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Description of teacher training with Digital Transformation

1:

1. Introduction and objectives

It is my pleasure to welcome you as part of your stay in the state of Bavaria here at my workplace in Dillingen an der Donau.

My talk today focuses on one main question:

How can a training concept for Teachers - which is intended to handle dynamic developments and changes in VET - look like?

When trying to answer that question I am aware that each nation/country has its own specific way of offering and organizing teacher trainings and teaching, but we all have the same intention:

We want to qualify our students for the labor market and we want to support them in becoming attractive for employers.

Therefore, in the context of our exchange, I am looking forward to the opportunity of reflecting my presented concept with you.

The task of the ALP is to professionalize the educational staff at vocational schools and consequently, to contribute to a continuous improvement of teaching.

In the context of vocational education and training, this objective always goes hand in hand with promoting professional skills and competences in students and meeting the requirements of certain professional activity areas.

This claim is particularly strengthened by the dual partnership between companies and vocational schools because students or apprentices get insights both into practical as well as theoretical aspects of their jobs.

Now, I would like to introduce the training initiative called "Digital Transformation" of the ALP in more detail.

In general, we offer a support service for teachers to overcome challenges that may arise in the context of the digitization in industry and economy.

Please note that the terms *Industrie 4.0, Wirtschaft 4.0, Arbeit 4.0* etc. are only used in Germany and are related to the digitization of the world of employment. The different terms denote different areas of application, for example the sector of industry or the sector of crafts.

In my presentation, I have to use the different terms, however, while focusing on the fields of metal,

electrical and information technology, I will use the universal and international term of "digital transformation" for the training concept.

4:

Framework Conditions

To begin with, I would like to give you some facts about the ALP and roughly describe its framework.

The ALP Dillingen is **the** central Bavarian institution for in-service teacher trainings of all school types – not only vocational schools - and all subjects - except PE and RE - in Bavaria.

We have a capacity of approximately 250 beds here in Dillingen but we also book other venues all over Bavaria for our courses which either can be classroom-based events or online course formats. Approximately 30,000-35,000 of a total of 120,000 teachers all over Bavaria attend our courses every year.

About 70% of these are classroom training courses of 3-5 days each. Approximately 30% of the total amount of courses is offered through various online formats, for example self-study courses, moderated online seminars and live web conferencing.

The ALP features five departments, which are topic-oriented and school-type independent.

In the past years, I was working in department 5 for information and education technology. Currently, I am a member of staff in department 2 for methodology

and teaching development. Focal points of this department are Mathematics / Science / Technology / Economics.

My change of departments in September last year involved an additional organizational unit in department 2 called “Digital Transformation”, for which I’ll be responsible in the future.

Consequently, a major focus of my work is the transformation of the world of work through the implementation of IoT (Internet of Things) systems in manufacturing companies of the metal and electrical industries. I also deal with the increasing digitization in other work areas, for example economy, nutrition, nursing and healthcare as well as in the craft sector.

Here, I work closely with my ALP colleagues from the vocational schools responsible for these areas. Basically, job description of people like me includes the development, co-ordination, implementation and evaluation of teacher training concepts and actual courses.

In addition to the initiative "Digital Transformation ", I also deal with other initiatives for digitization in other departments of the ALP. These are designed to be

more general and thus, relate to general education as well as further trainings for people working in school administration, for instance headmasters. These training initiatives also affect vocational schools in their general educational mission but are not the subject of my talk today.

Of the total of 120,000 teachers in Bavaria, about 20,000 teachers are employed at 7 various vocational schools types and about 9,000 teachers teach at vocational schools, so those are the dual partners in the dual system of IVET. Of these, there are about 1,500-2,000 teachers working in the fields of metal engineering, electrical engineering and information technology. This subset is the main target group of the initiative “digital transformation” I am going to talk about today.

Another aspect of the ALP framework that strongly influences my area of responsibility is the great variety of industrial trades and the specific requirements for different professional skills.

Because of that, we have many - but quite small - target groups. That is a result from the fact that there are about 250 occupations in Bavaria that require training.

7:

I’d like to give you an example: The target group for a general education subject such as mathematics in another school type (e.g. secondary school) can comprise several thousand teachers. On the other hand, a large target group for a "subject" in the vocational school - which is called a “lernfeld” and means a field of activity in a profession – only addresses about 300-400 teachers. This example should make clear that our courses feature very specific requirements and must set a focus.

The focus of the Digital Transformation initiative is particularly on fields of knowledge with short innovation cycles and the most relevant target groups. But who are those target groups? Well, we can determine them based on a scientific study which I introduce to you later.

Our range of courses for vocational schools at the ALP is complemented by teacher trainings of the 7 regional governments (regional sponsorship), which usually last only one day. To co-ordinate the regional courses is also one of the ALP tasks to ensure the effectiveness of all state training classes.

