NETKOM 4.0

Netcompetence
For A Digitized
Working World 4.0

Co-funded by the
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Intellectual Output O7

Development of Industry 4.0 competences in the EU context

This document contains a result from the NetKOM_4.0_v2 project.

It was created by the Europa-Universität Flensburg.

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Studies / Analyses - Good Practice Guides / Report

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1 Introduction

The concern of this analysis is related to the overall goal of the NetKom 4.0 project to professionalize teachers for the requirements of Industry 4.0. There is an interest in conditions that contribute to the success of teacher professionalization. What organizational and infrastructural measures are conducive to teacher training, for example? How can the transfer into the context of the own institution succeed? To what extent does the joint learning of teachers from different countries have an effect on professionalization? What difficulties, if any, also become apparent? On the one hand, these findings are important for the participating teachers, who will act as multipliers after the end of the project and carry out further training measures in their own institutions or beyond. In a broader sense, the results can contribute to improving the effectiveness of teacher training in general and can, for example, be incorporated into the training concepts of schools.

At the same time, the project partners in the previous project expressed a need for information on the actual skills requirements demanded on the labour market in the context of Industry 4.0 in order to justify corresponding learning concepts. The authors of studies on skills research in the field of Industry 4.0 share this problem and emphasise that there is still a need to identify skills requirements and, in particular, to discuss skills development opportunities (cf. Ahrens & Spöttl 2015). In other words, the connection between more or less certain knowledge about future labour market requirements and the learning pathways presented here, which are intended to prepare for these requirements, has not yet been adequately clarified. This article can contribute to clarifying the problem. Furthermore, a better match between the intended learning outcomes of VET programmes and the actual and future requirements of the employment system contributes to less mismatch and ensures a higher employability of VET graduates in the long run. Furthermore, it is necessary to locate the intended learning outcomes with suitable descriptors on the requirement levels in the context of the European Qualifications Framework. This can contribute to more transparency and support the further development of curricula of VET programmes in this context. The target group in this case is education planners at different levels.

From the teachers' point of view, there is also an interest in finding out to what extent the innovative learning concepts are suitable for performance assessments. This is an obligatory task that is usually neglected in addition to the provision of learning paths. In particular, there is a lack of procedures to validly test the "new" Industrie 4.0 competence areas presented. The results expected here can bring teachers closer to "good practice" examples, especially through collegial reflection, in order to transfer them to their own context.

2 Conditions for success of teacher training on Industrie 4.0 learning concepts

Various qualitative and quantitative methods, such as vocational observation, surveys and evaluation of the documents provided by the partners, contribute to the identification of facilitating and inhibiting factors of teacher training. This also includes the process of addressing relevant teachers and the necessary preparation. It is also envisaged that representatives of the biat can also take part in the training measure themselves and carry out a self-assessment as participating observers. Questionnaires with partly pre-structured areas (organisation, implementation, contents) as well as open categories will be prepared in advance. The results address both organisational and content/methodological aspects.

2.1 Pedagogical Double Decker in Teacher Education

Graduates of many training and further education programmes often have a common problem: they only insufficiently apply the expert knowledge they have acquired (cf. Wahl 2013, p. 9). Based on his own teaching experience, WAHL comes to the conclusion on the basis of various sources that this problem exists independently of the respective discipline. For example, students of business administration also have difficulties in applying their economic knowledge to problem situations, just as students of medicine find it difficult to carry out an appropriate diagnosis despite sufficient theoretical knowledge (cf. Wahl 2013). This problem is also blamed on initial and continuing teacher training; participants usually form "inert knowledge" that is not used to solve complex practical problems. WAHL's finding on the discrepancy between knowledge and action in teacher education is even more disturbing. Teachers apparently possess very stable subjective theories on the basis of which they carry out actions. Wahl describes a person's biographically acquired knowledge as "subjective theories" (cf. ibid., p. 17 f.). These theories prove to be resistant, further education and training projects rarely unfold a change. WAHL cites biographical reasons. Teachers often insist on tried and tested patterns in their teaching, new structures that guide their actions only bring about change in exceptional cases (cf. ibid., p. 12). The theories from teacher training at universities seem to be given little consideration in practice. For WAHL, the experiences from their own school days are important, in which today's teachers experienced dominant methods, e.g. questioning-developing lessons, as learners themselves and continue to do so today. Alternative didactic concepts have a hard time asserting themselves.

How can this gap between inert knowledge and competent action be overcome? WAHL comes to the conclusion that an appropriately designed, action-psycho-logically based learning environment is needed (cf. ibid., p. 16). He describes seven different approaches to make the "subjective theories" workable (see Wahl 2013, p. 45).

The "pedagogical double-decker" is a principle that has a special significance in educational work (cf. Geissler 1985; Wahl 2013, p. 65). The reason is the doubling of teaching and learning processes. In teacher training, the content to be discussed is directly tested in the seminar (cf. Wahl 2013, p. 64 ff.). The cognitive examination of a topic takes place through one's own experience. "One's own subjective theories as well as added scientific theories are used to interpret the experienced events." (ibid., p. 66) With this method, WAHL points to a high "chance of awareness" through the connection of two subjective theories. On one level, real action takes place, which causes thinking, feeling and acting. On the other level, the experienced events are reflected upon

- with the inclusion of one's own subjective as well as other scientific theories. "The participants experience first-hand how the intended action 'feels'" (ibid., p. 66). According to WAHL, the transfer to one's own field of work and its reflection allows alternative ways of acting to be understood much more quickly than if they only remain on a theoretical level (cf. ibid., p. 67).

2.2 Targeting teachers with precision

One element of the teacher training is the so called "pre-workshop webinars". They form the introduction to the overarching teacher training concept. Following the principle of the "pedagogical double-decker", the pre-workshop webinars are intended to flank the holistic experience of the practical exercises to be carried out with "planning action" in advance (cf. Wahl 2002, p. 236).

Pre-workshop webinars are online events. They are conducted by the respective partner institutions. The webinars are held approximately 1-3 months before the joint staff training event. An overarching goal of the workshops is to find the right addressees in the participating institutions. On the one hand, this is because a wide range of topics are offered in the context of I 4.0 and appeal to different teachers. On the other hand, the project aims to involve as many teachers as possible in the international cooperation. This ensures a higher dissemination and also makes it possible to distribute the additional time required in the colleges.

The content of a pre-workshop webinar usually consists of the following elements:

- Presentation of the partner institution including educational offers, number of pupils, teaching staff, partners, geographical location, etc.
- Introduction of the team of teachers with professional backgrounds and areas of work
- Presentation of the subject matter, classification into school types
- Presentation of the schedule of the training week (Joint Staff Training Event)
- Explanation of the competence requirements of the participating teachers
- Explanation of tasks to be carried out by the participating teachers prior to the training week
- Necessary material/equipment to be brought to the training week by the participants.

The agenda of the webinar is sent to all teachers of the participating partner organisations with the invitation in advance. This allows for a large group of participants, which is not limited to a certain number of participants due to the online implementation.

Insights from the pre-workshop webinars

Due to the online format of the pre-workshop webinars, all teachers of the participating institutions were informed about the events and those interested were invited. The result shows that first of all the teachers closely involved in the project or responsible for the project attended the events. In addition, other teachers not directly involved in the project were reached in the respective institutions.

After the webinars, both the participating and the lecturing teachers were interviewed about the webinar. Approximately 95% of the respondents stated that the webinar enabled them to assess the relevance of the following training event for their own work. Around 90% see this type of advance notice as more suitable for assessing training offers compared to conventional formats. The webinar motivates teachers and enables them to clarify administrative aspects at an early stage.

Adaptation of content

Another advantage of the upstream webinar is the inclusion of desired content. The participating teachers were able to give individual feedback on specific interests and wishes for the face-to-face event.

Please add aspekts you are interested in to be discussed/worked on in the joint stuff training week.
„Safety in work with cobots”
“I am interested to get more informations and have first practice steps over this possibility”
“Hands on", “technical aspect“
„Neben der Technik interessiert mich, wie die Softskills angesprochen bzw. integriert werden bzw. sind sie überhaupt integriert?“

Figure 2-1: Feedback questionnaire on the pre-workshop webinar: Interests and wishes in the training week

Furthermore, the survey can be used to identify both inhibiting and beneficial aspects of the training event. The host institution can use the information and incorporate it accordingly in the preparation of the training week. The open answer category contains the following suggestions, among others:

Please share your comments, worries and suggestions on the webinar.
„In agenda to show CET time:))) (we connected three times:))))))”
“The webinar was perfect. I´m looking forward the joint staff training event in Kongsberg. Thank you for your work.”
“Good and very precise information.”
“Looking forward to attend the joint staff event”
“It was a good opportunity to see what is goin on in Portugal.”
„Technical preparations were very well organized. It would be an advantage to open the virtual room 30 minutes beforehand so that you can test your own equipment.”
“Testing the access to the webinar a day earlier would be a good idea.”
“I think the ability to work self-motivated and independently, must be good developed already at the students. I've worries that this method is not suitable yet for our students (school based VET, Age ~15-19, EQF~4/5 (Level 6, after final exam. & 3Y. of practice) / short-term appointment for joint staff training event, personal time resources (??)”

Figure 2-2: Feedback questionnaire on the pre-workshop: Open answers

The feedback presented includes organisational aspects on the one hand. On the other hand, a content-related assessment on the suitability of a training method is reflected against the background of the students' competences in their own organisation.

Impact on the host teachers

Further effects can be identified from the survey of the host teachers.

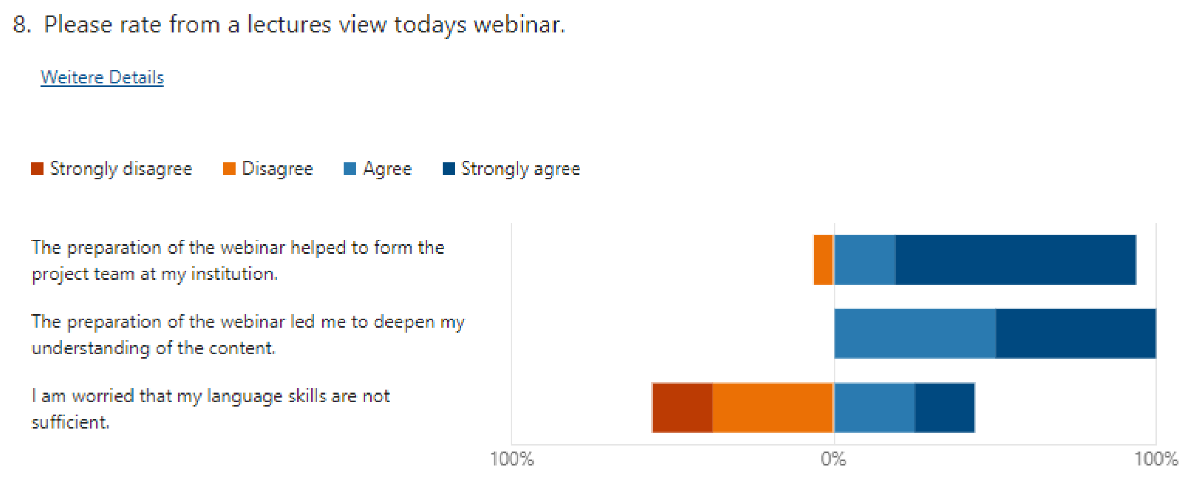


Figure 2-3: Evaluation of the pre-workshop webinars from the provider's perspective

Almost 94% of the teachers responsible for the webinar that took place stated that the preparation for holding the webinar contributed to team building at their own institution. All respondents agreed that the preparation for the webinar contributed to their own professional development in the specific topic. The language skills of the teachers are also heterogeneous. Just under half of the respondents have two-fel that their own language skills are sufficient.

The project implementation shows that a pre-workshop webinar can provide a large number of teachers with comprehensive information on the contents of a subsequent school week at short notice and at low cost. This can significantly increase the accuracy of the content of a teacher training course. The effort involved is very low compared to the benefits. The participating teachers represent their own institution for the first time in an international environment. It is evident that this can strengthen the team of teachers and break down language barriers. The preparation and presentation of the teaching concepts to a team of teachers leads to a deeper engagement with the training topic by the host teachers and thus promotes their professionalisation.

2.3 Learning together in an international team

The teacher training concept within the framework of the NetKom4.0 project is based on the "Pedagogical Double Decker". In addition to the creation of "good practice learning concepts" for Industry 4.0, they are also tested within the framework of "Joint staff training events". In these, the participating teachers are taught with exactly the methods and materials that they can later use themselves as teachers. The joint staff training events are held in the individual partner institutions. The host institution is responsible for organising and conducting the training. The subject teachers from the other partner institutions take part in the training.

The joint Joint Staff Training Events were accompanied on the one hand by representatives of the biat, and on the other hand the participating teachers were interviewed by means of a questionnaire after the event. A further differentiation was made by questioning the host institution in order to ascertain its perspective as a training provider.

Role Change in the Pedagogical Double Decker

One block of questions is dedicated to the method of the pedagogical double-decker. According to the assessment of the participating teachers, the change of role from teacher to pupil could be completed for the most part. (cf. Figure 2-4). The teachers as well as the scientific support of the biat changed roles and worked on the tasks with great motivation. "I really enjoyed tinkering with Arduino. (biat feedback).

It shows a great interest of the teachers to experience new technologies from a practical point of view. The training sessions showed a "normal" classroom experience as it is usual with pupils. Questions, problems and difficulties in solving the tasks arose and were solved by instructors or team members. The teachers' ability to reflect during the training sessions is remarkable. The usefulness of individual exercises was continuously reflected upon, and possibilities of transferring them to their own institution or teaching were discussed. In case of problems, the team immediately developed ways to improve the learning tasks.

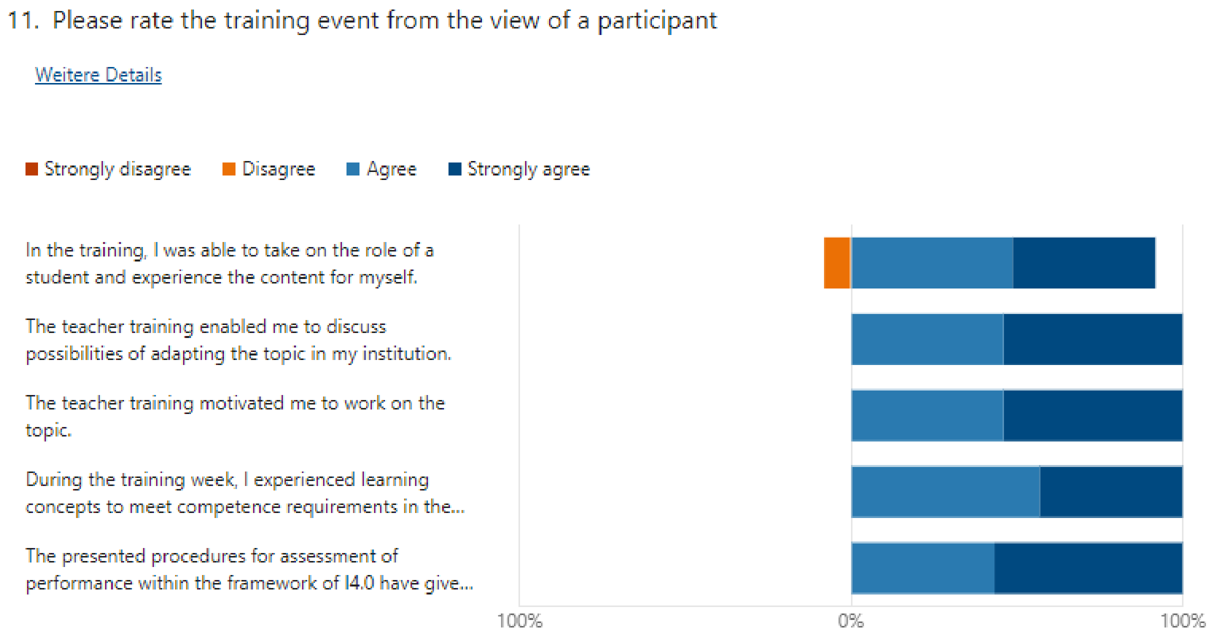


Figure 2-4: Reflection on the didactic double-decker from the perspective of the participating teachers

The deviating agreement of the teachers' feedback refers to a training week in which the principle was only implemented to a limited extent. The host teachers mainly presented their concepts and materials, the active participation of the training participants in the sense of the pedagogical double-decker was limited. The participating academic facilitators were able to observe this change of role more clearly (cf. Figure 2-5). Here, the difficulties reported by WAHL in the implementation of the "pedagogical double decker" can be confirmed (cf. Wahl 2013, p. 66). It is obviously easier for teachers to "only" talk about the teaching concepts than to implement them concretely. However, it should be noted that certain concepts can only be implemented with difficulty or in a weakened form in the sense of the double-decker. Experiencing the topic of "Learning Location Cooperation 4.0" took place, for example, through an intensive company tour including discussion with the participating cooperation partners and participating pupils.

The reflection phase in the pedagogical double-decker to transfer what was learned to one's own institution or to explore its possibility was carried out (see Figure 2 4, Figure 2 5). The observation shows that the reflection process also took place without active invitation. The external teachers continuously made comparisons with the conditions in their own institution. It was beneficial when several participants from one institution took part in a training week. There was a more intensive exchange and ideas and requests for changes for their own institution were discussed directly.

Diversity of content and methods

In terms of content, the participants confirm that they were able to learn new learning concepts in the context of Industry 4.0. In addition, new possibilities for performance assessment became visible, which can enrich one's own teaching (cf. Figure 2 5).

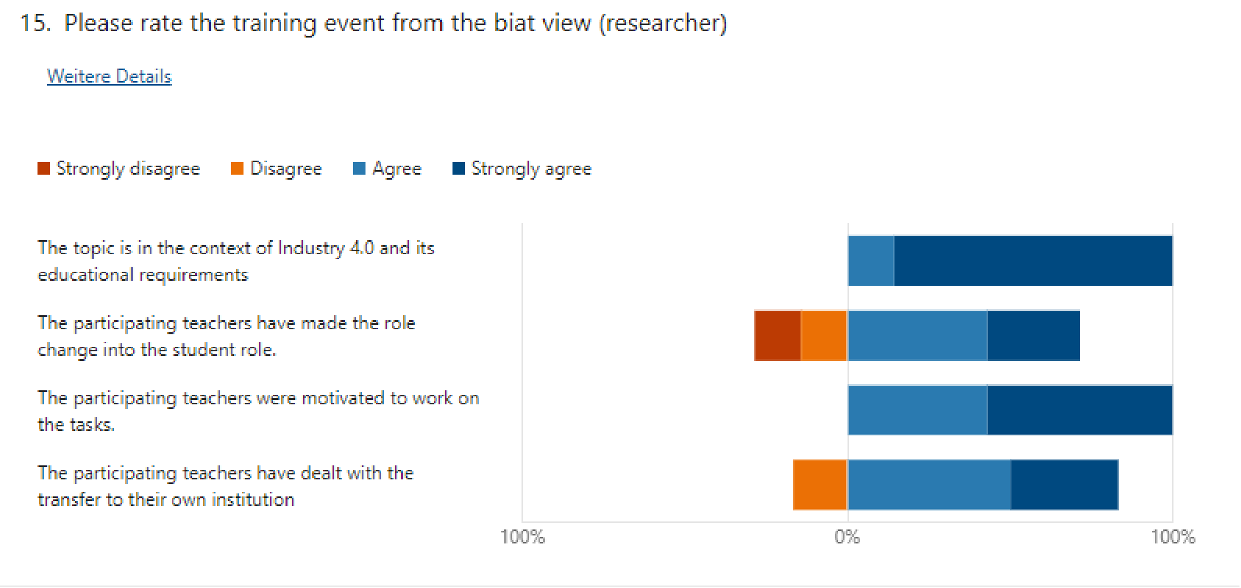


Figure 2-5: Reflection of the didactic double-decker from the perspective of the scientific support

The scientific monitoring positively emphasises that the teachers "try out" new methods in order to implement the changed competence requirements of Industry 4.0 in learning concepts (cf. Figure 2 6).

What I liked about the training event was that...

“There were no great expectations for the participants regarding content and skills.”

“Trainers have new ideas ("dreams") concerning realization of transferring industrial knowledge to education. They implement real-world problems in their curriculum that led to competences regarding problem-orientation.”

“The different method to implement technical knowledge with different kind of equipment.”

”I really enjoyed tinkering with Arduino.”

Figure 2-6: Reflection of the training week from the point of view of the scientific support

Equally positive is the low-threshold access to the training content. The learning concepts presented have the most diverse requirement levels and offer low-threshold entry possibilities throughout.

For future events, it is critically noted that the concept of the pedagogical double-decker should be transported more intensively in advance so that a more stringent implementation takes place (cf. Figure 2 7).

In a future training event I would do the following differently:

“The idea of the role change could be improved, if more parts of the workshop would have been actively doable for the participants.”

“Unfortunately, the didactic double-decker approach was not followed, so there should be more practice opportunities.”

Figure 2-7: Suggestions for future training weeks from the point of view of the scientific accompaniment

Action-oriented learning

The feedback from the participating teachers shows that the action-based learning approach is perceived as positive. Learning by doing or using real teaching material is seen as beneficial (cf. Figure 2 8). In the critical feedback, it was noted that this approach should be taken into account even more in the future (Figure 2 9).

What I liked about the training event was that...
„We learn by doing.“
“we could see learning materials and projects for/of students.”
“Help understand the topic from different viewpoints (technical, economical)”
“Discuss Ideas from different points of view.”
“Good interaction between different realities.”
“ ... we worked together in different groups ... we worked on real student-exercises ... we visited several companies and institutions beside working in the seminar”
“The access to the topic of big data is now much more clear now. Rasmus presented it so well structured and easily to understand. I would like to be a student of him :-) Concepts of the production line in the ID LAb are very informativ and useful for me.”
„Practical training“
„ Hands on experience”

Figure 2-8: Positive experiences from the training week from the perspective of the participating teachers

In a future training event I would do the following differently:
“Even more practical training and project presentations.”
“Longer trainings on the topic.”

Figure 2-9: Suggestions for future training weeks from the perspective of the participating teachers

2.4 Transfer potential of the new learning concepts

A fundamental aim of teacher training is to implement new learning concepts in VET practice in a sustainable way. This applies on the one hand to the teachers involved in the training courses and on the other hand to other teachers who use published learning material or participate in future training measures in their own institution or beyond. During the project, the participating teachers were asked about this. The question about the assessment of the implementation of the new learning concept in their own institution was mostly rated as very likely (cf. Figure 2 10).

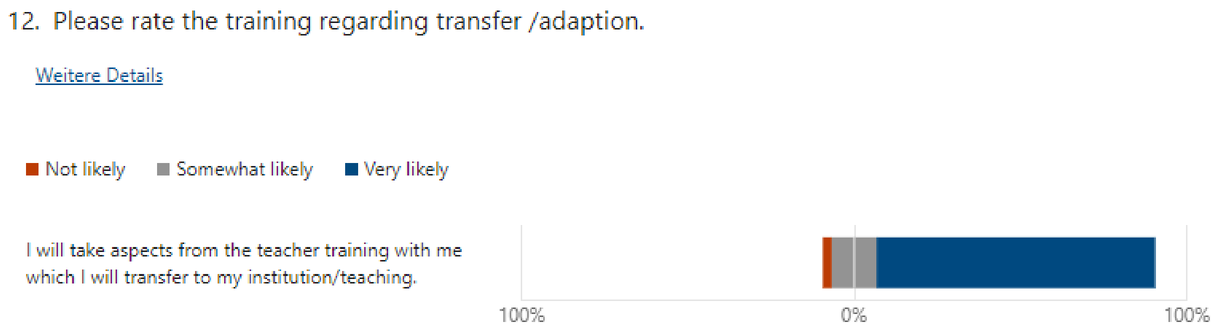


Figure 2-10: Reflection of the didactic double decker from the perspective of the participating teachers on the implementation of the concepts

During the project, newly learned concepts were already implemented in some institutions. This became visible in the final event of the project, where the interested public was informed about the project results. Representatives of the partner institutions involved reflected on the learning approaches they had developed and the learning experiences they had gathered during the training weeks. They informed about multiplier trainings in their own countries based on the NetKom teaching concepts. The approach of the "pedagogical double-decker" will be continued in a nationwide training on cobots. The Scienceshop concept has been further disseminated in Portugal, for example, in a nationwide training. In Norway, new robot purchases are based on the findings of the cobot training at the Eckener School in Flensburg. Furthermore, a teacher said that she would also practise project-oriented forms of teaching in the future. So far, these have not been common, but the experienced project-based teaching examples were convincing.

2.5 Positive impact on host teacher team

The implementation of a training week for teachers has a positive effect on the professionalisation of the host teachers. This assessment is based on the results of the survey and the observations made during the training week. From the feedback, it can be concluded that the host teachers deepened their own subject areas in the preparation for the training week and revised their training material. New technologies were didactically evaluated and prepared for learning purposes. The reflection of the implementation examples by the international subject teachers was very intensive. The participating teachers had many questions and showed great interest in the contents. This led to further impulses for the host teachers to optimise the implementation examples.

Some of the lessons are linked to the purchase of teaching materials by the school, which was also coordinated by the participating teachers. In addition, a team of teachers was established that took over the organisation of the training week in addition to the content-related aspects. This includes the scheduling of the event as part of the school day, the support of the guests with regard to accommodation, equipment and a suitable learning environment.

The evaluation of the training week in terms of organisation is mostly positive (cf. Figure 2 11).

Figure 2-11: Evaluation of the organisational aspects in the training week

It was found that the participation of a school in the NetKom project promotes cooperation among the teachers of an institution and contributes positively to its development. However, challenges also become apparent in this context. Teachers reported difficulties in recruiting motivated colleagues to participate in the NetKom project. The implementation of organisational tasks apparently succeeds more easily than generating professional contributions (cf. Figure 2 12).

In a future training event would do the following differently
„ I have learned that do the organizational stuff with less team members and do the work with more team members. Build two teams in the end. Very valuable experience.”

Figure 2-12: Feedback questionnaire on the training week, open response

The participating teachers report back that most of them have no experience in teacher training. The feedback shows that through the preparation and implementation of the teacher training week, the participating teachers feel able to offer further teacher training in the future (see Figure 2 13). This has already happened during the project. On the basis of the developed Netkom training, further trainings for external teachers have been carried out or have been incorporated into nationwide training programmes.

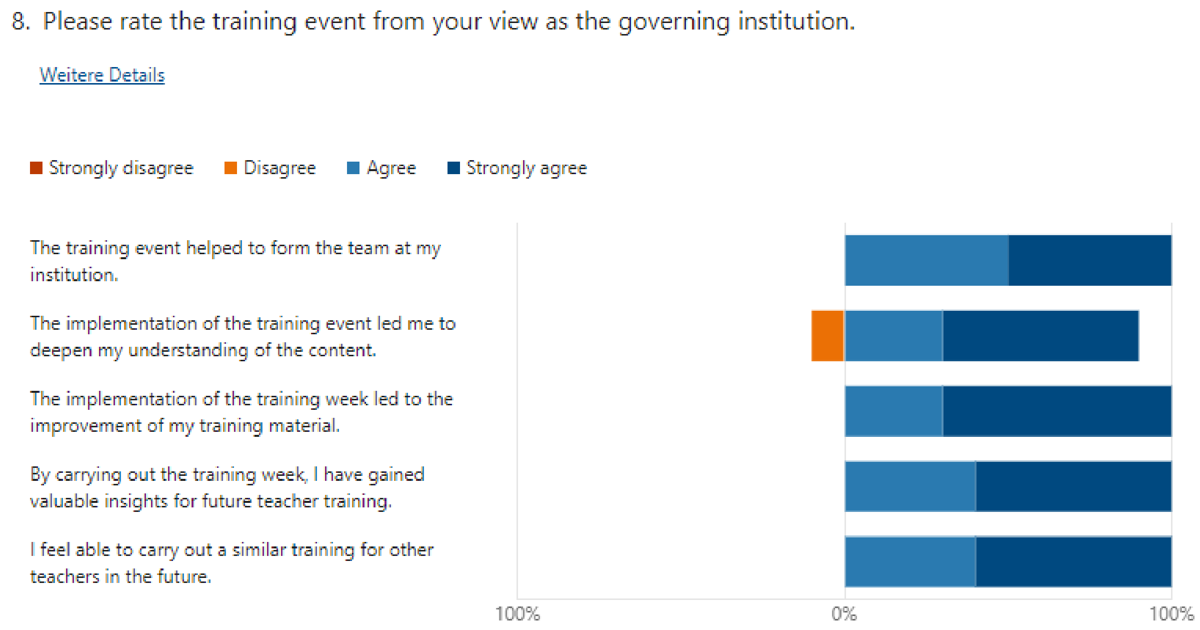


Figure 2-13: Impact of the training week on the host teachers

2.6 Close integration with the world of work

The close interlinking of vocational education and training with the world of work is visible in all project partners. Almost all participating institutions organised visits to companies at their locations that are related to the topic of Industry 4.0. The visits were not obligatory in the project, but came about on the hosts' own initiative. The connection between the teaching concepts and company practice became visible, not only at the respective locations. For example, the contents of the lessons in Portugal were directly reflected in the business practice of a company in Norway.

The teachers involved showed great interest in the visits. At the same time, the companies were open to the guests and facilitated an exchange of ideas. Among other things, they formulated current and, in their view, future requirements for skilled workers. The international team of specialist teachers was noted with interest.

Common forms of cooperation between companies and vocational schools in the different countries were identified. Often, for example, final theses are carried out by pupils in the companies. At some locations, the schools take on specific development tasks for special products. The teachers involved were thus able to experience new forms of cooperation.

Finally, the advantage of alumni networks became clear. Access to companies could be realised more easily and in a more targeted manner with the help of former pupils.

Cooperation with vocational practice goes hand in hand with the work-oriented, didactic approaches in vocational education (cf. Petersen 1996). The choice of subjects is made in accordance with the real tasks and requirements of the world of work. The "real world problem" is transformed into the centre of the learning setting and can thus lead to a higher motivation to learn. JAHNKE refers to the findings of LAVE and WENGER, who advocate the situated learning approach (cf. Jahnke 2016, p. 116 f.; Lave & Wenger 2008). Based on this, JAHNKE recommends selecting problems from the real world with regard to the following characteristics in order to design them as learning tasks and thereby satisfy the situated learning approach. The problems are based on authentic cases, are sufficiently complex, offer multiple perspectives, require group interaction as well as articulation and reflection to find a correct solution (Jahnke 2016) (2016, p. 116 f.).

In summary, company visits are a profitable element in the context of in-service teacher training. The analysis of the reality in the company is directly linked to the subject of the in-service training. This leads to higher motivation among the participating teachers and contributes to the success of teacher professionalisation.

