guideline (cf. Annex 2), the left column displays the just mentioned competence areas, and the second column written in italics displays the "big eight" competencies and their subdivisions.

[38] Cf. Bayern innovativ (Ed.): 2030 Automobilindustrie in Bayern. Einflussfaktoren, Szenarien, Handlungsempfehlungen. 2021. https://www.bayern-innovativ.de/de/seite/wie-sieht-die-automobilindustrie-im-jahr-2030-aus, 08.08.2022. p. 34.
[39] Cf. Bogner, p. 27.
[40] Cf. ib. p. 28-30.

2.5 Target group and sample: Approach and background

We approached people within our network with a call-to-interviews searching for the following expert profile:

- *We are looking for participants from the fields of mechanical and engine engineering as well as electrical engineers*
- *Optional: with leadership responsibility (team lead, with technical working methods and a personnel responsibility of up to 10 people) from middle management*
- *specialists with about 3-15 years of professional experience*
- *HR-experts with a focus on Lifelong Learning for their company in the field of Automotive Engineering*
- *Specialist scientists dealing with future scenarios in industry sectors*

According to the requests, a response rate of 33 interested people were determined from different contexts, of whom 12 confirmed to participate as an expert in the interviews. The experts represent a variety of job profiles and qualifications:

1. Head of project in mechanical engineering at a big Automotive supplier,
2. HR specialist for an OEM,
3. COO of an international service company for engineers with a background in electrical engineering,
4. Senior technical vehicle expert in Automotive engineering and a background in mechanical engineering and thermodynamics,
5. Software system engineer with a background in electrical engineering working in a small start-up company specialized on electric vehicle systems,
6. Team lead of industrial engineering carcass in a big OEM with a background in mechanical engineering and education and a PhD,
7. Agile coach and digital project manager working for a big supplier with a background in automotive engineering,
8. Head of department in a big service company for engineers with a background in mechanical engineering,
9. Director quality management in a big OEM with a background in mechanical engineering and a PhD in Political Science,
10. Vice president in a service company for IT with a background in mechanical engineering,
11. Professor for Sustainable Mobile Drivetrains,
12. Global Automotive Industry Lead and Chief Technologist Automotive for a big IT company with a background in informatics.

The age of the experts ranges from 27 to 52 years, the professional experience level from five to 22 years. Two of the interviewees were female, ten were male.

According to the existing data management plan (D1.3 BoostEuroTeQ), this deliverable implemented the following measures. Participants were asked to sign a form of consent, including the following information:

- The interview will be transcribed.
- All personal information will be deleted in the transcripts and the data will be used exclusively within the scope of the EU research project "BoostEuroTeQ".
- The data of the survey will be saved and stored in such a way that it is not possible to identify my person (i.e., anonymization).
- The anonymized data will be archived for at least five years after the end of the project, i.e., until December 2029, as the EU aims to ensure sustainable data use and availability.
- The data will be stored on the secured university servers of the Leibniz Computing Centre at TUM.
- At any time during participation and immediately afterwards, participants can request deletion of their data.

2.6 Additional explanations for the needs analysis' scope and procedure

Within the available time for the completion of the present deliverable in this project stage, we tried to identify engineers with various study backgrounds and working in different sectors (see section 2.5). Therefore the work package lead at TUM Institute for Lifelong Learning contacted suitable persons with a request to a call-to-interviews within the Alumni network, because it was assumed to receive a higher rate of positive answers via existing professional contacts. The call-to-interviews had been distributed among the network of work package members at CTU and DTU. Despite several follow-up messages and calls, there was a very low response rate from experts from the industry across sectors and the participating countries. Against this background and considering the limited availabilities of the interviewees that did sign up, some adjustments had to be made.

First, due to the availability of the interviewees group workshops were not possible time-wise. Despite several tries and different suggestions, it was not possible to find dates to conduct workshops with at least 5 experts present at the same time. Hence, the original intention of conducting workshops using the Delphi-method (in addition to the individual interviews) did not work out. As a consequence we appreciated the chance to schedule extensive 1:1 interviews via Zoom with a time-span between 60 and 90 minutes. The interviews gave deep insights into the competence and career level of mechanical and

electrical engineers and were conducted with the help of a questionnaire based on a competence framework of engineers (see details in section 2.2 and 2.4). As we used the questionnaire to follow the procedure of semi-structured interviews, we had some freedom in how the interviews were conducted. To best possibly account for the fact that workshops bringing together several experts did not seem feasible, we used the freedom during the interviews to share some insights from other experts (who had been previously interviewed) with new interviewees to make connections between the different perspectives and statements even in this format of individual interviews.

Second, we mostly received positive responses to our call-to-interviews from experts working in the automotive and related supplier chain industry. Positive answers mostly came from the TUM network, which is located in Bavaria or Southern Germany. Thereby the more focused (country- and industry-wise) target group of interviewees to some extent generated itself. However, after careful consideration we decided that a focus on one specific engineering sector might actually beneficial for us to reach the project objectives. To this end, it should be noted that the present deliverable D3.2 from BoostEuroTeQ is intended to complement deliverable 4.3 in the ERASMUS+ funded EuroTeQ project, which in the meantime had examined the future competences of the professional engineer as well (in a quantitative online survey with 336 respondents from 16 different industry sectors). We use the same competence model as a theoretical groundwork, and based on that, we saw the present deliverable D3.2 as an opportunity to aim at more profound and in-depths results. So rather than having the same holistic approach aiming at a wide spectrum of higher-level competences for various engineering disciplines, our approach allowed for more specific derivations about the developmental needs of engineers in a certain engineering sector. As a result, the two needs analyses of EuroTeQ D4.3 and BoostEuroTeQ D3.2 can be seen as truly complementary, using two different approaches to the same question (a generalist quantitative and a more narrow qualitative research method, respectively). While we focused on the automotive sector and the related supplier chain industry in one country, we argue that our approach covers many relevant perspectives in investigating the developmental needs of the professional engineers of the future. Our approach showcases a procedure how to gain an in-depth understanding of the future competences which is easily applicable to other sectors and countries. The interview guideline of the present deliverable D3.2 can be used for any engineering discipline, because it separates technical and personal/social competences.

In summary, we deviated from the original intention of a multi-perspective needs analysis (a) for practical reasons (i.e. lack availability of experts for joint workshops) and (b) due to the ultimate goal of the deliverable, which was to create additional insights into the developmental needs of engineers (i.e. a different and more focused approach made sure that we do not double work of D4.3 of EuroTeQ).

The resulting narrowed focus on one engineering sector and one country will be addressed in the second part of the project with the following measures that aim to complement the work that has been done so far:

(a) The resulting upskilling course (see next deliverable in BoostEuroTeQ D3.3) is offered throughout the whole university network and participants from all the different countries are invited to participate. All participants of the BoostEuroTeQ upskilling course take part in the respective course evaluation, which provides the opportunity to collect additional data to understand the developmental / upskilling needs of the engineers more widely.
(b) The exchange with the EuroTeQ WP4, that has also analysed future competences of engineers in Europe (in EuroTeQ D4.3), has been strengthened and will be further intensified to understand upskilling needs of the engineers more widely and to make sure that future work in BoostEuroTeQ continues to complement the work in the EuroTeQ project.
(c) Within BoostEuroTeQ, the work on a developmental needs analysis as it was presented in this deliverable will serve as a case study for prospective Learning Professionals (trained at the partner universities to facilitate knowledge transfer between academia and industry; work package 2 in BoostEuroTeQ). The Learning Professionals will be encouraged to use the procedure and interview guideline in this deliverable to gain additional insights into the upskilling needs of engineers in their country / other industries.

2.7 Evaluation method, limitations and expectations

The analysis of the interviews was conducted by the reference to the methodological competence areas mentioned beforehand (2.2). The twelve interviews were transcribed with the tool “Amberscript”, which uses an AI technology meaning that this process was done by a machine and improved by the scientist in person. The automatically produced transcripts were analyzed with the assistance of the software “MaxQDA”. This software maintains the standard in qualitative research scenarios and is quite popular within empirical social research. The interviews were coded by one person whereby the codes used reflected the competence areas. For instance, a quote from an expert was given the code “technical competences from first study”, when the person was talking about the skills, which they learned during their studies and which they still considered useful. All the interviews, extracted fitting statements and the matching codes were commented by the researcher and summarized in a synopsis of competence areas (cf. Annex 3-5). The results are subject to certain limitations. Most importantly, as has been stated, the interviews aimed at a theory-generating approach and thus a rigid focus on frequencies was less important, rather than getting new insights and first-hand information from the target group itself.

3. RESULTS OF THE ANALYZED INTERVIEWS

This chapter summarizes the findings on competence areas in the order of technical-methodological, social-communicational and personal competences. The subcategories of the SHL framework are also included. Annex 3-5 provides an overview of comments linked to statements from the interviews regarding this competence area.

3.1 Technical-methodological competence area of engineers

All participating experts mentioned the ***technical knowledge from their engineering studies*** (mechanical engineering, electrical engineering) as very useful for their current job positions or the jobs they had exerted in the past. Regarding the question “which specialist knowledge is still most useful at the moment from their studies”, a noticeable minority brought up that they wished they had been taught more theoretical knowledge and less technical procedures. Moreover, obtaining soft skills acquired in the group work assignments during the studies were most profitable for one expert in his current job. Especially the participants who are now filling a management position, mentioned that the engineering knowledge from their studies becomes less useful for the current managerial tasks.

As a consequence experts ***gained further knowledge*** during their career in a variety of topics. Starting with the technical knowledge, the experts deepened their knowledge due to particular challenges that popped up during their work, i.e. concerning topics such as electrical engineering or chemical processes for electric mobility development or data analysis. More than half of the experts mentioned not only technical knowledge but also learning internal business processes (with the use of specific software), Microsoft Excel for managing tasks, or problem solving techniques like the sigma belts.

Focusing in the third category, the current ***knowledge gap*** that experts describe as their own or for engineers in general can be summarized like this: knowledge in IT and programming (without any further specifications) was stated several times as a desired skillset. Mostly the experts referred to the ability of using cloud technologies or programming skills to develop the ability to analyze big data sets. One expert mentioned to be already practicing to write SQL queries in order to be able to receive crucial data. Furthermore, a systemic thinking of a sound product management including all aspects within the current digital transformation seems to be required. In addition, another aspect is discernible: mechanical engineers seem to reveal a lack in knowledge about programming languages and electrics, and at the same time, companies desperately try to hire good computer scientists, who have little technical knowledge and overview over vehicle functionality. This implies that the current development towards an increasing importance of IT knowledge raises the question – this aspect was also brought up by an interviewee - , to what extent an engineer is supposed to program and analyze data in order still to exhibit an engineering profile. Next he mentioned to upskill computer scientists with a systemic technical

understanding of electric cars vice versa, seems to be the easier way right now, but it would not reflect the target audience of the deliverable.

In order to effectively work as an engineer, the experts mentioned that they are facing more complex scenarios (VUCA world[41]) and therefore they need to work in an agile teams while also using these methods. To make crucial technical and business decisions, engineers not only need to know how to solve problems on a technical level, but also whom to approach in their network, assign tasks to specialists, act in a self-organized way, and broaden their point of view from an isolated technical part to a systemic view of the whole product. Moreover, a constant focus on the customer and a user-centric perspective were mentioned as required skills.

Besides, intra- and entrepreneurial thinking were named as essential competences consistently by the participants; first and foremost, obtaining a good relationship with customers, being open to fast changes, and living a culture of error, whereby errors can be made to the extent that economic loss is kept within limits.