8:

The ALP-concept - Overview

In addition to the Ministry of Education, we also work closely with the Institute for School Quality and Educational Research (ISB).

Role of the Ministry of Culture and Education

The Ministry supports financially the "Digital Transformation" initiative to promote the provision of teaching equipment at vocational schools. This enables a practical training in the requirements of the digital transformation for students at vocational schools.

This support was funded, on the one hand, by a funding program of the Bavarian Ministry of Economic Affairs entitled "Industrie 4.0" and, on the other hand, by the funding program of the Pact for Vocational Education.

Schools that participated in the application process received a grant from the State of Bavaria amounting to a maximum of € 112,500 each. In addition, the schools' municipalities, which are mainly responsible for their funding (city or district), must be prepared to contribute an additional 50% of the total amount.

Thus, every school could benefit from a maximum of € 225,000.

In 2017, there were 17 and in 2018, there were already 43 vocational schools in Bavaria that benefited from the funding.

Role of the ISB

In the context of the initiative "Digital Transformation", the ISB is responsible for the syllabuses of relevant occupations that require training.

The working groups of the ISB have examined the usability of selected syllabuses with regard to current competence expectations and then, examples of implementation aids for teaching were suggested.

In general, the working groups stated that the defined competence expectations of the syllabuses are overall still valid in the context of "digital transformation". This is mainly due to the abstract formulation of competence expectations in the curricula.

Specific implementation manuals and aids for teaching, especially with regard to cyber-physical systems, are still being compiled in the ISB working groups.

The working groups of the ISB and the working groups of the ALP work closely together. Some members are represented in both working groups to ensure the effectiveness of the initiative.

10:

Role of the ALP

The ALP plays a leading role in the development and implementation of the accompanying teacher-training concept "Digital Transformation".

The working groups of the ALP are composed of selected and very motivated teachers of vocational schools who teach in areas, which are relevant for the project. These dedicated colleagues get involved in three ways.

Firstly, they collect input while getting training themselves by the industry, secondly, they adapt this content for the use in teacher trainings and teaching, and then, they pass it on to their colleagues.

My role at the ALP is

- organizing training with industry partners, such as manufacturers, to train ALP working group members,
- chairing meetings, to develop teacher training and teaching aids together with the working groups
- and the actual implementation of the teacher trainings.

This close cooperation of the ALP working groups with the industry is the key factor in developing the training concept dealing with innovative technologies and their growing impact on the world of employment.

Furthermore, the cooperation of the ALP with organizations doing occupational research, for example the Federal Institute for Vocational Education (BIBB) or the Federal Working Group for Electrical Engineering, Information Technology, Metal Technology and Vehicle Technology, serves to transfer scientific knowledge into the classroom.

12:

Research

IT-Professions

The following graphic from the BIBB (Bundesinstitut für Berufliche Bildung) can be used as an indicator of the increasing digitization of the world of employment. It shows the results of a survey from 2015.

The graph shows the development of the 5 IT professions at Level 4 of the EQF in Germany.

The apprenticeship contracts, which were signed in the period from 2004 to 2015, determine the graph's development measures.

The upper line in blue refers to the apprenticeship of Fachinformatiker (IT specialist) with a focus on system integration. The second and red line from above refers to apprenticeships of Fachinformatiker (IT specialists) with a focus on application development.

Since the introduction of these IT professions in 1997, there has been a steady increase in recruitment numbers.

This development can certainly be interpreted as an increasing demand of the labor market, which exactly asks for these professional competences.

In contrast, the counts of the other 3 apprenticeships (IT-Systemelektroniker, Informatikkaufmann, IT-Systemkaufmann) fall slightly. However, this development is not interpreted as a lack of demand, but rather as a lack of selectiveness between the professional profiles.

Companies prefer to opt for the seemingly clearer profile of professional competencies of the Fachinformatiker.

Among other things, this development triggered a revision of the VET profiles.

The result of this revision of new VET profiles will be published in 2020.

The distribution of employment of IT professionals across the industries is especially interesting in the context of the "digital transformation". This is shown in the second graph.

Only one-third of IT professionals work in the IT-specific information technology and communications industry. Two-thirds work in non-IT-specific sectors.

It is no longer just the ICT service providers who run IT training, but also the IT departments of many companies in other industries, such as manufacturing

companies, sanitary companies, building materials dealers, shoe shops, mail order companies, etc.

The current driving technology behind this is generally the so-called IoT systems or in production, it is the cyber-physical systems that are used in all economic sectors.

By using sensors and actuators and the internet of things, or components of a CPS, value creation processes should be made more effective and efficient.

An IoT system thus complies with the well-known principle of input, processing and output, however it is location-independent, widespread and networked.

A well-known and comprehensible application, for example, is the intelligent lighting system of a SmartHome.