2.7 International „community of practice“

The majority of participants state that they have little international experience in working with teachers. Usually, training takes place on a national level and teachers get little insight into other training institutions abroad. Bringing together teachers of a common discipline from different countries leads to an international "communitiy of practice" of teachers (cf. Lave & Wenger 2008, p. 98). The participants show common interests in vocational education as well as in their common subject area. They move at different levels and share their knowledge in the community of practice and thus develop it further. From the observations and feedback, it appears that the teachers were very open to sharing their material and experiences in vocational education in an "inspiring atmosphere" (cf. Figure 2 14). This requires courage and trust. The latter was continuously strengthened during the project. It could be observed how mutual trust increased in the course of the project. The openness to share learning materials beyond the project is remarkable. This includes, for example, questions about school organisation, financing, measures to recruit pupils, learning space equipment.

What I liked about the training week was that...

„Most participants was very interested in training, asked a lot of questions, was very active feedback of trainings.”

“The group was very nice, people were very engaged, they were really willing to try something new and use offered training techniques.”

“Exchange with teachers from other countries”

“*) Exchange of (technical) knowledge on "digitization topics"; *) strengthen existing contacts (and getting new contacts); *) relaxed atmosphere;”

„Open communication“

„exchange with the other teachers”

“Offenes Klima, Partnerschaft und guter Einblick in Arbeit bei Atec. Keine Geheimnisse“

“Very interesting equipment, excellent connections to companies, perfect interaction between school and company”

“The nice an inspired athmosphere.”

“To see the school, the workshops and how the teachers are doing their work.”

“The working methods and attitudes of the students”

“we could see learning materials and projects for/of students.”

Figure 2-14: Feedback from "joint staff training event"

The community also discussed examples that are not successful in practice. They appreciated the honest exchange in an "open communication" about backgrounds and difficulties free from political constraints (Figure 2 14). The participants identified similar problems in vocational education and training in the different countries, but were also able to discover solutions that do not exist in their own countries. Learning materials beyond the specific topic area were discussed and shared.

Another positive aspect was the direct access to local students who presented their learning outcomes to the consortium. The guests sought direct exchange with the students and were convinced of their actual learning outcomes and learning attitudes (cf. Figure 2 14). More space should be given to this exchange in the future (cf. Figure 2 15).

In a future training event I would do the following differently:
„A longer phase of cooperation with the students”

Figure 2-15: Possibilities for improvement in teacher training

Overall, it can be concluded that the international participation of teachers in an in-service training series can lead to a community of practice and has a positive effect on the learning process of the participating teachers.

2.8 Culture, language and shared value formation

The participants also evaluated the training week in terms of culture, common values and language skills. As a result, they see increases in competence in all areas (cf. Figure 2 16). It is clear that in addition to the subject-related aspects, cultural content is also of great importance. The host teachers offered insights into the culture of their country and the local characteristics. The interest in this was high and the related exchange was intensive. The teachers discussed common values, historical developments and national characteristics. The major international crises during the project period (pandemic and war in Ukraine) illustrate the importance of international exchange and common value formation.

The open answers support this assessment:

What I liked about the training event was that...
„The training week led to the improvement of my language skills and I gained new knowledge and values about foreign cultures.”
“Everything fine, enough time for "networking". The "german danish friendship tour" was also very interesting!”

Further development of their own language competence frames the teacher training. Observations and feedback indicate that some teachers were reluctant to participate in the training because of their own assessment of their language competence. There are national differences in this respect. Those teachers who nevertheless took on the supposedly uncertain language barrier were rewarded with a higher self-esteem after participating in the project.

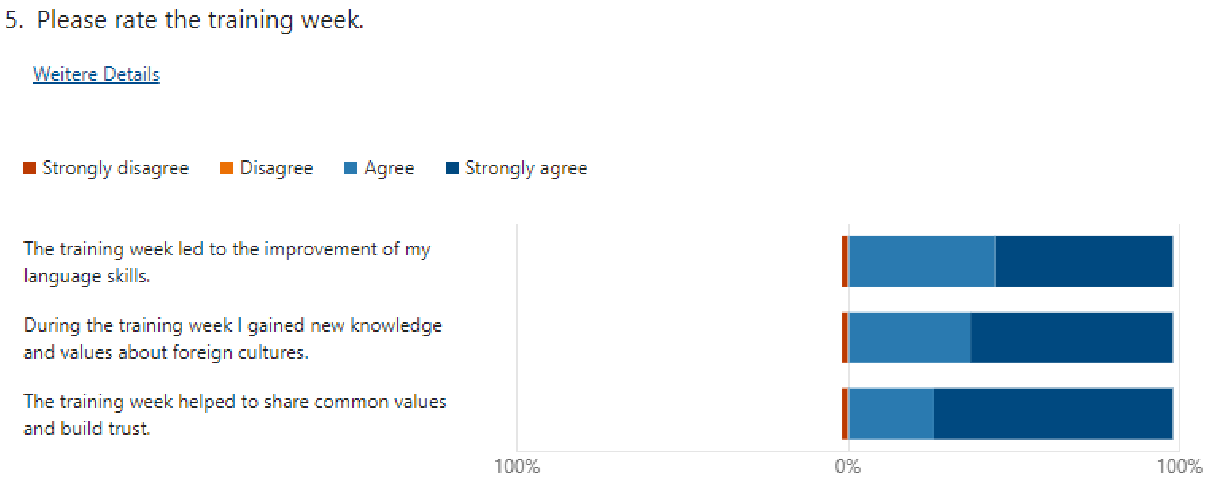


Figure 2-16: Competence gains in the areas of language, culture and values

In summary, it can be said that far more than purely technical competences can be promoted through teacher training. Shared values, cultural education and language are aspects that are of great importance in today's networked world of work and can be developed within the framework of the international teacher training conducted. It is clear that these aspects need to be taken into account in such in-service training and contribute significantly to motivation and overall success.

3 Professional work in Industry 4.0

3.1 Occupational research approach

The changes brought about by Industry 4.0 have an impact on professional work in a wide range of professions. New work tasks and requirements for skilled workers are emerging. In professional practice, the new tasks can come into the area of responsibility of workers in different ways. On the one hand, the scope of tasks of previous occupational holders may change. New tasks can be added, others can be dropped. On the other hand, completely new occupational profiles may emerge (cf. Dostal 2005).

The identification of changed job content in gainful employment can be done with the help of occupational skills research. The results of this research must be evaluated against the background of the processes and content of learning, social requirements and the personal development of learners. BECKER and SPÖTTL summarise the research area as follows:

"Qualification research oriented towards occupational science pursues the goal of identifying the work tasks characteristic of an occupation and the qualification requirements incorporated in them, and of investigating the didactic significance of these tasks for competence development". (Becker & Spöttl 2006, p. 4)

Various occupational research methods have developed, ranging, for example, from case studies to expert interviews and workshops conducted directly in work contexts (cf. Jepsen 2022, p. 85). However, the high empirical effort of the procedures is problematic in order to deliver valid and representative results.

A new approach is being pursued in the NetKom project. The evaluation of labour market and occupational information from the employment agencies serves as a basis for identifying requirements from gainful employment. Employment agencies continuously provide job content and job requirements for gainful employment occupations. The data can be used profitably in the context of skills research (cf. Jepsen 2022). The great added value lies in the actuality of the data and the research-economic procedure (cf. Jepsen 2022).

In addition, the findings of the project partners flow into the results. For this purpose, exemplary results from the empirical analyses on the use of cobots in Industry 4.0 are presented (ESFL 2023a, p. 5 ff.).

3.2 Specialists for Industry 4.0

Specialists for Industry 4.0" are chosen as a representative of a typical occupation in the industrial-technical field of Industry 4.0 work. In the German occupational classification system KldB 2010, the occupational profile is located below the occupational area "2 Extraction of raw materials, production and manufacturing" (see Figure 3 1, cf. BA 2021)3.2 The further classification takes place with increasing, specific occupational specialisation via the levels of main occupational groups, occupational groups, occupational subgroups and occupational categories (see Figure 3 1).

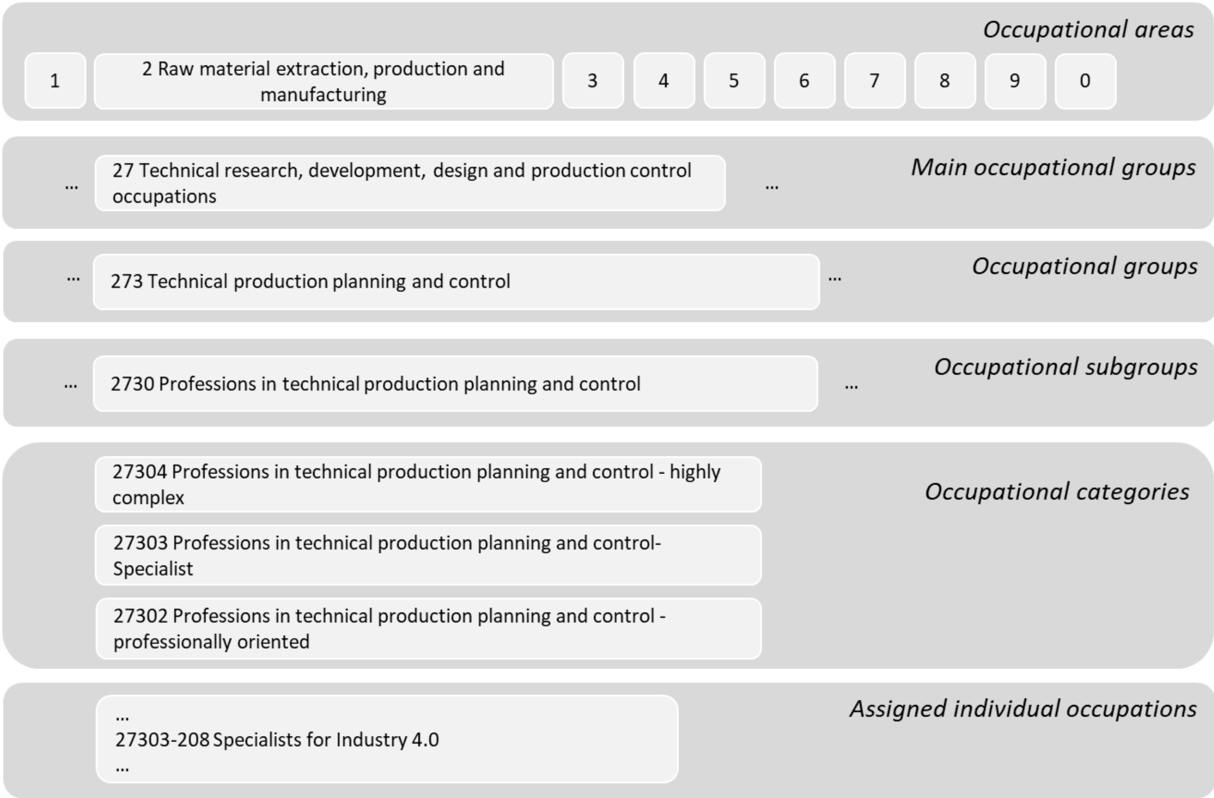


Figure 3-1: Specialists for Industry 4.0 in the German occupational classification KldB2010

Specialists for Industry 4.0 are assigned to the lowest level "27303 Occupations in technical production planning and control - specialist" with the classification number B 27303-208.

The occupational category represents the third of four ascending requirement levels - complex specialist activities. This level corresponds to the intended requirement level of the vocational qualifications that can be acquired through training programmes of the NetKom partners (cf. Figure 4 2).

The following occupational information contains selected contents of the BERUFENET data set of "Specialists for Industry 4.0" (BA 2023).

Tasks and activities in compact form

Industry 4.0 specialists combine commercial and technical knowledge to plan the digitalisation of processes and the introduction of new technologies. First, they record the business or production processes and identify optimisation potential, such as the digitalisation of production steps or the automation of recurring business processes. When they network production processes, Industry 4.0 specialists analyse how plants can be expanded or how systems can be made more efficient through adapted programming. To do this, they select technologies such as digital supply chain management, machine learning or IoT platforms. With the help of big data analyses, not only can production be improved, but further starting points for the use of artificial intelligence can also be determined. If the Industry 4.0 specialists are entrusted with the optimisation of business processes, they examine and design how work steps can be redesigned through automation. Business intelligence tools help them to manage, process and evaluate large quantities of commercial data in order to visualise them in a targeted manner.

In order to optimise production and work processes, Industry 4.0 specialists use methods such as agile project management. Once the designed change measures have been initiated, they follow their implementation, create training materials and inform specialists and managers about changed work processes and how to deal with new technologies.

The job at a glance

Industry 4.0 specialists develop concepts and plans for the digital transformation of companies and oversee their implementation.

Tasks and activities in detail

- Capture and analyse processes
  - capture and visualise existing business and production processes
  - Collect, analyse and process data
  - Identify optimisation potential with regard to digitalisation/networking
- Optimise production processes, machines and equipment
  - Check production processes and equipment for digitalisation and networking possibilities, clarify technical feasibility with technical and IT teams
  - Select suitable technologies, e.g. digital supply chain management, augmented reality, machine learning or IoT platforms.
  - optimise production processes with the help of big data analyses or explore the possibilities of using artificial intelligence
  - monitor development progress or accompany the introduction of new technologies
  - assist in the assembly, set-up, programming and networking of new machines and systems
  - Evaluate machine data in order to improve productivity or ensure quality.
- Further develop business processes and work steps
  - Checking recurring work processes for their automation potential and promoting their automation
  - develop concepts for process optimisation and identify implementation options
  - collect and manage large amounts of business data, e.g. with the help of business intelligence tools or data warehousing
  - Analyse, prepare and visualise business data for different purposes
  - Tap the potential for digital marketing measures
- Monitor implementation of process optimisation and guide employees
  - actively shape operational changes, e.g. by using agile project management or change management methods
  - Create documentation for changed processes and work with new machines and equipment
  - provide technical guidance to staff and accompany them during change processes
  - continuously search for optimisation possibilities through the use of artificial intelligence
- Keep up to date on innovative concepts, trends and market developments in the field of Industry 4.0
  - Take data protection and data security into account

Work items/work equipment

Plants, equipment and technical systems, e.g.: Automation systems, additive manufacturing (3D printing) systems, CNC machines, collaborative robots (cobots), augmented reality data glasses, networked production systems, embedded systems, PLC systems, sensors.

Documentation and software, e.g: Process optimisation concepts, process, material, machine deployment, budget and schedule plans, construction drawings, PLC programmes, software for computer-simulated production processes, machine data, quality guidelines, costing software, business intelligence tools, big data analyses, data warehouse systems, dashboards.

Office equipment, e.g.: PC, internet access, telephone	
Core competences • Agile project management • Work preparation • Automation technology, process automation • Change Management • Data competence, data literacy • Edge computing • Enterprise Resource Planning (ERP) • Manufacturing technology	• Industrial Internet of Things (IIoT) • Information technology, computer technology • Machine Learning • Production Planning • Project Management • Security systems (IT), data security • Supply chain management • Networked production systems
Further significant competences • 3D printing • 3D simulation • actuator technology • Application technology, application advice • Augmented Reality • Planning the use of operating resources • Data protection • Embedded Microcontroller, Embedded Systems	• Development • Production, order control • Design and construction • Mechatronics • Personnel planning • Production logistics • Robot and handling technology • sensor technology • Maintenance, repair, servicing

Figure 3-2: Excerpts from the BERUFENET data set "Specialists for Industry 4.0

(BA 2023)

The data set excerpt "Tasks and activities in detail" specifies various tasks of the occupation holder. Typical work objects and tools are, for example, collaborative robots (cobots) or programmable logic controllers (PLCs). The core competences section contains various keywords, including management tasks (change management, project management, agile project management, supply chain management) and technologies (data competence, data literacy, machine learning, 3D simulation) (cf. Figure 3 2).

3.3 Results of the empirical work analysis on the use of cobots

The results from the Intellectual Outcome "O1 Collaborating Robots in Industry 4.0" of the Eckener-Schule Flensburg (ESFL 2023a) serve as a further concretisation and empirical foundation of the previously described work tasks in Industry 4.0. The development of learning tasks was carried out by this NetKom partner on the basis of analysed work processes of a cooperating company. The company under investigation specialises in the production of adhesive tape and film products as well as packaging and printing solutions. The teachers of the Eckener School determined work tasks for the introduction and operation of an automation solution with the help of cobots on the basis of work analyses and expert discussions. The results are presented in a generic work process. The process follows an abstracted structure through the steps PLAN (planning aspects), BUILD (develop and implement the solution) and RUN (operate the cobot automation).

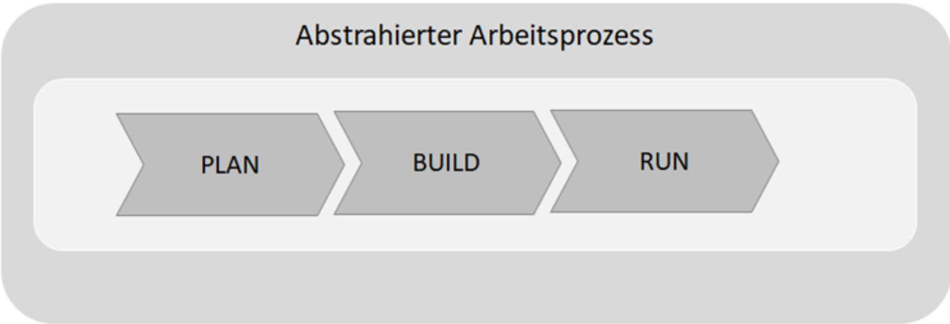
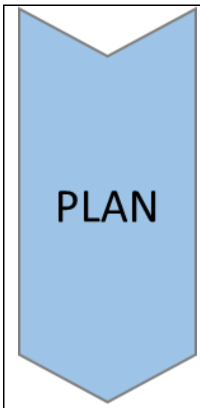


Figure 3-3: Abstracted work process to represent vocational work tasks (ESFL 2023a, p. 8)

In the following table, the work tasks and their requirements are specified and provided with examples.

	Skilled workers can... Analyse existing or new manufacturing processes to identify potential for optimisation through the use of cobots. Identify processes to be automated: - Analyse existing process structure to identify problems in the current process (quality, throughput, injury, accidents, ergonomics, worker fatigue, environmental conditions), - Identify sub-processes (e.g. packaging, palletising, quality assurance) that are suitable for automation by means of a cobot, evaluate them in terms of technical feasibility and economic efficiency, carry out preliminary costing, - Coordinate the introduction project with the company management. Tools, procedures and requirements in this task area: - Work observation procedures, time recording of processes, - Simulation of the automated sub-process with software, - Automated sub-process must not slow down the entire process chain (shift performance as indicator), - solution as cost-effective as possible. Carry out a preliminary risk assessment and take it into account in planning. - Evaluate space requirements, distances to people etc., - Environmental analysis, corrosion environment, explosion protection, etc. Select and procure suitable material - Carry out cobot product comparison, - Determine gripper tools, sensors, other attachments, components, fea-tures etc. according to requirements, - Select PLC if necessary, - Prepare request for quotation, - coordinate procurement with purchasing department. Requirement: Observe company philosophy, e.g. use standard parts from specified manufacturers.

	Draw up connection planning - Clarify electrical and pneumatic requirements, location requirements such as weight and working space.
BUILD	Develop automated solution - Manufacture, assemble, connect and commission mechanical, electrical and pneumatic components, - carry out signal check. Carry out programming of the cobot - Prepare the cobot (reset passwords if necessary, delete old programs, create the current software version), - Create, test and adjust the sequence programme with the operating panel, - If necessary, interlock the cobot programme sequence with the PLC programme, - Document the programme in the code, - Ensure unauthorised access to program code, - Run test series parallel to the production process, revise solution. Implement cobot automation in the production process. - Instruct/train operating personnel, - Implement without interrupting the production process if possible. Create final documentation - Symbol table, - programme flow chart.
RUN	Carry out conversion of the production line - Converting the robot to another system/production line - Load and test programmes for alternative production line - Complete risk assessment and carry out CE marking Optional: Evaluation of statistics on - shift performance - quality, repeatability, - profitability etc. Carry out maintenance of the cobot - If necessary, carry out software updates to ensure a uniform software status in the company.

Figure 3-4: Work process for the introduction and operation of an automation solution using cobots (ESFL 2023a, p. 8 ff.)

The concrete tasks are described in a result-oriented way. In addition to concrete tasks, they also include tools used, procedures and requirements.

Results of the empirical study in comparison to the reference occupation

The presented occupational work tasks from the empirical analysis of the Eckener School can be assigned to the reference occupation "specialists for Industry 4.0" (cf. section 3.2). One of the superordinate tasks "Record and analyse processes" with the goal "Optimise production processes, machines and systems" is also in the foreground at the industrial company studied. The descriptions provide a concrete context.

In the reference profile, planning tasks have a high scope, the actual implementation of the automation solution is only subordinately performed by "specialists for Industry 4.0" "assist in the assembly, set-up, programming and networking of new machines and systems". The specialists mainly take on the management function of "providing technical guidance to employees and supporting them in change processes". In the company studied, the specialist took over the implementation of the cobot automation himself and ensures the safe operation of the system after its introduction.

The empirical study shows only a small proportion of tasks dealing with data analysis. In the reference profile, much more space is given to this topic - "optimise production processes with the help of big data analyses or explore possible applications of artificial intelligence" (see Figure 3 2). In this respect, the company visits carried out in the NetKom project make a contribution. The "Smart Facto-ry" concept, which was thematised at the Rittal plant (https://www.rittal.com/de-de) during the "Lernortkooperati-on 4.0" in Dillenburg, should be highlighted. The visits to the injection moulding machine manufacturer Engel (https://www.engelglobal.com) in Austria and GKN Aerospace (https://www.gknaerospace.com/) in Norway show further examples of the analysis of data in working practice.

4 Industry 4.0 learning concepts

4.1 Network competence and social aspects of Industry 4.0

Industry 4.0, Economy 4.0, Work 4.0 and VET 4.0 will result in changes in skilled work at all levels. The industrial-technical sector is affected in that forms of work, work content and work areas will change. The core idea of 4.0 progress can be summarised technologically in a few elements: Data collection, data management and intelligent use of data.

Based on the automation pyramid, there will be changes in the traditional level model. Manufacturing execution will play an increasingly important role in the production network. There will be a stronger link between the Manufacturing Execution System (MES) and the automation level. As a result, levels and thus interfaces will disappear and data from production will be integrated directly into the standard business software (e.g. SAP). In this way, the ERP (Enterprise Resource Planning) is integrated with the MES level. This means that all the necessary information is available in real time across the entire company. The goal of making production economically feasible even with a "batch size of 1" requires the merging of product and production life cycles on the basis of a uniform data model. In this way, the requirements resulting from individualised production and ever shorter product life cycles can be designed technically and economically. If machine-to-machine communication is to be implemented in intelligent production using IP-addressed sensors and actuators, cyber-physical systems (CPS) are required that enable the interconnection of information technology and software components with mechanical and electronic parts, for example on the basis of the internet. Technical progress is therefore linked to the progressive diffusion of information technology content. Without information technology and computer science, Industry 4.0 cannot be implemented.

Due to the diffusion of information technology content and techniques into all professions, which has already begun and will continue to progress, the competent use of IT will continue to gain in importance within the framework of Industry 4.0. GRIMM, following WORDELMANN, sees IT competences as part of network competence, which also includes cooperation, communication, learning and reflective information in networks (cf. Grimm 2016; Wordelmann 2000). Network competence subsumes subject-specific and methodological individual competences that could be needed to remain adaptable in a changing world of work. At the same time, they are a prerequisite for enabling communication in heterogeneous teams. With the construct of network competence, an individual disposition is to be developed on the basis of which people can find orientation and support in a digital society and working world today and in the future. Data networks are an indispensable communication medium for data exchange in human-human, human-machine and - increasingly - machine-machine interaction. Data exchange takes place in the private and social environment as well as in the networking of product systems and components.

Building on WP1, WP2 and WP3, the conditions for success and the learning outcomes are also located in the developmentally open theoretical construct of network competence (e.g. Grimm 2016). The term network competence does not reduce the network concept and the competent action of people solely to dealing with technology or information technology networks. In its origins, network competence understands the challenge of networked work with the internet and the newly emerging contexts and networks. In the context of 4.0, an increasing virtualisation of activities and the networking of interpersonal communication can be assumed. In conclusion, skilled workers in the information society need network competence as a cross-sectional competence. As a result of the increasingly complex production processes in Industry 4.0, people, machines, products and processes are growing closer together on logical and physical levels.

One educational goal for the development and didactic implementation of this cross-sectional competence can be to strengthen people and their actions in the newly emerging networks, in the working world and in the overall social environment. With this strengthening, people will be able to understand the new contexts more holistically. The degree of convergence of this competence and their active participation in these networks, of a social and/or technological nature, in the world of work and society, could thus develop in parallel with the increasing degree of innovation of the artificial networks.

Reflective network-competent action is an integral part of vocational education and training and serves to strengthen professional and personal development in a knowledge society, both for learners and teachers alike.

4.2 NetKom 4.0 qualifications in the EQF context

The relevant national training offers of the participating institutions in the NetKom 4.0 project are diverse. They are determined by interviewing the participants or on the basis of the documents provided. The educational offers range from vocational orientation to initial vocational training to continuing vocational training. All schools offer educational programmes in the industrial-technical fields and partly beyond (cf. ATEC 2023a; ESFL 2023b; FTO 2023a; GSD 2023a; HTL St. Pölten 2023b; VTDK 2023b). The variety of formal qualifications to be obtained at the schools is correspondingly large. The technical school in Norway, in contrast, specialises only in continuing vocational education and training. The ATEC Training Academy in Portugal is a private non-profit organisation with a state-supported educational mandate. The composition of the partners represented in the NetKom project reflects a typical picture of the industrial-technical qualification offers of vocational training institutions in Europe. The topic of Industry 4.0 in the overarching context is relevant for all partners. Overall, the results can therefore be transferred to other vocational training institutions.

With the help of the European Qualifications Framework (EQF), the formal qualifications of the individual countries can be compared. The EQF can be used as a meta-reference for the various national qualifications frameworks (cf. Figure 4 1).

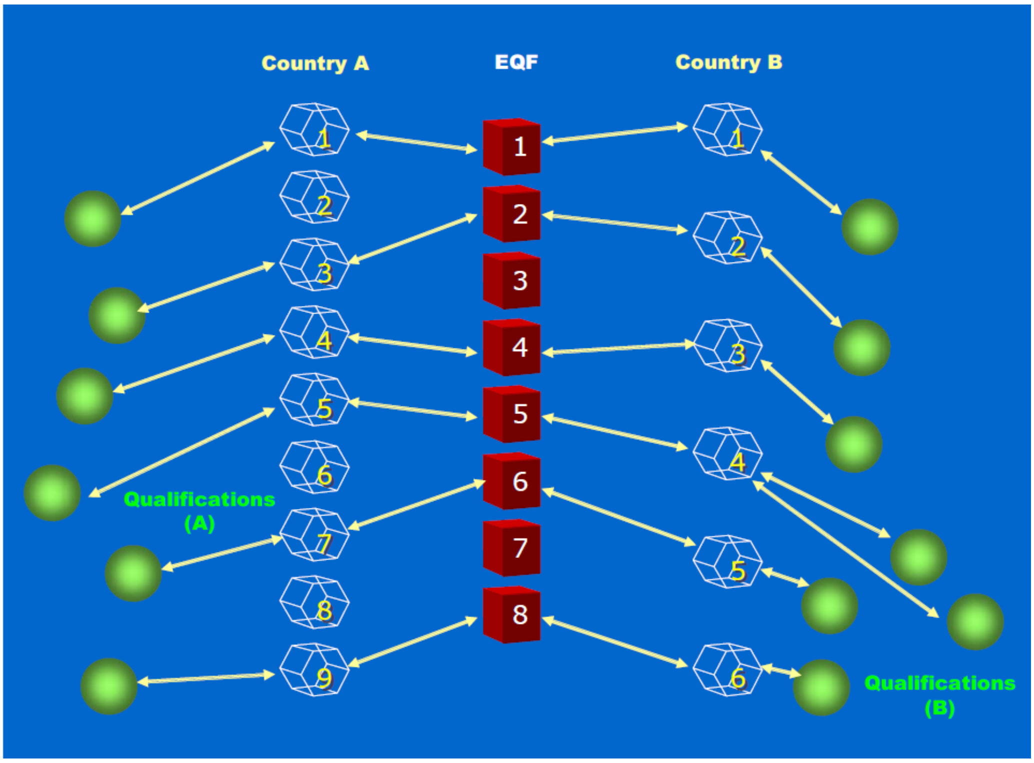


Figure 4-1: The EQF as a meta-framework for creating and promoting links between national qualifications frameworks and systems (EC 2005, p. 15 f.)

The framework divides learning contexts into eight levels (see Figure 4 1, cf. EC 2005, p. 28 ff.). For national educational provision, there is usually an allocation to the national qualifications framework, which in turn establishes the reference to the EQF.

The qualifications offered by the partners involved in the NetKom project are assigned to the reference levels of the EQF (see Figure 4 2). The training courses or training offers shown refer to the learning concepts developed in the NetKom project. The concepts usually originate from initiatives by teachers in individual courses of education and have been tested there. The teachers involved also use the concepts in other courses of education or successively extend them to other courses of education.

O1 Collaborative robots in Industry 4.0		
Course of education	Education programmes	EQF-Level
Technical college	Techniker/Technikerin (Staatlich geprüfter) - Bachelor Professional in Engineering in the fields of • Mechatronics • Mechanical Engineering/Machine Construction Technology • Electrical Engineering • Wind Engineering	6
Vocational school	A wide variety of dual training courses in the fields of metal, electrical and IT technology	4
Vocational college I	Training courses in the fields of electrical engineering, metal technology	3
Vocational college III	Technical assistant for information technology	4

O2 Promoting interdisciplinary thinking in Industry 4.0 with "Science Shops"		
Study programmes in the faculties • Design • Civil Engineering • Technical	Professional Bachelor of Engineering Sciences in • Automotive Electronics Systems • Automotive Technical Operation • Civil • Smart Building • Business and Customs • Information Systems • Mechanical • Electrical and Automation, Railway Transport • Renewable Energy • Energy	6
O3 Learning concepts for the Internet of Things (IoT) security		
Vocational training	Training courses • Car Mechatronics, • Industrial Maintenance, • Mechatronics, • IT Network Management, • Programming	4
Technological Specialization	• IT Networks and System Management, • Cybersecurity, • Mechatronics Technology, • Automation, Robotics and Industrial Control, • Technology and Programming of IT-Systems, • Energy Management and Control	5
Adult Training	• Car Mechatronics, • Electronics, • Automation and Control	4
O4 Augmented Reality with real-time data		
Technical college	• Industrial Engineering, • Informatics – Cyber Security, • Electrical Engineering, Electronics & Computer Science, • Mechanical Engineering	5
Evening school	• Electrical Engineering, • Mechanical Engineering	5/6
Vocational school	• Electrical Engineering, • Electronics & Computer Science, • Mechanical Engineering	4
O5 Production planning and production control in authentic Industrie 4.0 environments		
Higher Vocational School Department of Electrical Engineering	• Battery school • Automation • Infrastructure Technology for Data Centres • Electrical Energy • Industry 4.0	5.1 5.2

O6 Concepts for Learning site cooperation 4.0		
Vocational orientation workshops	Offer for students in the E-Phase of the Wilhelm-von-Oranien-Schule Dillenburg	2
Technical secondary school	Consistent teaching principle according to the framework curricula	4
Vocational school	A wide variety of dual training courses in the fields of metal, electrical and IT technology	4
	Elective course "Digital manufacturing processes	4
	Elective course "Technology for Business People	4
Technical college	Consistent teaching principle in the fields of mechanical and electrical engineering	6
Cooperation with the IHK Lahn-Dill	Adaptation qualification: "Fit for Industry 4.0	

Figure 4-2 Relevant educational offers of the NetKom learning concepts located in the EQF

The learning material for "O1 Collaborative Robots in Industry 4.0", for example, was developed and tested in the technical college at EQF level six (see Figure 4 2, cf. ESFL 2023a). The learning package also contains sequences that can be used directly in other courses. The scope of use can vary. For example, the introductory learning sequences on robotics are suitable in the educational programmes of the vocational school (cf. ESFL 2023a). The approach "O2 Promoting interdisciplinary thinking in Industry 4.0 with 'Science Shops'" has so far only been used for study programmes at level six (cf. VTDK 2023a). A possible expansion of the concept to other educational programmes still needs to be examined or further developed. The SMART approach within the framework of "O3 Learning concepts for Internet of Things (IoT) security" is currently mainly practised in educational programmes at EQF level 5 (cf. ATEC 2023b). The contribution "O6 Concepts for learning location cooperation 4.0" has a school-wide extension (cf. GSD 2023b). Learning venue cooperation between VET institutions and companies is fundamentally of great importance. Their design can vary depending on the course of education. The school in Dillenburg is closely linked with local industry in this respect. The Norwegian approach "O5 product planning and production control in authentic Industry 4.0 environments" is aimed at higher vocational education due to the education offered in Kongsberg. Deviating from this, the learning material developed in Austria can also be used in educational programmes below the "Bachelor Professio-nal Qualification".

The educational offers addressed as examples in the NetKom project can be compared with the help of the EQF. Other institutions can use this as a basis for locating their own training programmes and benefit from the learning concepts.

4.3 Addressed competence areas of the NetKom4.0 learning concepts

The European Commission has proposed to describe qualifications in terms of learning outcomes in order to compare them. Learning outcomes are understood as "statements of what a learner knows, understands and is able to do after completing a learning process. They are defined as knowledge, skills and competences" (EP & Council 2008). Knowledge, skills and competences serve as descriptors to describe learning outcomes in a more differentiated way.

The European Commission defines the descriptors as follows:"

> *In the European Qualifications Framework, knowledge is described as theoretical and/or factual knowledge;*
>
> *In the European Qualifications Framework, skills are described as cognitive skills (logical, intuitive and creative thinking) and practical skills (dexterity and use of methods, materials, tools and instruments);*
>
> *In the European Qualifications Framework, competence is described in terms of assuming responsibility and autonomy".* (EP & Council 2008)

The identification of learning outcomes is based on the documents provided and the analysis during the training. The learning concepts developed in the NetKom project support competence development in all areas of the descriptors presented. However, the focus is different. The competences are described in different ways, abstracted by individual terms and as learning outcomes.

The following is an exemplary presentation of the competence areas addressed in the developed learning concepts. The competences presented are not complete; the focus is on competences in the Industrie 4.0 context.

O1 Collaborative robots in Industry 4.0

Knowledge	
• Robotics • Computer Aided Planning • Process Model • Process Visualisation • ABC analysis • Process list • Gantt chart	• Network planning • Resource planning • Lead time • Setup time • Buffer time • Machine safety • …
Skills	

The students analyse
• Analyse complex sorting and packing processes to identify potential for optimisation through the use of cobots.
  ○ Analyse a sorting and packing process.
  ○ Define sub-processes as "operations".
  ○ Draw up an activity list with current times ("duration")
  ○ Set up a network to map the current process
  ○ Comparing actual and calculated lead times
  ○ Identify sub-processes (from the network) whose automation is particularly effective.
  ○ Use CAP (Computer Aided Planning) systems.
 	
The students	

- differentiate between terms in connection with a purchase price calculation, e.g. purchase allowance, purchase discount, purchase costs,   - carry out a purchase price calculation with the aid of spreadsheet software,   - identify criteria relevant to supplier selection,   - carry out a utility value analysis with the help of spreadsheet software,   - identify advantages, disadvantages and possible applications of utility analysis.   The students   - describe the motivation for (machine) safety,   - distinguish between safety at work and safety of machinery,   - identify the relevant national law on the basis of the European guidelines on machinery safety,   - explain the scope and main purpose of CE marking and the Machinery Directive,   - distinguish between the terms "machine" and "partly completed machinery" in the sense of the Machinery Directive and name the resulting requirements for the purchase of a cobot.   The students   - programme a sequence of movements using the appropriate types of movement and taking into account boundary conditions such as the shape and position of the workpiece,   - connect several sensors to the robot's control system and integrate sensor signals into the programme sequence,   - use ready-made programme blocks, in this case the pallet function.   The students   - realise a complex sorting and packaging process with the help of the robot,   - produce suitable documentation.   - The students   - carry out a process evaluation and optimisation on the basis of a network plan   - Adjust the operation list,   - Record current lead times   - Determine a new lead time   - Evaluate and carry out a performance review.   The students   - describe the process of CE marking,   - identify the main issues related to this process, using the implementation of a robot as an example,   - explain the process of risk assessment,   - identify aspects to be considered during the risk assessment process.
Competence
The students

• solve problems • optimise • are making independent decisions • ...

Figure 4-3: Collaborative Robots in Industry 4.0 - Competences

The learning package "O1 Collaborative Robots in Industry 4.0" developed by the Eckener School Flensburg is characterised by a holistic approach. A team of teachers arranges a wide variety of learning tasks in the moodle course on the introduction of collaborative robots in industry (https://moodle.esfl.de/course/view.php?id=4762). The learning sections are structured according to the previously analysed work process in the cooperation company. The requirements for skilled workers in the real working world were recorded by way of example and evaluated didactically. This includes, on the one hand, evaluating the contents against the background of the educational mission of the vocational school and, if necessary, supplementing aspects. For example, the contents on machine safety were supplemented. On the other hand, the didactic preparation and development of the learning tasks is carried out. Cobots form a technical focus in the learning tasks in relation to Industry 4.0, framed by planning, development and implementation tasks for solving an automation problem with the help of cobots. The learning development steps are presented. The PLAN-BUILD-RUN model enables the structuring of learning tasks that follow the real work process (cf. section 3.3).

O2 Promoting interdisciplinary thinking in Industry 4.0 with "Science Shops

Knowledge	
In the context of the task at hand	
Skills	
• Ability to observe, evaluate and draw conclusions • Adequate evaluation of oneself and of environment, etc. • Appropriate presentation of the work done, oratory skills • Multifaceted and intercultural communication when working with the client and in a team • Ability to act • Ability to assess the impact of team solutions and actions • …	
Competence	
• Search for answers and seeking to broaden horizons • Tolerance and empathy, ethical thinking • Social involvement and participation in public life; • Helping other • Commitment • Creative thinking when solving engineering problems and looking for alternative solutions	• Focused pursuit of goals; • Ability to adapt and meet challenges • Conflict management • Emotional stability • Openness and transparency • Taking responsibility • Initiation and generation of new ideas • …

Figure 4-4: Promoting interdisciplinary thinking in Industry 4.0 with "Science Shops

The "Science Shops" approach developed by the VTDK makes it possible to promote interdisciplinary competences in particular. The ability to solve problems in interdisciplinary teams with the help of creative thinking processes characterises this innovative approach. Self-organised teamwork is in the foreground. The VDTK locates the competency areas mainly addressed in "Science Shops" in the OECD Learning Compass (cf. OECD 2019). Furthermore, the competences are reflected against the background of Industry 4.0 requirements (cf. VTDK 2023a, p. 15). With reference to the European Qualifications Framework, the focus of the competences to be acquired lies in the area of skills and the assumption of responsibility and independence. The Science Shop learning approach can address a wide variety of problems and - depending on the application - also enables the acquisition of technical knowledge.

O3 Learning concepts for the Internet of Things (IoT) security

Knowledge	
• Cyber physische Systeme, Architektur • RAMI 4.0 Referenzmodell • IIRA Architektur, OPC UA • Internet of Things (IoT) • Cybersecurity • Types of Cyberattacks • Denial of Service (DoS) • Distributed Denial of Services (DDoS) • Man-in-the-middle (MITM)	• SQL Injection • … • Risk Management Konzepte • Digital Transformation • node-red • python • grafana • influx db • …
Skills	
• Assess IoT security risks in an industry sector. • Use industry standard models to explain security requirements in IoT systems. • Recognise threat models to assess security vulnerabilities of physical devices in IoT systems. • Recognise threat models to assess security vulnerabilities of communications in IoT systems. • Identify threat models to assess security vulnerabilities of applications in IoT systems. • Use threat models and risk management frameworks to recommend mitigation measures. • Explain the impact of new technologies on IoT security. • Develop automation projects.	
Competence	
• Problem solving ability • Ability to work in a team • Interdisciplinary cooperation • …	

Figure 4-5: Internet of Things (IoT) Security - Competences

The examples for the learning outcome-oriented description of competences in ATEC also include taxonomic gradations (ATEC 2023b, p. 13).

In addition to the subject-specific aspects of IoT security, the "SMART" learning approach developed by ATEC is characterised by a method mix of Challenge-Based Learning (CBL) and Project-Based Learning (PBL).

„Challenge Based Learning is an engaging multidisciplinary approach to teaching and learning that encourages students to leverage the technology they use in their daily lives to solve real-world problems. Challenge Based Learning is collaborative and hands-on, asking students to work with peers, teachers, and experts in their communities and around the world to ask good questions, develop deeper subject area knowledge, accept and solve challenges, act, and share their experience." (ATEC 2023b, S. 72)

"Project Based Learning, or PBL, is an instructional approach built upon learning activities and real tasks that have brought challenges for students to solve. These activities generally reflect the types of learning and work people do in the everyday world outside the classroom. PBL is generally done by groups of students working together toward a common goal."

The SMART learning approach mainly takes place in the areas of Automation, Robots, IoT, Vision & Virtualisation as well as AR, VR and Cybersecurity (cf. ATEC 2023b, p. 71).

Pupils from IT courses work in joint teams with pupils from automation courses in projects that are based on real-life problems. Networked laboratories with different focal points were used for this purpose. Open and new tasks can be worked on through this approach. The teachers find themselves in a new role as learning facilitators. They contribute in a targeted way according to their own competences. The SMART approach also integrates students in international exchanges and thus makes it possible to promote the participants' linguistic and cultural competences.

O4 Augmented Reality with real-time data

Kenntnisse	Fertigkeiten	Kompetenz
• Cyber Physical Systems • Software Development Environment • Sensors • Virtual and Augmented Reality Systems • 3D Devices • MQTT • ...	• Animation • Creating Thingworks projects • Writing and reading data • Creating CAD models • Visualising data • ...	• Problem solving • …

Figure 4-6: Augmented Reality with real-time data - Competences

The learning material of the HTL St. Pölten offers the possibility to create augmented reality applications with real-time data. This enables participants to understand the complete interrelationships of this technology and to help design it themselves. The extensive learning material supports learners in acquiring comprehensive expertise in the fields of sensor technology, cyber physical systems and the Internet of Things, among others. The learning tasks, which are described in detail and provided with video links, are arranged in increasing complexity. Learners get access to background knowledge and in-depth tasks (cf. HTL St. Pölten 2023a).

O5 Production planning and production control in authentic Industrie 4.0 environments

Knowledge
The candidate • has knowledge of relevant machines and systems that are part of a company based on the principles of Smart Production, Industrie 4.0 and industrial digitalisation. • has knowledge of operation and maintenance strategies as well as project and quality management that are part of the principles of Smart Production, Industrie 4.0 and industrial digitalisation. • has knowledge of the possibilities of condition monitoring, tracking, data collection and analysis in the optimisation of production systems as well as the importance of data security. • has knowledge of concepts, theories, computational models, production processes, design tools and documentation used to develop automated production systems, including mechanical, electrical, electronic, computer engineering and industrial digitalisation. • has industry knowledge of intelligent automation and production and is familiar with the professional field. • has knowledge of functioning and physical principles as well as systems understanding of various existing technical components and solutions common in modern industrial contexts and production. • has knowledge of the general principles of logistics and product flow. • has knowledge of financial management, organisation, HR function and management, and marketing management. • can assess own work against norms, standards, laws and regulations relevant in modern industrial contexts and production and whether the necessary environmental aspects have been taken into account. • knows the history, tradition, uniqueness and position of industrial production at local, national and international level. • can update his/her professional knowledge in modern industrial contexts with professional literature and relevant forums within the sector. • has insight into their own development opportunities and increases their competence according to technological development. • has knowledge of the importance of health/safety/environment for automated processes.
Skills
The candidate • can state condition monitoring, tracking, data acquisition and analysis and explain how these can be used to optimise production systems according to the principles of Smart Production, Industry 4.0 and industrial digitalisation. • can use tools and components to build modern industrial systems based on modern industrial processes and technologies. • can explain the choice of maintenance strategy. • can explain the choice of tools, methods and principles in the areas of production planning, logistics, data security and production flow. • can reflect on own professional practice in the field of intelligent automation and production and adapt it under guidance.

• can find and look up information and topics related to modern industrial processes and assess their relevance to a professional problem. • can map and identify technical issues in the construction and operation of modern industrial production facilities and the need to implement measures. • can explain the importance of HSE for automated processes. • can consider the financial situation, market and management challenges of the company and make appropriate and justified decisions.
Competence
The candidate • can plan, design, implement and operate equipment for modern industrial processes in collaboration with other professions, based on a holistic understanding of systems, ethical, ecological, health/safety/environmental and data protection requirements and sustainable development. • can carry out work according to the needs of the company and/or the client. • can build relationships with colleagues in modern industrial operations across disciplines such as electrical, mechanical and computer engineering, and with external audiences such as government and local authorities, through the formation and development of teams and networks. • can exchange views on modern industrial enterprise issues with others who have experience in the field and participate in discussions on developing good practice. • can contribute to organisational development by keeping up with new technologies in modern industrial processes that can lead to new creations and innovations.

Figure 4-7: Production planning and production control in authentic Industrie 4.0 environments- Competences

The authentic Industrie 4.0 learning environment is at the centre of the learning approach developed in Norway (cf. FTO 2023c). In the elaborate laboratory, students can acquire knowledge and skills for understanding complex Industrie 4.0 systems. Students learn to comprehend processes - which are not immediately tangible - to assess them and to make decisions based on them. The "Industri 4.0" education programme at the technical college in Kongsberg includes the learning outcomes described (cf. FTO 2023b). The contribution from Norway provides information about the historical development towards Industry 4.0 in the region of the technical college. In addition, the contribution provides a comprehensive overview of the driving technologies (cf. FTO 2023c).

O6 Concepts for Learning site cooperation 4.0

Knowledge
• Basics of automation technology • Manufacturing processes • Networking • Identification technologies RFID, QR • CPS - Factory • Programmable logic controllers (PLC) • Digital twin • Data analysis • IT security • Ethics in the context of Industry 4.0

• …
Skills
• Demonstrate system understanding • Analyse processes • Carry out troubleshooting • Develop digital twin • Implementing controls in simulation • Integrate cyber-physical systems • Operating CAD software • ...
Competence
• Kollaboration im digitalen Zwilling • Reflexion • Präsentation • Probleme lösen • Teamfähigkeit • Ethische Aspekte, Rolle des Menschen in der digitalen Transformation bewerten • Mitgestaltung der Digitalisierung • …

Figure 4-8: Concepts for Learning site cooperation 4.0 - Competence

The contribution of Gewerbliche Schulen Dillenburg (GSD) addresses the fundamental need for cooperation between vocational training providers and companies. Depending on the educational programme, the cooperation can be structured differently. In joint training programmes - such as dual training - closer coordination is necessary. Further education programmes benefit from cooperation by taking regional requirements into account and ensuring that the learning content is up to date. According to the GSD, the following are among the success factors of successful learning location cooperation

- open communication
- joint planning
- qualified teachers and trainers
- practical equipment (cf. GSD 2023b, p. 5 f.).

For the implementation of learning location cooperation, the teachers recommend taking the following aspects into consideration:

- Establishment of cooperation structures
- joint projects and practical phases
- internship and training plans
- Joint in-service and further training
- use of digital media and learning platforms

- Feedback and evaluation (cf. GSD 2023b, p. 6 ff.).

The examples listed in the Dillenburg contribution illustrate how cooperation can be developed, and also identify obstacles.

Due to the digital transformation in society and industry, the GSD sees the need for subject didactic reflection in vocational education and training. It discusses the learning object "digitalisation" and explains an approach to process-oriented didactics. This results in central challenges to integrate digital tools or digital technology in concrete work and learning tasks (cf. GSD 2023b, p. 8 ff.). The implementation at the school in Dillenburg is described in the following sections. Especially the solution for the implemented IT infrastructure and services can be transferred to other institutions (GSD 2023b, p. 16 ff.).

A concrete teaching implementation on the "digital twin" is done with the help of the Factory IO software. The opportunities for using the medium in vocational teaching are manifold. Technical and methodological skills (programming, robotics, CAD), problem-solving skills, teamwork and communication as well as data analysis skills can be promoted (cf. ibid.).

The ethical aspects in the context of Industry 4.0 form the final topic area. "What role do people play in the digital transformation?" and "How should education react to this?" are exemplary questions raised by Dillenburg representatives. The undoubtedly important topic will be illustrated by various examples, especially before the challenges. Approaches need to be found to enable people to understand and help shape the digitalisation of tomorrow. The presentation of ethical aspects in the Industry 4.0 context is linked to the demand for VET 4.0. Ethical aspects must be integrated into the learning concepts (GSD 2023b).

4.4 Approach to competence-oriented performance assessment

The performance assessment formats of the NetKom partnership contain both formative and summative elements.

Performance assessment takes place in the context of the intended learning outcomes of a subject. The Norwegian specifications for assessment are exemplified:

"In each subject, a final assessment of the student must be made in relation to the learning outcome descriptions of the subject. After completion of the entire subject, an overall assessment of the student's knowledge, skills and general competences shall be made." (FTO 2023b)

There is a fixed weighting of formative and summative examination results.

The examinations can be designed using different methods.

For example, the college in Kongsberg uses the following methods to assess performance:

- Supervised written examination, conducted at the place of study.
- Unattended written examination, for example a home examination
- Oral examination
- Ability tests
- Laboratory exercises

- Project work
- Practice
- Oral presentation (ibid.).

Digital examination formats are also part of the repertoire. The Moodle course at the Eckener School contains examples of this. In addition to exercises, the learning sequences include short interim examinations that were created with the help of the moodle examination tools (see https://moodle.esfl.de/course/view.php?id=4762).

The grading systems contain different scales depending on the country. The curricula determine the extent to which individual grades or group grades are awarded.

A concrete examination design for the assessment of skills is shown in the article on cobots (cf. ESFL 2023b, p. 21). In an examination time of 60 minutes, the aim is to put a cobot into operation and set it up according to customer specifications.

The programme flow chart to be sketched and the function check according to the customer's requirement is carried out together with the examinees and the examiner (cf. ESFL 2023b, p. 21 f.).

5 Resume

In the now completed NetKom_4.0_v2 project, it was successfully demonstrated that current and innovative technological changes in didactic teacher training successfully provide multifunctional added value. The technical developments towards Industry 4.0 do not herald a paradigm shift in professional work and teacher training. The constant technical progress in private and professional environments reveals the converging developments with regard to information technology penetration of almost all areas of life. In order to be able to respond to this in a sustainable, demographically stable and responsible manner, the construct of "network competence" has been devised and used. Comprehensive network competence can be seen as the basis for developing awareness, understanding and critical reflection skills in a digitalised world of life and work.

Network competence was developed among the participants in the workshops organised by the project partners. Through the principle of the pedagogical double-decker, the participants were guided to integrate this knowledge, skills and abilities into a self-concept and to carry it into their own educational institution as multipliers, as well as to further develop their own teaching in terms of content and methodology. Furthermore, it was found that the educational initiatives of the NetKom_4.0_v2 project have added value to the further development of educational institutions as a whole. Accordingly, there is added value at the meta-level of school development, the meso-level of lesson design and at the micro-level of lesson delivery.

From the point of view of the project support by the biat of the European University of Flensburg, the project was carried out successfully and purposefully despite the start-up difficulties caused by Corona. The set goals were achieved and the reflections clarify the qualitative added value.

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