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## **AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR): THE FUTURE OF INTERACTIVE VOCATIONAL EDUCATION AND TRAINING FOR PEOPLE WITH HANDICAP**

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### **Abstract**

*The aim of this paper is to present our didactic-methodical concept for a virtual interactive vocational education and training using the VR and AR technologies. Since we are a dual VET Institutions for handicapped, we primarily focus on young people with special needs, autism, and significant social interaction difficulties. Our concept can also be applied to other target groups. The virtual environment offers the trainees the ability to interact and experiment with items and constructs in a similar way they would do in real world. The AR-Glasses promise through the free visualization meaningful application scenarios for the teaching and learning concept; the wearer is supported during his activity by additional context-based virtual information and objects. Our method is based on the educational goals, the cognitive and psychophysiological aspects of the trainees, the technological aspects and the pedagogical strategies of goal-oriented teaching. In this paper we present some application examples of these technologies in different areas of our VET such as automotive mechatronics engineering, electrotechnology and Automation, technical product design, information technology and In-house virtual vocational School.*

## **Keywords**

Virtual Reality, Augmented Reality, VET, Virtual Learning Scenarios, Educational Tool

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## **1. Introduction**

With advances in new technologies, education is rapidly taking off in new directions that will substantially change the way learners learn but also the way teachers teach. In today's digital world, finding new ways to engage students is becoming more difficult. When home technologies such as mobile phones, tablets and games consoles are highly advanced, finding educational engagement with technology in the classroom can be even harder, especially if the technology deployed there is less advanced than the technology used at home. For this reason, new technologies such as tablets (Major L. et al., 2016) and smartphones (Ferry, B. 2009) have been used in the classroom in order to improve the learning process. Further new technologies that have been making headlines in recent years are virtual reality (VR) (Freina, L. 2015) and augmented reality (AR) (Akçayir, M. 2017) (Sanna, A. et al. 2016). Relevant studies show the exponential growth of these innovative technologies in different areas and in many parts of our lives (Chen, P. et al. 2017) (Aromaa, S. et al., 2016). Education will benefit from these technologies (Cieutat, J.-M., 2013) (Saunier, J. 2016). Vocational training will also begin to feel the impact of virtual and augmented reality over the next few years (Fehling, et al. 2016) (Wentworth, 2018). The ability to experience training in 360° is invaluable e.g. with VR it is possible to view a working engine from all angles without leaving the classroom. Vocational training is all about the interplay between theory and praxis i.e. gaining knowledge and building experience to learn through practice. The key to success in vocational training is giving Trainee the opportunity to experience the reality of being in an unfamiliar working environment, but this is often difficult and expensive to achieve. AR and VR offer in this context a great advantage by enabling students to go back through scenarios again and again, without additional expense or inconvenience and to revisit challenging situations at their own pace (sevgi 2018).

## **2. Problem Formulation and Solution Approach**

When it comes to education, we should utilize the most advanced options in order to teach children in the most effective and efficient ways. Technology plays a large role in the education system because it gives students new ways to experience learning, to create their own media, to gain a deeper understanding of the world around them and ignite their imagination. For

this reason, the integration of technology tools into the curriculum is becoming part of good teaching.

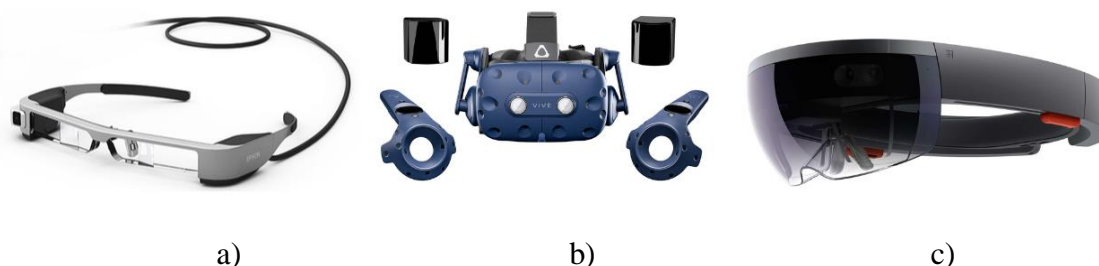
One of the major challenges facing this integration of new technologies is the lack of conception and convenient didactical models for these innovations. New technologies present daunting challenges for educators (Velez 2017). Teachers must not only learn how to use these rapidly changing technologies themselves, but they must also rethink their teaching practices, design new activities for teaching and learning, and try to evaluate the learning of students as they engage those activities

In order to deal with this problem, it is helpful in a pre-development phase to generate a step-guide and start work based on it:

- Define educational objectives and how the integration of VR/AR into the curriculum can enhance teaching and learning
- What are the pedagogical advantages (enthusiasm, better engagement, increased simulation, improved knowledge retention, learning time optimization)?
- Understand how to use VR/AR to implement your educational content and support your teaching method.
- Create meaningful educational scenarios by thinking about the pedagogy and a convenient modern didactic schema to meet the individual learning needs.
- Set goals, define success criteria and know how to measure them.
- Analyze your requirements and infrastructure in order to plan the technology implementation

Our vocational school is strengthening media skills through the use of smartphones and computer tablets in some courses. We also believe that the use of new powerful digital interaction devices based on VR and AR as an educational tool is necessary and it brings great benefits to our diverse target groups in improving the learning process. They play an essential role in improving the practical knowledge of trainees and their ability to solve problems independently. They enable the transfer of the students' theoretical knowledge to a real industrial problem without taking any risks. This can be applied in experiments that have proved difficult to perform, in traditional classroom settings, or in training and analysis of unrealized or elaborate processes. We are currently working on the implementation of the learning scenarios to be presented in the next section. The devices we are using are (figure 1):

- *HTC Vive Pro* to implement the virtual reality, which is an interactive realistic immersive computer-generated experience taking place within a three-dimensional simulated environment.
- *Epson Moverio BT-300* for implementing augmented reality i.e. for the integration of digital information with the user's environment in real time. Unlike virtual reality, which creates a totally artificial environment, augmented reality uses the existing environment and overlays new information on top of it.
- *Microsoft HoloLens*, a holographic computer and head-mounted display enabling the interaction with holograms and real objects in the physical world. This advanced augmented reality is also called “mixed-reality”.



**Figure 1:** *Augmented-Reality Glasses (a), Virtual-Reality Headset (b) and Mixed-Reality Head-Mounted Display (c)*

### 3. Practical Usability in our Educational Institution

The support of education and training by VR / AR consists of two sub-concepts: i) training process of the trainees during the lesson using VR headsets and ii) support process throughout the work in the labs using AR glasses. The recording of VR scenario data allows the teacher to reconstruct a teaching situation in order to discuss individually made mistakes with the student in an educational conversation. The ability to individually address the strengths and weaknesses of the learner improves the learning process. We consider these new digital interaction devices such as VR and AR as a necessary educational tool, which brings a high benefit to the improvement of the learning, reviewing and training process. The learning scenarios are generated according to the educational goals and adjusted to the progress of training and target group. Leaving reality using VR-Headsets can help the trainee to perform and understand certain tasks that previously could not be realized due to the elaborate designs and security considerations. In the following table we show some potential applications of virtual

and augmented realities in relation to our laboratory infrastructure and how it can improve the education in our vocational school. The concept is also applicable to other VET institutions.

### 3.1 Practical use in the Automotive and TPD (Technical Product Design) Professions

Students can create 3D models in CAD and use them virtually, for example, for virtual assembly of electronic control units and for the execution of various controls in production. This reduces the cost of building a real prototype and encourages students to unleash their creativity and assess the value of their solutions. In the automotive sector, AR technology is used to visualize hidden components or the complex relationships between the control modules, to display additional information and technical documentations in order to speed up the fault detection and repair process as well as the animation of assembling processes for better understanding of the knowledge gained in the theoretical lessons (figure 2).



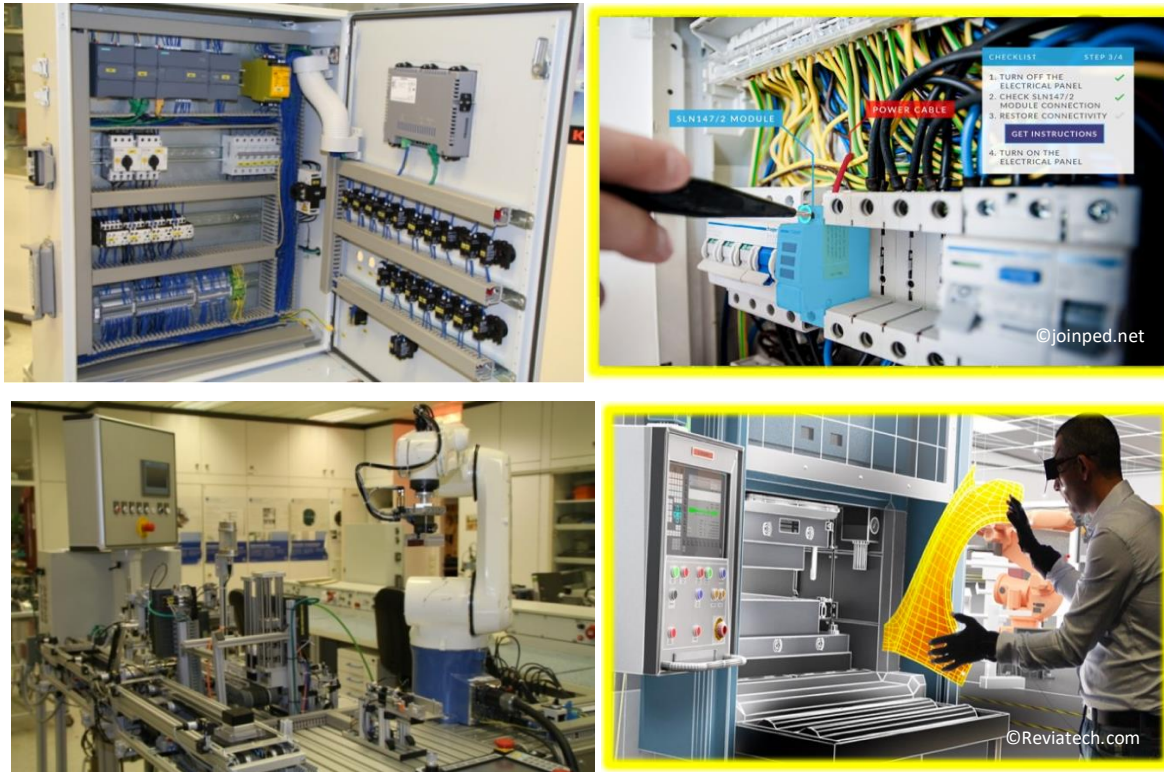
**Figure 2:** *Current and Desired State in Automotive and TPD Professions*

### 3.2 Practical use in Electronics/Electrical Engineering and Automation

During practical wiring work, the AR-device can be used as a supporting device (for wiring schemes, error and safety notes, datasheets, system information, etc.). The necessary data is displayed either context-dependent or depending on the user requirements (figure 3). During the learning process, the learner is assisted by visual cues (insertion of symbols, arrows, etc.) or



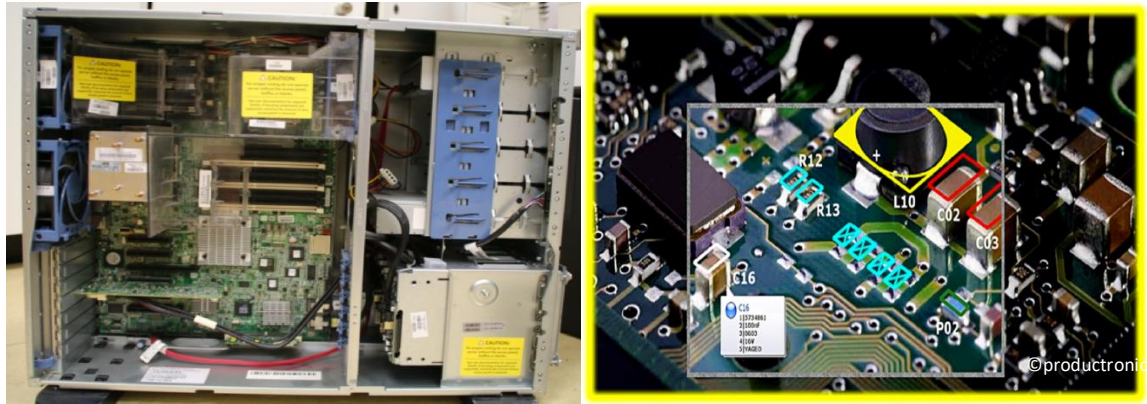
audible signals. Thus, increases the efficiency of the trainee and reduces also search times for information and improves the fault handling.



**Figure 3:** *Current and Desired State in the IT Laboratory*

### 3.3 Practical use in Electronics/Electrical Engineering and Automation

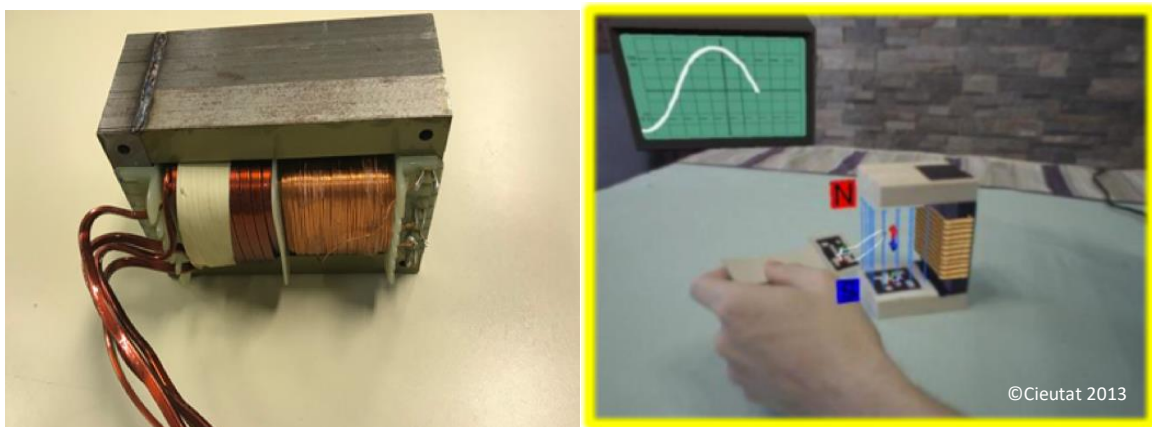
Visual inspections of computer parts such as Circuit boards (figure 4) are a good example of application; the constant comparison of the schematic drawing and the circuit board often leads to the rapid fatigue of the trainee. In addition, searching for the right components on the board and the necessary information in the datasheet or technical documents for the correct evaluation of a component takes a long time. AR optimize this verification process by displaying the test-relevant information corresponding to the current component, the parts list, the conducting paths, etc. Using AR, the assembly plan can be faded in over the board to be tested. Information such as colored markings, component polarity can now be compared with the board by a glance (figure 4).



**Figure 4:** AR for Inspection of Circuit Boards

### 3.4 Use in Theoretical Lessons

VR benefits from theoretical instruction and educational goals when it comes to providing teaching material or explaining complex issues (magnetic field (figure 5), behavior of electronic components and circuits, etc.), testing concept ideas, checking practicality, visualizing processes, as well as a communication basis for interdisciplinary teams.



**Figure 5:** Explaining Magnetic Field using AR

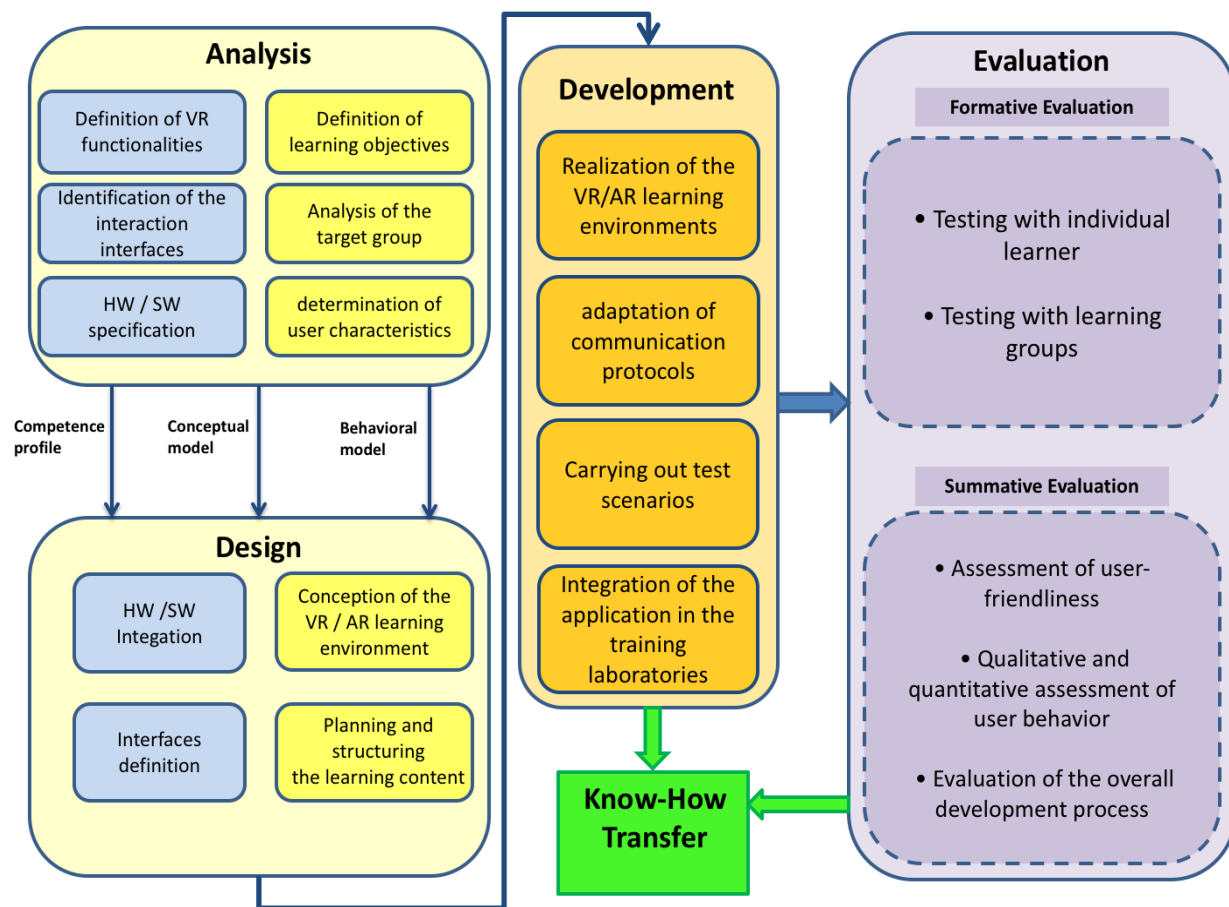
## 4. Didactic-Technical Conception

A didactic-methodical and technical integration of these technologies in the learning and education process requires a purposeful conception going through the four major phases: Analysis, design, implementation and evaluation (figure 6).

### 4.1 Analysis and Specification

In this phase, courses and learning objectives are identified and an analysis of the target group is carried out (trainees with social phobia, autism, insecure personality, increased distractibility, difficulty in focusing, significant social interaction difficulties). The learner is

considered as an actively constructing individual in this model. Initial requirements of learners can be determined by pre-tests on a representative sample of learners or by a selection of the results in previous training processes and by interviewing their trainers. This step enables the determination of the addressee's characteristics for the learning situation (previous experience, knowledge, skills, learning motivation, cognitive strategies, mental models). The behavioral model of the task can be determined according to the desired goals and functionalities of the virtual environment as well as to the behavior of the user and its corresponding action-level. The learning scenarios and situations of the VR should be selected based on the learning mode of the learners (level of internal differentiation).



**Figure 6:** Didactical-Technical Concept of the Project

## 4.2 Design and Modeling

The results from the analysis phase are used in the design phase as a basis for planning and structuring the content, including learning activities, exercises and learning tests. The learning material should be prepared with didactic tools (such as proven examples, applications,



notions, rules, questions and tasks). This step consists of selecting the appropriate behavioral interfaces and the physical environment in order to determine the appropriate mental representation for user interaction. A physical model of the virtual environment is created according to the application goals. The selected 3D content is prepared (object scan, photogrammetry, CAD constructions). The interfaces for the software and hardware integration are defined and the communication protocols for the interaction are adapted.

#### **4.3 Application and System Development**

In the development phase, the interactions, exercises and graphics are developed and incorporated into test scenarios. The hardware and software are integrated, the headsets are tested for software connection and the virtual learning environment is built up. The learning environment is characterized by many factors, such as the handiness, degree of reality, interaction and intuitiveness. VR is especially effective when used in an interactive environment. The interaction with the content should therefore be implemented as realistically as possible in order to promote active learning. The learning system should be straightforward, easy to access and uncomplicated. Functional tests should be performed in the various stages of development.

#### **4.4 System and Process Evaluation**

In the final step, tests are carried out to evaluate three aspects; some tests evaluate the usability of the interfaces. These tests make it possible, on the one hand, to quantify the adequacy between the measurement properties of the system and the psychophysical properties of the user. On the other hand, they allow the actual usage behavior of the interfaces to be quantified and qualified in order to verify if they correspond to the desired and programmed one. It is also a matter of analyzing the mental strain while using these interfaces. The results of these tests are intended to improve the interfaces design process. Further tests evaluate the data history to measure whether and how well the goals defined in the analysis phase were achieved. The reversibility of actions also makes it possible to bring a strategy into question and to examine the impact of a new one. Technical tests have to be carried out in order to optimize the overall development process for quality, safety and robustness, as well as cost and improvement of functionality if necessary. The following methods are suitable for evaluation: Assessment based on behavioural observation and analysis, content and media analysis, performance measurement, comparative investigation, interview survey, cost-effectiveness analysis, etc.

### **5. Pedagogic-Didactic added Value in Vocational Training**

A conscious use of the VR/AR systems benefits the educational process, because the VR environment with the 3D representation makes the teaching or training more interesting and enjoyable. At the same time, it provides learners with the necessary information needed for their educational goal. For this reason, the following aspects should be taken into account when implementing the concept:

- The continuous development of media literacy of the trainees during the whole training.
- Perform teamwork in a virtual environment and generate knowledge together (teamwork and communication skills)
- The promotion of core competencies, self-management, personal responsibility and self-reflection through tasks and scenarios developed together with psychologists and educators.
- The promotion of teachers' teaching skills through task analysis, the breakdown of generic goals into more specific goals and the attribution to corresponding learning activity.
- Recording of the learning situations and restoration of the scenes after class, in order to draw the learner's attention to his mistakes and improve his learning behavior.
- An increased learning efficiency and an improved learning process through targeted and individual e-learning
- Sustainable and effective learning in spite of complex, abstract and demanding issues
- To design the different learning scenarios based on each other and with different entry points depending on the existing pre-training, so that the present learning situation can be meaningfully integrated with different previous experiences

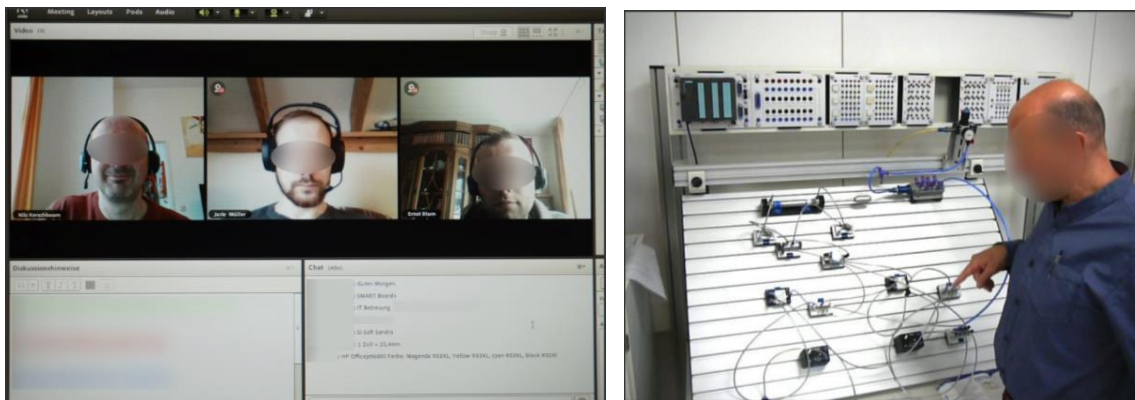
## **6. Conclusion**

Immersive technology has come a long way in a short time and will continue to evolve. It has finally progressed to the point where it can be adapted to any mobile phone. The introduction of Google Cardboard (<https://vr.google.com/cardboard/>) has shown the public that any smartphone of this generation can be turned into a virtual reality machine with the help of an HMD (head-mounted display). Thus, all students with a smartphone and a VR HMD were able to enjoy the extensive experience of VR applications and share their ideas with a whole new medium. This positive, playful experience has only encouraged students to expand their skills in a professional environment, including: in the labs during the training. The acceptance of

technology by students has a major impact on the teacher's attitude. The Strength of VR/AR in technical education lies in the fact that it makes students want to learn more about the topic, which in turn contributes to the success of the lesson.

Our institution would go a step further and integrate immersive technology in our Virtual Vocational Training. Since the year 2000 we are offering young people with disabilities the chance to obtain virtual vocational training via internet as individually needed (figure 7). Using VR, it will be easier to teleport the Trainees in a virtual control room and enable them to realize virtually control processes e. g. in pneumatics or mechanics. We are currently working with the industry and through in-house research on this project.

Since we are a mixed team made up of computer science teachers and trainers, IT professionals, software and hardware integrators and experts in human sciences such as ergonomics, psychologists and educators, who work closely together, this breadth of expertise and competences will reflect and positively impact the design of the interfaces and structuring of the virtual learning environment. By taking into account the intuitive, realistic interaction and high psychological involvement of the human being, the VR learning system will be made user-friendly, which in turn increases the effectiveness of the learning.



**Figure 7:** Training via Internet in our Virtual Vocational Training Center (VBBW)

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