A photodiode serves as a sensor and defines the state light or dark, which controls an actuator via the network. For example, it can be used to switch on or off a lighting device or it can open or close a blind.

Either the logic of processing can be decentralized at home or it can be centrally available to the provider. Accordingly, we talk about edge, fog or cloud computing.

Depending on the application scenario in which the IoT system works, this is referred to as Smart Home, Smart Factory, Smart City or Smart Grid.

The professional activities in the field of IoT systems also require competences from several classic professions or disciplines.

The networked components and the handling of process data - whether the collection, the processing, or evaluation of data - also demands IT-skills in the professions of mechanical engineering and electrical engineering. And IT-specialists are faced with applications that are not to be found in traditional IT environments.

Study in the metal and electrical industry

The impact of the introduction of these innovations on the world of employment and the future development of skills was examined in a 2016 study for the Bavarian Employers' Association (vbw).

The study was designed for the field of metal and electrical industry and is among other things the basis for modifications of relevant VET profiles.

The usefulness of the study for us and thus, the development of a further training concept lie in its recommendations for training and further education courses.

For example, business case studies and expert discussions identified requirements and tasks in areas that are typically for IoT environments.

A total of 9 occupational activities were identified, which form the basis for the competence development of a skilled worker. The typical occupational activities in the field of industrial production are e. g.

- plant enginieering

- plant monitoring

- plant maintenance

- troubleshooting

These are supplemented with target perspectives, which are necessary because of the introduction of IoT systems, e.g.

- Simulation of a plant design,
- Networking of a plant,

- Troubleshooting in a networked system,
- Collect and analyse and process data

The 9 occupational activities for Industry 4.0 were used to cover numerous occupations in the metal and electrical industry and two IT occupations.

This approach follows the demand of the industry to check occupations for suitability for use and to make corresponding adjustments instead of defining a new Industry 4.0 occupation.

Another question should be answered, namely: which professions are suited best in terms of having no or only minor problems in adapting to the demands of industry 4.0?

Or let me put it simpler: "Should an extra specialist in computer technology be trained in addition to a mechanic and electronics engineer, or should mechanics and electronics engineers just acquire more IT-skills?”

The answer can be found in the Industry 4.0 Occupations Atlas.

The four occupations at the center (mechatronics, industrial mechanics, IT specialists and automation technicians) are already close to the requirements of cyber-physical systems and have little need for adaptation.

The company Audi already has Fachinformatiker (IT specialists) in training who are used in production and are additionally qualified as electrician and then, they plan, install, maintain and monitor industrial networks (ASI-BUS, Profinet, ...).

The farther out in the Industry 4.0 Occupations Atlas, the less close the job profile is to the requirements and the greater the need for adjustment. All occupations either require a small or large adaptation to the VET profiles. Which adjustments are necessary is currently being investigated.

These results of the study could be used to establish the primary target groups and objectives for a specific training series.

The target group size mentioned at the beginning is derived from the number of apprentices, students or classes in the industrial metal and electrical professions.

The number of classes roughly corresponds to the number of teachers who need good and relevant support.

Likewise, the results of the study identify the vocational schools that have benefited from the ministry's funding programs.

20:

Modular offer

The training modules of the teacher-training concept were roughly sketched in a kick-off event entitled "Paths to Industry 4.0" in November 2016. Participants were the members of the working groups of the ALP.

The individual training modules have been derived from a CPS that maps an industrie4.0-compatible production process.

The following criteria of the system were taken into account:

- high degree of networking from the sensor via the controller to the actuator
- individualization of the product or batch-size 1 production
- flexible production logistics
- control of the process via an enterprise resource system

This model has been divided into its sub-disciplines and knowledge areas and it was structured to cover appropriate areas of knowledge and skills.

The temporary result is about 25 to 30 training modules, which have been divided into the following categories.

- Data communication (from the basics of data communication to horizontal to vertical communication in a CPS and cyber-security)
- Actuators / sensors (especially e-pneumatics, e-hydraulics and electric drives)
- CAx, for example CAD, CAM, rapid prototyping
- Robotics (from basic courses to robot programming on collaborating robots)
- Control (from the small controller to industrial control via function blocks and structured text)

The modules of a group have a vertical progression.

The progression concerns

- the relevance within a professional field (electrical engineering, metal technology, information technology)
- the requirement level.
- an increase in specialization

This T-shape model is especially designed for the three occupational fields of metal engineering, electrical engineering and information technology in the upper areas, that means the contents are equally important in the disciplines of metal, electrical and IT

Horizontal to the vertically arranged modules are modules that use the methods of Design Thinking.

In "Design Thinking", prototypes are built in multidisciplinary teams, which are evaluated by third parties, for example users.

From the IT sector, it is mainly the Hackathon, which is widely known. Other names are Creathon, Makeathon or simply interdisciplinary project work.