When asking for ***future skills*** we referred to the future scenario of the automotive sector in 2030 (see 2.2) and asked participants to derive possible skills of engineers in five, ten and to fifteen years. A few times, the experts mentioned the application and high importance of AI in order to receive data on which product and business decisions can be based on. According to the experts, along with existing challenges in the automotive sector, future skillsets can be derived such as the ability to detect, analyze and interpret data. In this context, the knowledge of mechatronics, signal and data processing, circular life cycles of a software and hardware product and programming skills for autonomous driving seem in high demand. Moreover, according to the experts, the engineering job profile is characterized by an agile and flexible thinking, having engineering skills in a broad, rather than in an artisanal sense plus software product development and systematic methods. Another hypothesis from the experts counteracting the increasing importance of programming skills, was the expected development of AI aims in the long term (ten to fifteen years) to the point that the engineer of the future will need less skills in data analysis and will be able to focus more on other skillsets like product management or user-centric procedures to create a mobility service, rather than just a car.

Focusing more on the ***digital skills***, a few experts also mentioned the skill to work and collaborate with digital tools and maintain the productivity during the shift towards virtual or remote work during the pandemic, especially for engineers within the age span of 50 to 65 years. To list a few concrete examples, the use and apply of simulation software (MATLAB), CAD and vendor applications, life-cycle-

[41] Cf. Pechstein, Arndt: Hybrid thinking – Zukunft neu denken in Zeiten des exponentiellen Wandels, in: Spiegel, Pechstein, von Hattburg, Grüneberg (Eds.): Future skills. 30 zukunftsentscheidende Kompetenzen und wie wir sie lernen können. Munich 2021. p. 20-27, here p. 20-21.

management tools, diagnosing semiconductor with the associated applications or command and control of technology.

3.2 Social-communicational competence area of engineers

To understand the disposition of a person "to act communicatively and cooperatively"[42] and reveal their social-communicational competences, the interviewees reported that transparency in leading and involving the team, agility and the willingness for change as well as empowering diversity are useful characteristics, when it comes to ***leading and deciding*** issues. Moreover the experts stated that empowering the individuals in your team has a leverage effect on the productivity. In order to lead it seems important to have a vision for the team and the product, be empathic and overall be mores-setting. A single candidate mentioned expertise and authority still to be a crucial asset for leading skills. An expert from a big OEM reported that the trend of people managers who lead a team only from a social perspective does not work as expertise and knowledge are still required to estimate certain decisions.[43]

A competency component of ***supporting and cooperating*** are *values and social skills*. Humility, sincerity, working on eye level, mutual support and team spirit, as well as caring and being empathic as a team leader are required but also effective values to build a team nowadays. Within the team, high social acceptance and conflict management and an open error culture are highly appreciated. Especially agile values, i.e., transparency, low hierarchies and a sharing culture were mentioned as well. During the pandemic, a loss of team spirit and social bond was lamented by some interviewees. One expert mentioned a deep connection to colleagues and customers as one of the highest values nowadays. Similarly, one expert recommended the establishment of prosocial architectural office structures to boost social exchange and relationships.

Additionally, in order to solve problems a necessary tinkering mind-set, curiosity and positive thinking were mentioned as prerequisites to succeed. ***Values*** were also understood in a societal context, such as values of sustainability or biodiversity, which could have a motivating effect on employed engineers to work efficiently.[44]

[42] Erpenbeck, p. XXV [translated by the author].
[43] Cf. Annex 4.
[44] Ib.

3.3 Personal competence area of engineers

In order to analyze the personal competences of engineers, i.e., “the disposition of a person to act actively and holistically in a self-organized manner and to direct this action to implement intentions, projects and plans”[45], the experts were asked personal questions and name personal examples from their career. Alongside the competence domains “creating and conceptualizing”, “organizing and executing” and “adopting and coping” were included together with “motivation and interest”.

Coping mechanisms also refer to ***emotions*** of people.[46] When addressing emotions, the experts reported that emotions can be expressed in showing enthusiasm for work or in bonding with team members. One interviewee stated that emotions do not dominate decisions yet, but he’s often tempted to be influenced by them whereas in the end, decisions during work are made on an objective level.[47] Another expert mentioned that he reveals emotions, when he has a deep conviction about a topic and wants to influence a decision.

The ability to interact and cope with people from different cultural backgrounds ***(intercultural competence)*** seems inevitable for the interviewees these days and can produce new ideas on products and also make business with customers on a global market possible. One participant emphasized the advantage of different cultural quirks, i.e. a positive attitude in American culture and a penchant for creativity among Europeans.[48] Merely one expert brought of the point that intercultural diversity is not a game-changer.

Furthermore, interviewees were asked about the importance of ***creativity and conceptualization*** abilities as well as their attitude towards ***(lifelong) learning*** *(designated as self-regulated learning in the interview guide)*. Creativity was mostly appraised as an added value, but not as a default. Hence, the mere existence of creativity was not assumed to enable a team to work properly. Beyond that creativity is seen as useful, but as a stable characteristic (cannot be taught) that is highly valuable for the expert from a start-up-perspective. When it comes to the question of how to learn and develop new skills, experts reported either that they were limited time-wise in attending trainings or qualifications, or that in big OEM the resources for HR measures had been trimmed down due to the pandemic economic situation. When naming effective trainings on the job, smaller learning units seem to be effective, especially for younger people, offering a space for individualization. Small digital learning units using a LMS or short online tutorials with instant application scenarios would work best. In that context, learners could be motivated to be creators of learning material while sharing it in a community and having active dialogues about solving problems and generating new insights. Without naming an age range, older people seem to tend to on-site formats and are harder to motivate for online learning activities based on

[45] Erpenbeck, p. XXV.
[46] Cf. Prifti, p. 61.
[47] Cf. Annex 5.
[48] Cf. ib.

the reporting of an HR expert. Some people referred to classic search engines like Google and YouTube to deep dive into an issue, when facing a specific challenge. An academic input was also seen as enhancing knowledge within an intercultural setting.[49]

4. KEY RESULTS AND DERIVATIONS FOR UPSKILLING STRATEGIES

In short, the ***technical-methodological competences*** and ***future skills*** discussion could be summarized as being able to sovereignly collect, steer and utilize data-driven processes and having the necessary informatics knowledge while not essentially having a technical engineering background. As a consequence, two job profiles of experts working in the automotive industry will be quite likely: (a) "classic" mechanical engineers, who deepen their general informatics knowledge in the basic functionality of emerging and relevant technologies and (b) IT-experts, who are strong in programming specific products and applications while having the minimum requirement in technical expertise in order to understand the hardware of a car. These findings are in line with assessment of the WEF report (cf. 2.2). Therein "AI" and "Big data analytics" are mentioned besides "encryption and cyber security" and "IoT" (not specifically mentioned by our experts) as likely to be adopted by 2025 inside the automotive sector.[50] Moreover the report cites a likely transition for engineers moving towards "Cloud Computing", "Data and AI", "Product Development" and a likelihood of staying in the STEM field of 20-30%.[51] Again most of these findings align with the results from the conducted interviews.

What can be derived from that are considerations for lifelong learning activities for engineers of the future, but also framework conditions under which these upskilling or reskilling activities should take place: One factor, which needs to take place in big OEM, would be the change of mindset mentioned by an interviewed expert with a background in IT who suggested that IT specialists should be implemented on every process level and not just as problem solvers. The digital transformation in big companies should be continued with the involvement of computer scientists, establishing a new sense of appreciation of this expertise next to "classic" hardware specialists. In addition, agility, flexibility and the willingness for self-regulated learning seem indispensable combined with an attitude of "bias for action" and "diving deep" before submitting a task.

[49] Cf. ib.
[50] Cf. WEF: The Future of Jobs Report 2020, https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf, p. 27-28.
[51] Ib. p. 33-34.

As a result for lifelong learning activities, a first possible approach could be to show the rise of various specializations and job profiles for engineers, give guidance and feedback to their personal competence profile and developmental areas in form of a self-assessment tool. Additional small steps towards the goal to qualify engineers in that way could include for example learning to write SQL queries in order to be able to get crucial data. The interviewed experts talked about a non-specified knowledge gap in IT and programming which the WEF report might add the missing information to: Accordingly, within engineering jobs, Python developer, Full Stack Engineers, JavaScript Developer or Backend Developer might be emerging roles.[52]

When looking at the ***social and personal competence*** area, motivation based on contemporary values of new work is needed in order to manage rapidly changing working environments of engineers in the automotive industry. Low hierarchies, conflict management abilities, empathy, visionary thinking and an intense cooperation between interdisciplinary colleagues could be generalized to other industry sectors. The abilities to be future-oriented, flexible and seeing change as a constant factor, where lifelong learning and self-motivation is needed could be seen as pivots for engineers in general, whereupon a technical specialization follows after.

5. IMPLICATIONS FOR BOOSTEUROTEQ AND EUROTEQ

Based on the findings of the present deliverable the next designated steps are to develop a synopsis with the quantitative research results from EuroTeQ 4.3 (mapping the EuroTeQ professional) and initiate further measures within the involved University partners of the Boost-Work package group (TUM, DTU, CTU and other universities). The internal next steps of WP3 include the development of future engineer profiles, the associated “future” skills or competences, the precision of technical content, the naming of learning objectives and development of a scalable program within the network (D3.3). While doing that a multi-perspective view through the different universities and expertise might be a valuable option. When proceeding, it is important to have the offerings from competitors and already existing programs of professional education institutes within the EuroTeQ alliance in mind.

[52] Ib. p. 32.

6. REFERENCES

Action Plan D4.3 EuroTeQ Professional, 30.06.2021

AgenturQ: Future skills: Welche Kompetenzen für den Standort Baden-Württemberg heute und in Zukunft erfolgskritisch sind. 2021, in: https://www.agenturq.de/wp-content/uploads/2021/10/2109091_Broschu%CC%88re-Future-Skills_FINAL.pdf, 09.08.2022

Bayern innovativ (Ed.): 2030: Automobilindustrie in Bayern, https://www.bayern-innovativ.de/de/netzwerke-und-thinknet/uebersicht-mobilitaet/seite/wie-sieht-die-automobilindustrie-im-jahr-2030-aus, 12.08.2022

Bogner/Littig/Menz (Eds.): Interviews mit Experten. Eine praxisnahe Einführung. Wiesbaden 2014

Deci, Edward L./Ryan, Richard M. (Eds.): Intrinsic motivation and self-determination in Human Behavior. New York 1985

Ehlers, Ulf-Daniel: Future skills turn, in: https://nextskills.org/future-skills-overview/future-skills-turn/, 08.08.2022

Erpenbeck/Rosenstiel/Grote/Sauter (Eds.): Handbuch Kompetenzmessung. Erkennen, verstehen und bewerten von Kompetenzen in der betrieblichen, pädagogischen und psychologischen Praxis. Stuttgart 2017³

Kirchherr/Klier/Lehmann-Brauns/Winde (Eds.): Future skills: which skills are lacking in Germany. 2018, https://www.future-skills.net/which-skills-are-lacking-in-germany, 09.08.2022

Pechstein, Arndt: Hybrid thinking – Zukunft neu denken in Zeiten des exponentiellen Wandels, in: Spiegel, Pechstein, von Hattburg, Grüneberg (Eds.): Future skills. 30 zukunftsentscheidende Kompetenzen und wie wir sie lernen können. Munich 2021, p. 20-27

Pittich, Daniel: Dispositional approaches for measuring professional competence, in: Journal of Technical education, Vol. 2 No. 2 (2014), https://www.journal-of-technical-education.de/index.php/joted/issue/view/4

Pittich, Daniel: Kompetenz als Zielperspektive technischer Bildung, in: Zinn/Tenberg/Pittich (Eds.): Technikdidaktik. Eine interdisziplinäre Bestandsaufnahme. Stuttgart 2018

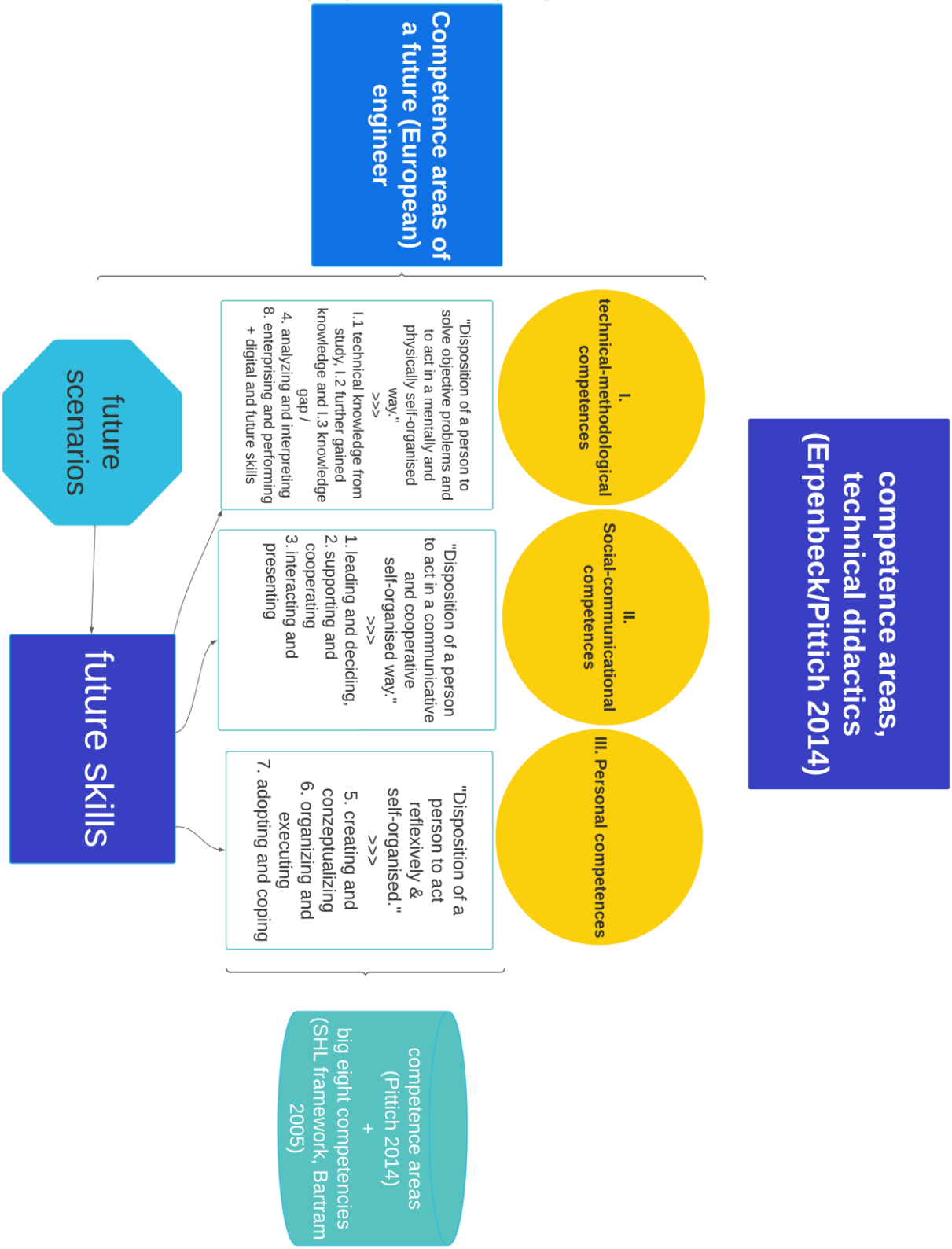
Prifti, Loina: Professional qualification in „Industrie 4.0: Building a Competency Model and Competency-Based Curriculum. 2019, http://nbn-resolving.de/urn/resolver.pl?urn:nbn:de:bvb:91-diss-20190215-1447234-1-0, 11.08.2022

Spiegel/Pechstein/von Hattburg/Grüneberg (Eds.): Future skills. 30 zukunftsentscheidende Kompetenzen und wie wir sie lernen können. Munich 2021

World Economic Forum: The Future of Jobs Report 2020, https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf, 20.08.2022

7. ANNEX

Annex 1: Illustration 1 and concept by Patrick Lenz (2022)



Annex 2: Interview guide | Upskilling-Strategies of future engineers

Name interviewee:
Name interviewer:
Date, time:

Introduction part (standardized, read off):

Thank you for supporting us with your expertise in identifying the contents and competences for the future skills of specialist engineers. Our work package in the project "BoostEuroTeQ" wants to scientifically research and practically implement qualification possibilities on the existing needs.
In this step, we focus on the competences and needs of engineers from the automotive industry.
The aim of our discussion is to sharpen together with you your work tasks and your personal assessment of the change in your industry.
<Start Recording>
We have about 60 minutes and will discuss different aspects together. We would record the interview and analyze it anonymously afterwards. If you want to stop the recording at any point, please let us know.
Do you have any questions beforehand?
Then I now look forward to the conversation and start the recording.
<LAST OPTION TO STOP THE RECORDING.>

Semi-structured interview guide

Welcome, background of the person	
- Introduction Name, age, academic background, current position *- Private life circumstances, voluntary only*	• Please introduce yourself briefly. What is your name? How old are you? What is your academic and professional background and what is your current position? • How would you explain your current tasks to your grandmother?
Competence areas and categories	
Technical-methodological competences (T)	

Technical knowledge, digital skills & IT knowledge *Self-regulated learning / 5. Creating and conceptualizing*	1. What interests you the most on your current profession? 2. Which specialist knowledge from your studies do you find most useful for your work today? 3. If you were to leave university today, what specialist knowledge and skills would you wish you had learned? 4. What specialist knowledge and skills have you developed in your professional career since leaving university? - Why? 5. Where and how did you learn additional specialist knowledge and skills? (5. learning and researching) 6. Future skills: Probable future scenario 1&2: Which skills for engineers will gain more importance in regards to these mentioned scenarios? Which engineers should engineers at the moment, who you would hire?
Social-communicational competences (S) & Activity and implementation oriented competences (A)	
(4) Analyzing and interpreting: Problem solving, Analytical skills, cognitive ability…	*(4) Analyzing and interpreting: Problem solving, Analytical skills, cognitive ability…* 7. What helps you most to master challenges at work? a) Your professional knowledge from your studies b) The exchange with colleagues c) Your personal qualities and character traits - what are they? d) Other? 8. How do you go about solving new challenges in your professional environment? (A) - Have there been moments in the last five years <u>when you were not well prepared</u> because of your prior knowledge? What were they? - Can you describe how you handled the situation?

	- Could you resolve them today? What qualification would you have wished for at that time? 9. Were there moments in the last five years when you <u>were very well prepared</u> because of your previous knowledge? What were they? Why were you able to solve the task well? (A) (10. Do you feel that you are learning on the job while solving problems? - What do you learn?)
Personal competences (P) & Social-communicational competences (S)	
Ethics and values: • *Environment* • *Sustainability* • *economical: profit maximisation* • *Societal impact* • *…* *Social-communicational:* *Problem solving (Analyzing > 4. Analyzing and Interpreting)* *2. Supporting and cooperating* *3. Interacting and presenting* • *organizing and executing* *7. Adapting and coping*	*(2) Supporting and Cooperating: Teamwork, Collaborating with others, Communicating* 11. Which values are important for the successful performance of your job? (P) 12. Describe a situation where working with other colleagues has helped you. (S, A) - How often do such situations occur? *(3) Interacting and presenting: Emotional intelligence* 13. Do you feel able to convince other colleagues with your thoughts and moods at work? (A, S) 14. How important are your thoughts and feelings at work to you? (P) 15. Describe a situation in which you let your feelings or moods influence your work. (P, A) 16. How often do you have such moments or situations in your daily work? *(7) Adapting and coping: work in interdisciplinary environments, intercultural competency, flexibility, adaptability* 17. How important are contacts and experiences with colleagues from other cultural and linguistic circles and other disciplines for your work? (S, P) - How do they influence your work? 18. How important are professional networks for your performance on the job and your personal development? (S)

PAUSE (5 Min.)	
Personal competences (P)	
1. Leading and deciding *5. Creating and conceptualizing* *8. Enterprising and performing*	*(1) Deciding and Initiating Action, Leading and supervising -* ***Only if person has leadership responsibility*** 19. How crucial do you consider the leadership skills in your field of activity to be in the next ten years? (such as active listening, ability to give feedback and criticism, empathy, communicating decisions) (P, S). *20.* Where and how do you take responsibility in your role? (specifically meant as enthusiasm, decision-making skills, proactivity, entrepreneurial thinking) (P) *(5) Creating and conceptualizing: Learning and researching, creating and innovating, formulating concepts and strategies* 21. What is the role of creative and conceptual thinking in your job? (e.g. innovative thinking, change of perspective) - Can you give an example from your work? *(8) Enterprising and performing: self-management and -organization, entrepreneurship* 22. Do you personally set yourself specific goals regarding the tasks in your daily work? (made concrete in working efficiently, being results-oriented, structured, flexible and adaptable) (P) - If yes, how satisfied are you with your goal setting and achievement? *23.* To what extent will areas such as "entrepreneurship" play a role in your field of activity in the next five years? (P) *Project management:* 24. How does project management change in itself and what is needed for future result-oriented-work?

	Self-Regulated Learning (motivational and meta cognitive strategies) (P) / 5 creating and conceptualizing: learning and researching 25. Have you already thought about taking part in further training / continuing education activities? - Why? How did the thought come about? (external, internal factors) - Where would you like to continue your education? (university, non-university institution) 26. How do you imagine your perfect working and training environment? 27. What should a training program look like that you would definitely take part in? 28. What could technical universities provide in order to increase the level of qualification of engineers?
One last concern: Would you be interested in participating in a group discussion with the other experts after finalizing the interviews? *[Yes / No]* Then thank you very much for the in-depth conversation and your personal insights.	

Annex 3: Interview evaluation competence area I.

	knowledge from first study	further gained knowledge	knowledge gap	future skills	digital skills	4. analyzing and interpreting	8. enterprising and performing
I. Technological-meth.	Nothing is useful anymore for the management position; basics of engineering	insufficient application of practical parts	combination of it and software know how	computer scientist with engineering knowledge is more needed than vice versa	IT knowledge, AI and the application; know how in automotive manufacturing	agile working methods to be successful	economic challenges require a more agile work than long term planning
	business operations for factoring processes, quality management, automotive engineering, thermo dynamics	e.g. constructing a harness, a printed circuit board, computer based drawings, electrical circuits	more IT knowledge	technical knowledge from studies cannot be replaced or left out for a swap with digital skills	mechanical engineers is obliged to learn IT knowledge	planning needs to be agile in a vuca environment; Chinese planned economy as a counter example	entrepreneurs hip as an essential competence
	fundamental important theoretical knowledge of mathematics, switching technology, digital technology	craft activites, i.e. soldering, cutting a cable	workshop, presentation techniques, digital work	connectivity as a future demand	practical skills of an engineer in knowing how a processor or printed circuit board is constructed; simulating a matlab	solving challenges: complex reconciliation with colleagues and the team	entrepreneurs hip as an essential competence for added value
	basic knowledge about IT, realizing it projects himself, the more responsibility the more management skills, IT knowledge at universities still at a contemporary state of the art	difficult to invest in further gained knowledge (phd) because of time restrictions and non combinable theoretical and practical knowledge	technical vocabulary in English	agility	testing and simulating in virtual environments	analytical problem solving	basic knowledge in how to build a company

	broad knowledge in engineering studies; german planning of engineering projects as a strengths for foreigners	deepen understandings of electronics while also understand the complexity of processes in an enterprise	intercultural competence	chances in software driven businesses for new start ups	(it specialist): my people have to know how to code, understanding software architectures, basis technology, open source, cloud techn., automotive specifications; products for the automotive and embedded software spec. E.g. function safety	step by step analysis	entrepreneurial thinking much more needed in start ups than big OEM
	knowledge in chassis, dynamics of machines, electrical engineering, steering and braking systems	mentoring	effects of home office working culture on productivity and cooperation		knowledge gap in how to integrate IT and exploit most of the potential for a coherent digital transformation strategy	pressed for time in order to perform	suppliers wish to obtain a mutual partnership
	literature and youtube videos (> I.2)		IT experts who have little technical knowledge and overview over vehicle functionality and the other way round. An engineer with too little knowledge in IT		software development, programming languages (HR is not sure which aspects to focus on)	technical analysis needs to be enlarged with a user-oriented perspective (e.g. gender of the user)	the relevance for entrepreneurial thinking for executives is higher than for qualified employees

	fundamentals in physical mechanics	excel as a compromise solution to compensate lack of programming knowledge also value-added chain and business administration	older colleagues have to develop in the direction of digitalization, the younger ones in the direction of expertise	shift from mechanical engineering and electrical engineering towards data science but also control engineering for autonomous driving	within the specialization in corporate contexts a flat hierarchy is needed to stay productive	user-centric perspective over technical perspective	error culture is a question of mind-set, but the line is drawn where economic backlashes can evolve
	soft skills acquired in the engineering studies are most profitable for current job, e.g. project management, organization of work	intercultural understanding to be competitive on a global market	it knowledge has to be extended in the area of mechanical engineering and also in the occupation area of business admins	not future scenario but happening right now	systematic thinking and know who to ask for special digital knowledge	self-organisation	
	immersion in manufacturing engineering and operations management as interesting, but hardly very helpful		knowledge gap in cloud technologies, agile methods, cloud native development, application of relevant software systems in corporate contexts / stronger intro to enterprise applications	lightweight design as a future scenario, whilst additive manufacturing, industry 4.0, autonomous driving, individualization are missing	product development and automation processes from different perspectives but leading to a final product. The necessary knowledge is needed in terms of digital skills	user-centric perspective in a real scenario	
			more IT programming knowledge, business administration for engineers and finance	Agility and more flexibility from OEM are needed	deeper understanding of semiconductors, computer science, command and control technology	technical analysis of a problem and directed approach of specialists in the team	

	reducing the technical aspects of a study and deepen the theoretical abstract part plus the entrepreneurial input		mechanical engineers reveal knowledge gap in programming languages and electrics; internal corporate processes in an OEM	change in appreciation of IT knowledge in mechanical engineer dominated spheres is needed; hardware driven approach as an established process has to be changed in order to create synergy with IT development	project management apps	testing multiple hypothesis	
	thermodynamic as a helpful asset for understanding new processes in e-mobility	intagible knowledge taught in the university assisted the everyday work		integrate IT competence on all levels in an OEM, not just as an add-on		using data and analyse the mechanical problem	
	attempts to teach agile work in university	problem solving techniques like six sigma or red accs.	more programming skills and ability to analyse data sets; more focus on value-added chains in the study	outsourcing of IT processes to i.e. Indian companies as an unfortunate avoidance to build own it capacities	cloud working	knowing the right person / expert	
	constructing is the basis of everything, which occurs in the current job. Physics of an automotive, thermodynamics and simulations in order to enterprise		expert in mechanical engineering sees his abilities in developing electronical simplifications and making his position obsolete	lifelong learning attitude	CAD and software, Vendor	auto didactical learning of new special knowledge in order to solve a problem	
	electrical circuit design	knowledge in vehicle construction, C02 and sustainability learned in an OEM	computing, focus on software processes; application of AI scenarios	agility and flexibility, because products and customers are in constant change still; therefore understanding of digital transformation and software application scenarios		support of colleagues, read literature	intrapeneurial thinking
	focus on microchip development	vehicle physics as an enlarged competence area, which now is crucial for business decisions.	computing with big data as the biggest potential	systematical thinking how a car can be implemented in a software environment		thinking outside the box	20 years ago it was already in high demand

	construction management and building law	electronical engineers learns in the first few years about the vehicle functionality (macro system of a car) and gain skills in abstracting things	product and software development; knowledge in special corporate tools and the network aspect of corporate software systems	Electrical engineering and software knowledge	analysing data sets, simulations, networking	problem management process (internal)	good relationship with customers
		knowledge in combustion engine and so be able to combine electrical consumption to save fuel in the engine	easy approach to knowledge in how to apply AI	agile	model characterizatio n and classification	software analysis	
		knowledge about the mechanical construction of plastic parts	education scenario in the scope of one year to shift the focus from mechanical to data knowledge and show paths for specialization	in the next two years it is foreseeable mechatronics and interdependencies and data driven development; not a single formula defines the product but a mixture of automated permanent collected data	software driven product needs skills accordingly	broaden the view to a socio-technical one	
		trainings and seminars provided by the company in construction management	show learning paths to older, left-behind experts	in the next five years: circular life cycle of a product, hardware and software processes are uncoupled, so hardware is set, software is to be chosen		software and hardware / mechanical interaction	
		changes in legal basis	analysis of data driven systems	in ten years: completely individualized car	life cycle management tools like PTC		
		plant manufacturing	SQL queries in order to get the desired information	the more complex situation will be dissolved in having a AI software where the user does not have to know algorithms and data sets			
		processes at a supplier, in the in house manufacturing and change knowledge	basic knowledge in data science and generating SQL queries to be more autonomous		diagnosis of semiconductor application		
		emission model	software skills in order to be able to make reliable answers	mobility as a service concept; completely individualized cars			

		learning about data collection and data networks as well as ability how to deal with change; wishes to have gained more knowledge in system engineering	systematic rather than an isolated technical approach to product solutions	signal processing and data processing			
		auto didactical acquisition of knowledge in chemical processes (chemical reaction engineering area)	interdisciplinary approach in engineering subjects, i.e. the combined approach of aerospace and automotive engineering technologies	which data needs to be entered in a system is the question nowadays; shifts to an analysis of data			
				cloud technology, blockchain (not a long term trend)			
				current mix of engineering and software know how will be to complex in the future so it needs to be separated			
				new job profiles e.g. apprenticeship in IT and working with automotive engineers; so the current merging of competences will be dissolved in the future			
				general systemic thinking and be more independent from a single product responsibility			
				product development tools and their application based on automotive standards			
				car is seen as a commodity and carrier of software features			
				engineering skills in a broad sense plus software product development and systemic thinking for the product and the target group; implementation of innovative ideas as an advantage in Europe			
				in depth knowledge not needed in practice; less artisanal knowledge needed in the future			
				clear communication of industrial requirements for students before they start a job			
				enable engineers to interprete data sets and include these insights into work processes			
				enable engineers to dissociate from mechanical systems and show possible career paths			

				target-group-specific proposals for the respective target group			
				which skills do i need in order to develop mobility concepts; customer-oriented thinking			
				empowerment of classic mechanical engineering and show further career paths without learning how to code			
				software development and data analysis			
				hands-on programming for functionalities like advanced diver assistance systems & data analysis for a distant maintenance			
				shortage in competence because automotive never invested in a mixture of IT and engineers			
				solid understanding of engineering and add digital or electrical competences on the top			
				strengthen self-regulated learning			
				design, create and build technologies in-house, e.g. semiconductors			
				security of systems			
				simulation of processes rather than testing			

Annex 4: Interview evaluation competence area II.

	1. Leading and deciding	2. Supporting and cooperating	3. Interacting and presenting
II. Social - communicational	mores-setting; meaningful	humility and sincerity as values in order to build trust	presenting skills and convincing attitude
	empowering diversity	sustainability as a value for corporate acting	managing conflicts for executives
	agility, willingness to change; gender and challenges for men to come; compliance and bribery; data protection	biodiversity as a topic in the sustainable context	positive thinking
	transparency in leading and involving the team	team spirit and mutual decisions	tinkering, creativeness, questioning and handling a problem
	expertise and authority	supplier see equal footing as an aspiring value	
	taking decisions will be challenged by the interpretation of data for business decisions; beyond there is a feeling of established leaders how to decide	willingness to change and enable OEM to let bottom-up development happen	
	two principles: bias for action and deep dive	agile values, transparency, low hierarchy, networking and sharing	
	leverage the skill and the intelligence in your team; empower employees within a set framework		
		social acceptance higher than expertise as a value for younger leaders	
		open error culture	
	as a project lead you need to learn enterprising and deciding knowledge	team spirit and knowledge sharing	
		lack of creating a team spirit after the pandemic	
	empower people to be a good link	people manager without expertise won't work	
		use empathy in order to understand employees and align it to the company's mission	
	create harmony in order to reveal everyone's potential	work with people	

	engineers (people within a discipline) cooperate better than people lacking this special discipline	empathic and cooperating, cherish connection	
	be visionary; emphasizing the value of a topic for the company	mutual consecutiveness	
		really connect and interact with people is a high value nowadays	
	empathic leader to empower staff		
		mutual support and team spirit	
		caring as a value to demonstrate as a leader	
		performance of the team depends on harmony	
		curiosity	
		allow staff to connect with each other; design social architecture	

Annex 5: Interview evaluation competence area III.

III. Personal Competences	**motivation & interest**	**6. Organizing and executing**	**7. Adopting and coping**
	Sustainability as a value to motivate employees and create intrinsic motivation; sensemaking and good income	team supporting and self-organizing attitude	emotion driven decisions in both ways
	Visionary thinking in a team building environment / a self sustaining team	agility team work	emotions do not dominate decisions yet
	Open innovation, open source software as a value and motivation;	classical project management	intercultural competence needs mutual respect and esteem
	Non motivating environment: no freedom or support for a PhD or personal qualification of the employee	agile coaching in hands-on environment in high demand	intercultural approach reveals new perspectives on approaches
	to turn what I learned into something practical very different from university	networking within a company in order to build more effective teams	emotions appear ambivalent, do not bother, but can have a positive influence in the end
	second to be part of developing new products bring in something new or make a change, make an impact. Either it's increasing the safety or reducing the emissions or whatever.	solve dilemma between high quality standard and fast development; project management as a necessary evil	reveal emotions in form of deep convictions in order to force a decision
	Lifelong learning attitude from leaders to their staff; motivation to qualify within their company; 70-80% further training measurements are seen as mandatory; motivating, if certificates have a cross-company accreditation	English as a necessary form of communication	intercultural diversity does not make a game-changing decision
	To create a product, which thrills the customers and transform the once theoretical acquired knowledge into a product	agile work methods	adapt to constant change and the awareness of which skills are needed in the future

	People who are already working about five to ten years. They have a high self-competency but are low in empathy in what their colleagues might need in terms of qualifications / low in motivating abilities to others		cultural sensitivity
	Transformation as a motivation		health management, burn out prevention
	Speed and agility of new work companies		emotional intelligence
	General overview and leading role in the digital transformation		intercultural competences for expats
	Variety of tasks as a project lead		cultural sensitivity
	Motivation working environment: Freedom of exploration, creative atmosphere		emotional bond in virtual teams as a challenge
			cultural sensitivity with customers
			disconnected from emotional relationship with colleagues
			emotions as an intrinsic motivation
			express enthusiasm (emotions)
			intercultural competences inevitable
			divers, international team culture as a huge potential
			project management evolves to an ownership
			rapid development needs a good established team
			challenges have to be addressed by the leader like a trainer coaching a team
			intercultural aspects: positive thinking in the US, creative thinking in Europe,