All those offers are designed in a way that the modules can be offered continuously and according to vocational teachers’ needs.

The development of modules

The development of the individual modules takes place within the 5 subject groups according to a Train the Trainer concept. As already mentioned at the beginning, the members of the section take on a maximum of three tasks as disseminators.

1. In phase 1, the working group members (about 10 per Workgroup) receive training, mostly by manufacturers from the industry.

2. In phase 2, they reflect on and use the external input and prepare it for the specific target groups of teachers at vocational schools. Then they develop concrete suggestions for the implementation in theory and practice.

3. In phase 3, they disseminate the upgraded content among the target groups, about 1,500 teachers of vocational schools. The objective of this phase is to transfer usable content into vocational education.

Not all members of a workgroup attend the teacher training in phase 3; some may limit their contribution to only the first two phases of module development.

Since (the voluntary) participation in the working groups depends essentially on committed and dedicated colleagues, it is important for us to ensure a balanced distribution of the work load. This is a real challenge for my work for the following reasons:

Firstly, only if the core business of the participants in their schools (namely, teaching students) is taken care of and secondly, only if all persons involved (disseminators, replacement teachers and principals) are happy, this concept works and will do so in the long run.

The feedback from the workgroup members so far shows that they enjoy participating because they profit from knowledge they have acquired in the work groups and that gives them advantages for their own lessons at school and for own professional progress.

One reason for this is that the manufacturer training is free of charge for them and their schools. Another aspect is that the ALP facilitates the continuous exchange and networking of vocational schools throughout the process of dissemination.

Another feedback we got from headmasters is that the whole school benefits from the backwash effect in terms of staff development through this type of partnership with the ALP.

In addition, the time the work group members spend on this project is deducted from their working time at school, this holds true for the developing work in phase 1 and 2. In phase 3, they even get financial funding of some sort.

The actual lessons at school with students or apprentices are represented in Phase 4.

The results of the module development will be documented in so-called lab booklets.

A lab booklet consists of individual laboratory exercises, which gradually promote teachers’

competencies in working in typical classrooms of vocational schools, where it is possible to combine the teaching of theory with hands-on training.

Recommendations for the equipment of these classrooms are also included in the lab booklet. Additionally, learning scenarios for selected industrial trades provide advice and orientation for the implementation of lessons based on activities in the CPS environment.

27:

Partner schools

Currently, about 23 ALP partner schools participate actively in the further training initiative.

Because of the dual partnership in initial vocational training, the partner schools are mainly competence centers that were formed exactly where the relevant industry is located.

At least one of the apprenticeships relevant to Industry 4.0 is being trained in all ALP partner schools.

In addition to vocational schools, the so-called Technikerschulen (Level 6 of the EU qualification framework) are often located at only one location. Moreover, these schools are usually extremely well equipped for their tasks or are strongly supported to be a powerful training partner in the dual system.

The balance between investment and operating costs on the one hand and the utilization ratio of the expensive teaching and learning equipment at these competence centers on the other hand is thus given.

As the equipment is located in the classrooms, the teaching concepts can immediately be reflected and discussed in terms of their effectiveness.

These conditions at the partner schools and the central support by the ALP complement each other perfectly - especially from the point of view of the ALP because they produce in the end a high-quality training concept.

Taking into account the large number of training modules, target groups and the specific requirements in teacher training, it would not be a good idea to mobilize these resources in the ALP alone.

Conclusion

I believe that we tailored our training concept to our target group's needs and wants in order to support them in taking up the challenges they face at vocational schools. This is because we took into account the teaching concept of vocational schools as well as their typical framework conditions (e.g. heterogeneous student groups, organizational framework conditions, special needs, balance between generalization and specialization).

The reasons for my confidence are the following:

- First, the teachers themselves (that means teaching specialists) develop and disseminate the modules.
- Secondly, there are cooperations with external partners from the industry and from occupational research.
- And thirdly, networking takes place through the ALP organization, to ensure an ongoing process of developing training concepts, in which all relevant addressees take an active part. You cannot take it for granted that these three pillars carry the weight of our concept:

One of the biggest challenges we have to face is keeping up the commitment of our participants –

especially in times where teachers at vocational schools are not easy to find.

The willingness of the industry and other external partners to co-operate with state institutions on their terms is not always given.

In addition, the state of Bavaria is one of very few federal states that is able to afford such a centralized institution as the ALP for teacher training with full-time employees.

I hope to have answered the initial question in the context of digital transformation, which was:

How can a training concept look like to facilitate current and dynamic developments and changes in VET?

If there are any questions from your part, I will try to answer them – either today or during the next few days/ learning activities.

Speaking for myself, I am very much looking forward to gaining new insights in Wuppertal, the Netherlands, Finland and Iceland in order to reflect on my own concept and to improve it where necessary.

Thank you very much for staying with during my presentation and your attention!

31: