



Virtual Welding Trainer Systems (VWTS) for Training and Further Education

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List of abbreviations

AfB	The Education Committee within the DVS	FG	Expert Group (within the AfB)
AfT	The Technical Committee within the DVS	GSI	GSI – Gesellschaft für Schweißtechnik International mbH
AG	Working Group (within the AfT)	IIW	International Institute of Welding (IIW)
AGFW	Energieeffizienzverband für Wärme, Kälte und KWK e. V.	MAG	Metal shielding gas welding
BZ RR	Bildungszentren Rhein-Ruhr	SLV	Research and education institute for welding technology
DVGW	Deutscher Verein des Gas- und Wasserfaches e. V.	SK	Teaching facility for welding technology
DVS	DVS – German Welding Society	MESA	Use of media in welders education
EFW	EFW – European Federation for Welding, Joining and Cutting	VWTS	Virtual Welding Trainer System
		TIG	Tungsten inert gas welding

Introduction



VWTS - A useful instrument for training and further education?

“For they know what they do” - this quote by the Branch Manager of the Bildungszentren Rhein-Ruhr puts it in a nutshell: After successfully participating in a welding course by means of Virtual Welding Trainer Systems (VWTS), most participants are confident in handling welding torches and have attained profound technical and practical knowledge. In the practical training they were taught which welding parameters to select, how to determine the correct welding speed and which torch position yields the optimum weld seam, as well as how to do all that without burning their fingers.

Virtual course contents also provide benefits to lecturers and instructors. On the one hand, the welding instructor can provide help to their trainees in a faster and more accurate manner than in a confined welding booth; On the other hand, participants study in teams, so they learn together and from one another at the same time. This method of working in groups is of particular advantage for beginners and people with language barriers. The facts and figures and empirical data included in this brochure prove that fact.

Nevertheless, many lecturers and instructors and even trainees remain sceptical (so far) about the increasing digitalisation rate in training and further education. They have reservations with regard to costs but also the qualification work for the lecturing and instructing staff.

The DVS – German Welding Society has created this brochure to discuss arguments in favour of and against this method, consult

experts and potentially also objectively substantiate reservations. It provides information on the advantages and disadvantages of VWTS and illustrates successful application cases in educational centres and in the industry by means of examples. In that chapter we have instructors, participants, manufacturers and users give their opinion and share their experiences with the “Virtual Welding Trainer System”.

Before we start: In their current state of development, VWTS cannot replace real experience using a real welding torch. However, they can supplement that experience. The aspects and scope are explained in this brochure.

The DVS has been performing research and providing training on various topics of joining technology for decades. Structuring this knowledge, making it available and imparting it to its members is one of the paramount missions of the DVS. The society has been contemplating and researching the application options for virtual welding trainer systems in training and further education for a long time. For this purpose, special DVS guidelines have been developed. The DVS educational facilities increasingly use virtual welding trainer systems in their daily teaching processes. With the “Virtual Welding Trainer Systems (VWTS) for Training and Further Education” brochure, the DVS lives up to its role as a multiplier of technical knowledge and makes exciting developments from the industry available to the public.



The DVS relies on VWTS

VWTS is represented everywhere throughout the DVS

As the German experts committee in the field of welding and associated processes, the DVS is leading in the further development of technical joining processes. The various bodies in research, engineering and education within the society develop guidelines and technical bulletins for use, e.g. in the form of DVS regulations and information leaflets. In this way, the potential for joining, cutting and coating engineering that lies within the concept of “digitalisation” has been discovered at a very early stage. Therefore, the Expert Group (FG) 2.8 “Welding trainer systems” was founded in 2011. Its task is to develop recommendations for the existing training regulations on welding engineering. This means that no major new concepts are required for training programmes using virtual welding trainer systems, but the existing ones must be extended by the new technologies.

The best example for this is the globally renowned training for welding supervisors established by the International Institute of Welding (IIW). In the current regulation DVS-IIW/EFW 1170 (IAB 252) “IIW Guideline for International Welding Engineers, Technologists, Specialists and Practitioners” the training contents are described for the following levels:

- International Welding Engineer
- International Welding Technician
- International Welding Specialist
- International Welding Practitioner

The regulation states the following on the practical training: ***“It is possible to use the advantages of Virtual Weld Training systems but maximum to 50% of the practical training hours!”***

This statement in an international regulation has a profound effect on the scope and structure of welding technology training, including in Germany. The DVS was quick in recognising this, and therefore the FG 2.8 is assessing and developing recommendations for the appropriate training, taking into account the internationally applicable provisions. Moreover, two other Expert Groups, i.e. FG 1.2 “New Concepts” and FG 2.2 “Welders” are closely collaborating to integrate the significant developments from the industry into this topic. The results of the work of these experts groups have an effect on many teaching and certification concepts within the DVS.

DVS regulations are path-breaking

For example, FG 2.8 developed the DVS regulation 1108-1 “Use of virtual welding trainer systems in combination with computer-aided welders qualification in DVS training centres”, among others. It gives users of virtual welding trainers more security for purchase, installation and daily use of the devices within the teaching facilities. In this DVS regulation, the Experts Group recommends for the VWTS training places in all DVS educational facilities to be considered equal with real welders training places and merely represent another method for improving the skills and knowledge of the training participants. We also want to expressly point out that learning and training in the welding booth cannot be replaced by the virtual machines, but is extended and supplemented by more, advanced training systems.

The DVS 1108-1 regulation lists all advantages that integration of VWTS into the teaching and training concept brings.

These are “direct feedback in real time”, “objective analysis and evaluation” or “consistent documentation of the welding results”, among others. The DVS regulation particularly regulates the use of workshop areas for VWTS as well as the parameters for the ratio between trainers and trainees, and also the requirements for the systems used.

The regulation issued by the DVS is an important basis and valuable support on the market for establishment of virtual workshop areas and, although it was developed in 2013, it is still up-to-date.

Moreover, FG 2.8 has developed a course for the use of VWTS in educational facilities: In the DVS 1160 regulation on the DVS training course “DVS-Welding Instructor VWTS” as of February 2019, which is offered as a further education course for welding works masters and welding instructors, the authors reveal an option for qualified further education, which is also part of the certification process. This DVS course is particularly suitable for teaching further skills to qualified welding trainers, such as media competence. In addition to the merely technical orientation of welding engineering know-how, so far, the DVS course

focuses on extensive media knowledge and method orientation that goes far beyond the previous spectrum. FG 2.8 will continue to develop more recommendations for action in future. New members are always welcome to participate and contribute.

VWTS is also an interesting topic among DVS subsidiaries

The DVS affiliated company GSI – Gesellschaft für Schweißtechnik International mbH (Society for welding technology international) has been collaborating with FG 2.8 since its foundation. The GSI focuses on training and further education and thus actively participates in the expert discussions on VWTS.

Other DVS subsidiaries also focus on the topic of VWTS: SLV Halle GmbH, for example, who presented their own welding trainer to the public as early as in 2005. These systems are used in various facilities for training operations.

DVS Media GmbH discovered one area in the field of VWTS, long ago. The specialist publisher has developed teaching and training documents for the “Soldamatic” virtual system in various languages and for various welding processes. Implementation of these teaching documents for other welding trainers is also discussed.

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VWTS media at a glance

- DVS regulation 1108-1 “Use of virtual welding trainer systems in combination with computer-aided welders qualification in DVS training centers”
- DVS regulation 1160 on the training course “DVS-Welding Instructor VWTS further education for Welding Teachers and Welding Instructors”
- DVS-IIW/EFW 1111-1 (IAB 089) “IIW Guideline International Welder Part I: General information, prerequisites”
- DVS-IIW/EFW 1170 (IAB 252) “IIW Guideline for International Welding Engineers, Technologists, Specialists and Practitioners”
- Poster: Career paths in welding engineering (in German, English and Arabic)
- USB stick “DVS reports, issue: 315, 316 & 317. DVS Congress, Welding Trainer, Robot 2015”



Training of MAG welding in PC position.

GSI SLV welding trainer: The pioneer with regard to VWTS

In 2005, SLV Halle GmbH was the first company worldwide to present a computer-aided welding trainer at the globally leading trade show WELDING AND CUTTING - the GSI SLV welding trainer. It was developed and produced by in-house engineers and welding trainers. At that time, the completely new methods for training of welders induced major changes in the traditional welder training. Since then, it has been possible to train basic motoric movement patterns, which are extremely important for welding, outside the welding booth before the welders focus their entire concentration on creation of the weld joint under real conditions in the welding booth. For SLV Halle, the motivation behind the development of their own VWTS was a practical one. They did not necessarily want to use a molten puddle for learning the basic motion patterns, such as igniting the electric arc, maintenance of a constant arc length or correct handling of the weld torch.

Use of the GSI SLV welding trainer

The GSI SLV welding trainer has been firmly established in the training of welding staff - not only in SLV Halle but also in many national and international educational centres. Through constant further development and close collaboration between developers, welding trainers and customers, a system has been made available that combines the characteristics of a real electric arc with a computer-based, intelligent curriculum, digital error correction and digital evaluation of individual exercises. The participants are capable of training and exercising independently and autonomously. The software of the welding trainer performs evaluation

of the exercises and increases the level of complexity after successfully completed training modules.

In the field of “practical training” the GSI SLV welding trainer is generally used at the beginning of every initial welders training. Depending on the scope of the training determined for the individual participants, motoric motion patterns are trained in the “welding trainer cabinet” of SLV Halle. Up to four systems are available for this purpose. Work is performed in teams with maximum four persons per welding trainer. For every team, an additional computer workplace is available with every welding trainer, which serves for teaching technical basic knowledge for the respective welding processes by means of e-learning. The intelligent curriculum of the welding trainers guides the participants through the practical exercises. After successful completion

of all modules at the welding trainer, the participants change over to the welding booths and continue their training under real conditions. Thanks to the previously learned and practised motoric motion patterns, the participants can then fully concentrate on the molten puddle.

In the field of “theoretical training” the GSI SLV welding trainer is generally used for training and education of welding supervisors (WSU). During the courses for International Welding Engineer (IWE), International Welding Technician (IWT) and International Welding Specialist (IWS), the participants get to know the basic welding processes of hand-held electric arc welding, as well as MAG and TIG welding, at the welding trainer at first.

“The motivation behind the development of our own VWTS was a practical one.”

In the practical parts of the respective courses, the WSU to be deepen their knowledge during practical welding in the welding booths.

VWTS is used for this purpose, as well.

School classes and visitors from Germany and abroad often visit SLV Halle to gain an insight into welding engineering. In addition to guided tours of the laboratories and workshops, trying out the welding trainer hands-on is an integral part of the visitors' programme.

Outside SLV Halle, the GSI SLV welding trainer is highly successfully used during education fairs, for example. Through demonstrations at the welding trainer during the fairs, visitors are encouraged to contemplate the topic of welding in more detail. In many cases, this awakens their interest in a vocational training in the fields of joining technology or materials engineering.



Training welding skills without material wastage.

Knowledge modules for virtual welders training

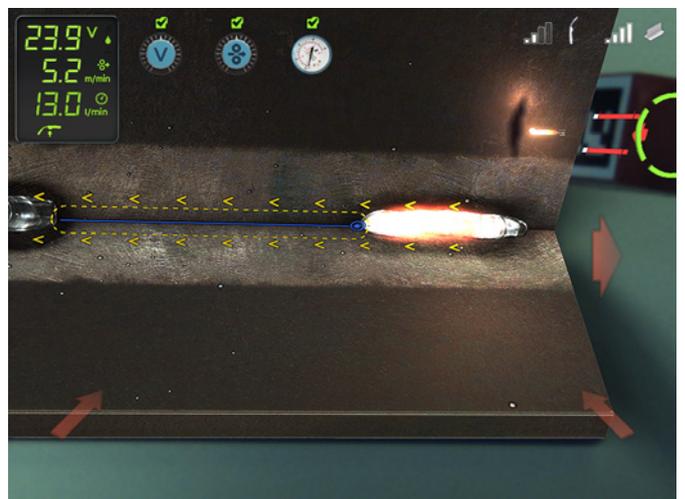
DVS Media GmbH in their role as a specialist publisher offers a vast range of information for joining, cutting and coating engineering in the form of printed and digital media. Be it through books, brochures, e-books or apps - provision and distribution of special knowledge for various target groups is always in the focus. The portfolio of the specialist publisher also includes provision of welding engineering know-how through virtual welding trainer systems. Cooperation between DVS Media and Seabery,

the Spanish provider of the "Soldamatic" virtual welding trainer system was established in 2015 and has already been highly successful. The publishing company offers their expert knowledge and practical expertise through basic courses for Soldamatic.

The courses initially offered were in German and covered tungsten inert gas welding (TIG), metal shielding gas welding (MAG) and hand-held electric arc welding (e-hand).



As soon as the welding parameters are set, ...



... virtual welding can be performed.

Meanwhile, these courses are available in many languages: DVS Media now offers courses in English, French, Russian, Chinese and Korean. Soon, there will also be courses for TIG, MAG and hand-held electric arc welding available in Arabic, Albanian and Serbian.

Theory modules and welding exercises

With their educational portfolio, DVS Media relies on the know-how of the DVS. Consequently, the theoretical parts and practical simulations correspond to the standards of the DVS training system. The exercises are suited for new, inexperienced welders. Each of the three basic courses is divided into seven modules for the participants. Each module comprises a theoretical part, a quiz and a welding task. The theoretical modules cover:

1. Welding processes
2. Technical basics
3. Welding equipment
4. Welding parameters
5. Fillers and shield gasses
6. Occupational safety
7. Joints, seams and welding positions

In the subsequent quiz, the learning success of the participant from the theoretical part is determined by means of multiple-choice questions.

Every module also includes a welding task in three levels of difficulty. For every welding task a Welding Procedure Specification (WPS) is available in the system, which demonstrates to the welder how to make the joint. With the help of the VWTS, the basis weld joints, ranging from application beads to fillet welds and butt welds, are simulated and trained.

With this concept, the basic course provides a great number of benefits for both trainers and trainees:

The theory modules:

- Through the theory modules, the participants are integrated into the self-learning process from the beginning.
- The tasks are self-explanatory and can be performed independently.
- Every participant can determine their own, individual speed of learning.
- The learning success for the theoretical part is determined through multiple-choice questions.

The welding tasks:

- Through use of welding instructions, the participants are trained in handling the WPS.
- The welding tasks can be repeated at any time without material wastage.
- The level of difficulty is increased continuously.
- Fast learning start and progress through combination of theory and practice in one device.

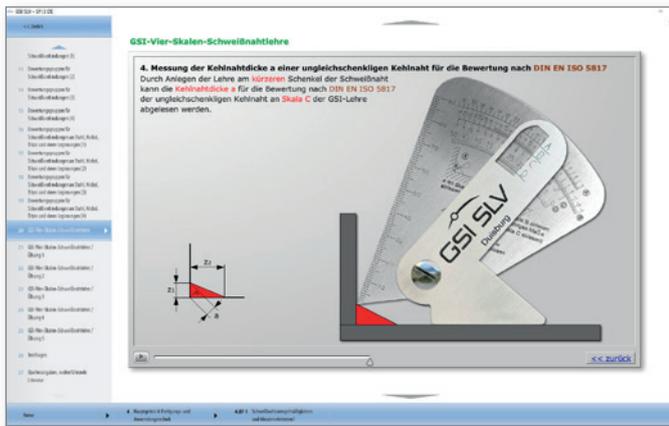
DVS Media GmbH already has more offers planned in the field of VWTS. For example, courses are going to be designed to increasingly incorporate multi-media. Also, customer-specific, individually designed courses are going to be included in the service portfolio.

Moreover, cooperation with other manufacturers of virtual systems is intended. With Fronius International GmbH, collaboration has already been agreed. In future, DVS Media will develop courses for the "Fronius Virtual Welding" trainer.

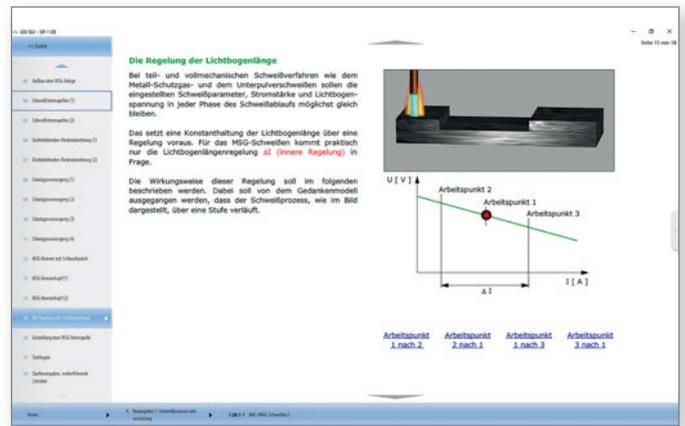
Corporate e-learning in welding technology

In almost no other fields are the requirements applicable for personnel and products higher than in the field of welding engineering. However, high quality can only be achieved and maintained with appropriately trained personnel. Due to the modern-day dynamics in development and technology, a gap between the previously learned contents and the current requirements may easily arise. Therefore, the major quality characteristics are constant training and further qualification of employees. But how can a feasible balance between deadlines, daily business and further qualification of employees be achieved? One possible solution would be the e-learning services by the GSI – Gesellschaft für Schweißtechnik International mbH.

For more than 15 years, the GSI has been active in the development of interactive learning media for welding engineering. The current service offer for private persons and companies includes courses from traditional training as an international welding engineer, welding technician or welding specialist through to special further trainings, e.g. for laser specialist, ultrasonic inspector or coating inspector. Training and further qualification of staff in practical fields, such as welders, operators and inspectors are also on trend at the moment.



Through additional use of “explanatory videos”, the correct use of theoretical teaching contents on weld joints is illustrated in practice.



Animations in the learning modules illustrate and explain complex topics, such as internal regulation in MAG welding.

Learning management systems as a useful supplement

The benefits of e-learning are unbeatable, particularly in further qualification and for permanently required and repeated training. Flexible, independent of time and place, with directly transparent monitoring of the learning success, e-learning is the solution for many problems. A useful supplement and support of the e-learning contents is a web-based learning management system (LMS). It provides the learning contents and structures the learning processes. The benefits of a learning management system are in easing the burden for companies through clearly structured information, performance of the required administrative tasks and support of the learning process.

Development of customised company training can be implemented at low cost using e-learning. Extensive available general contents from welding engineering can be customised for the respective company and individually extended by special requirements. Specific group sizes, integrated monitoring of learning successes, documentation and evaluation options offer every company the possibility of re-defining quality assurance.

The benefits at a glance:

- Reduced costs, such as travel costs, travel times and allowances
- Near-term training of employees
- Use of the internet without any administrative expenditure by the company
- Tried and tested learning format, incl. modern methods, didactics, navigation and operation
- Sustainable learning results through direct sense of achievement
- Customised course contents for individual companies with easy content update
- Specific group sizes and evaluation options (e.g. by personal learning status)
- Integrated monitoring of learning successes, documentation and evaluation
- Installation of a separate learning platform
- Adapted to company-specific quality management systems

For the training and further qualification of welders, this option also provides a useful extension for e-learning:

- Training and preparation for the theoretical test
- Prompt and verifiable learning results, including documentation
- Easy documentation of repeated training sessions, such as safety instructions

Corporate e-learning by GSI is an offer for welding staff. Available in various languages, this format of interactive learning helps students to meet the quality requirements in welding engineering.



Figures and empirical data

SLV Nord: Study determines VWTS success in training

Although virtual welding trainer systems have been integrated into training and further education for a few years, there have only been a few statistical surveys that illustrate the learning effect of VWTS. SLV Nord gGmbH has collected data from their training courses for displaced persons during 2016 to 2018 and evaluated these data in December 2018. These are the results:

In addition to practical training courses on all conventional metal and plastic welding processes, SLV Nord offers theoretical further education up to the advancement qualification of "International Welding Engineer". All courses and seminars are performed under high quality requirements as per the regulations of the DVS-IIW/EWF, DVGW, AGFW. SLV Nord operates an accredited test laboratory as per DIN EN ISO 17025 for non-destructive and destructive material testing and performs engineering services within the framework of company certifications for quality assurance and construction monitoring.

In the field of practical training and further education, work was initially performed on rented VWTS devices by various manufacturers. Then, within the scope of a master's thesis, a profitability analysis, including purchase recommendations, was performed in 2014. This was used for orientation and in February 2018 the virtual welding workshop of SLV Nord was opened. All welding instructors have been trained in handling of VWTS and were able

to gain initial experience during training of vocational trainees, exchange with colleagues, group events and other events.

The first course with planned and scheduled use of VWTS was the fourth training course on "Learning to weld - learning German" (briefly referred to as SLDL), a measure for displaced persons funded by the "Integration through qualification" network, which also included lessons in technical German and support of participants in their daily lives in addition to welding engineering aspects. The SLDL course was performed four times during 2016 to 2018 and included a total of 51 participants from 17 countries, for example Afghanistan, Iraq, Syria, UK, Spain or Turkey.

The prerequisite for being granted a place in the SLDL course was participation in an activity week. During this activity week with a focus on "metals/welding/electrics", the participants were given the possibility of proving their manual skills in practical tests, receiving a statement on their language level in language exercises and getting to know the three crafts in more detail. At the end of this 35-hour week, all participants were informed about their results and the resulting options for further qualification in individual interviews. The participants that were skilled and interested in a welding engineering qualification were invited to take part in the SLDL course.

"The SLDL course was performed four times between 2016 and 2018."

The “Learning to weld - learning German” course comprises three major components:

- a preliminary 40-hour German language course with a large proportion in technical language
- an international welder’s qualification in compliance with the regulation DVS-IIW/EFW 1111-1 (IAB 089) “IIW Guideline International Welder Part I: General information, prerequisites” (MAG process).
- accompanying classes in technical German of eight hours per week, where the participants could practise competent use of the technical terms used in the specialist training.

The decision in favour of the MAG welding process was made on the basis of the labour market orientation in and around Hamburg and the vacancies available for welders, since the goal was to achieve a high integration rate in the labour market.

Finally, all participants were given six welding tests to successfully execute in the MAG process (two fillet welds for panels, two butt welds for panels, two butt welds for tubes) through which they could obtain three diplomas for international fillet welder, panel welder and tube welder.

Since VWTS was only used in the fourth course (2018 I), there is a data basis available that is easily evaluable for the profitability study on the use of VWTS in practical training of welders. During the 2018 I course, 3.5 days of the 60 days in manual skill training in the welding workshop of SLV Nord were used for exercises and practice in the virtual welding workshop. The first practice sessions in the virtual welding workshop were held directly after the one-week language training and a half-day safety instruction session. At the VWTS, the participants performed initial manual

skill exercises in hard-face welding to fillet welds, either in pairs or in threes. After successfully welding the two fillet weld tests, the participants performed more manual skill exercises for butt welds during two more days in the virtual welding workshop before they went back to the real welding workshop to perform further welds.

Prerequisites of the participants

To check comparability of the four courses, a preliminary comparison of the participants’ prerequisites was performed.

Comparison 1: Age of the participants

The participants were aged between 20 and 52, with the average age through the four courses only deviating slightly.

Comparison 2: Language levels of the participants

The language skills of the participants were determined on the basis of the language levels defined in the European reference framework, i.e. A1 (beginner) to C2 (expert) and on the basis of presented documents.

The language levels were rather low in all four courses. However, the minor differences do not seem to have been critical for success; for, on the one hand, the actual language skills significantly deviated from the documented levels, and on the other hand, the language skills of the participants had greater effect on passing the theoretical tests than on learning the practical manual skills.

Comparison 3: Professional qualifications

The presented professional qualifications were also compared. A differentiation was made for professional qualification in a metal-working craft, professional qualification in another craft or no qualification.



Overall, the most participants of the SLDL courses had no qualifications. This situation was similar throughout all four courses. However, this criterion was given relatively low priority, since a professional qualification, e.g. as car mechanic, lies within the metal-working craft but does not hold any information on the technical welding skills of a participant.

Comparison 4: Welding experience

The comparison of the welding experience of the participants seemed more important. For that purpose, all participants were interviewed at the beginning of the activity week.

Average experience in welding		
Training	Ø Experience in years	min and max
2016 I	5	from 0 to 12 years
2016 II	3	from 0 to 10 years
2017 I	10	from 0 to 18 years
2018 I	2	from 0 to 7 years

A significantly higher number of participants already had welding experience than in the other courses. In view of obtaining sound study data, this course should be neglected in the comparison. This becomes clearly evident when comparing the average welding experience (see table 1).

Results of the studies

For assessment of the efficiency of VWTS in the SLDL course, two criteria were considered:

- the success rate in welding of a test piece
- the time required to achieve the qualification goal

Success rate in welding of a test piece

All welded test pieces were included. Each participant was intended to weld six test pieces. A comparison was made between the test pieces that were rated good by the inspector at the first try and test pieces that failed inspection and had to be repeated by the participant.

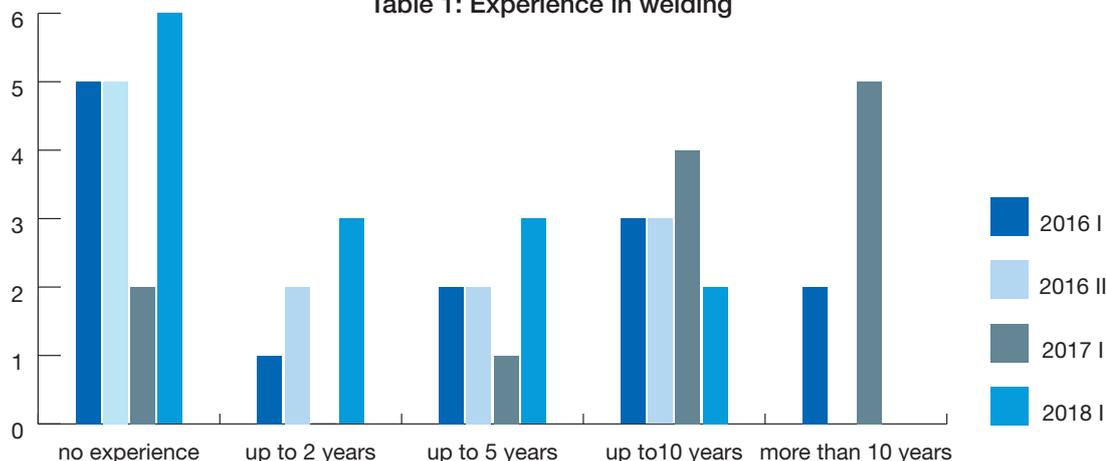
Despite consideration of all four courses (i.e. also the 2017 course with a high rate of welding experience) it soon became clear that the participants in the 2018 course (using VWTS) had a 10 per cent higher success rate than the other groups.

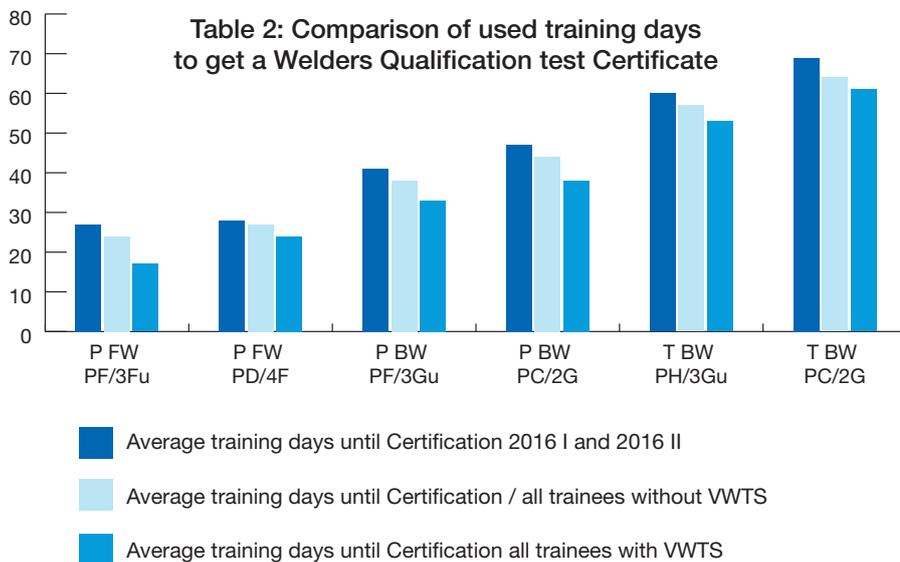
Success rate in welding of a test piece in percent		
	Success rates of the 2016 - 2017 courses in %	Success rate of the 2018 course in %
first test piece failed	11	1
first test piece successful	89	99

Time required for achieving the qualification goal

In comparing the participation time until the welding test is successfully performed (i.e. the six qualification goals), distinctive effects become evident. For reasons of completeness, all four groups were initially compared (see table 2).

Table 1: Experience in welding





A decrease in training days is clearly visible, but this effect becomes even more evident when taking a look at the actually comparable groups.

While participants without VWTS on average required the scheduled time for achieving the educational goal, the group using VWTS undershot the scheduled times for all educational goals. Especially the initial success (first educational goal) reveals that VWTS is a suitable means for training the basic manual skills (see table 3).

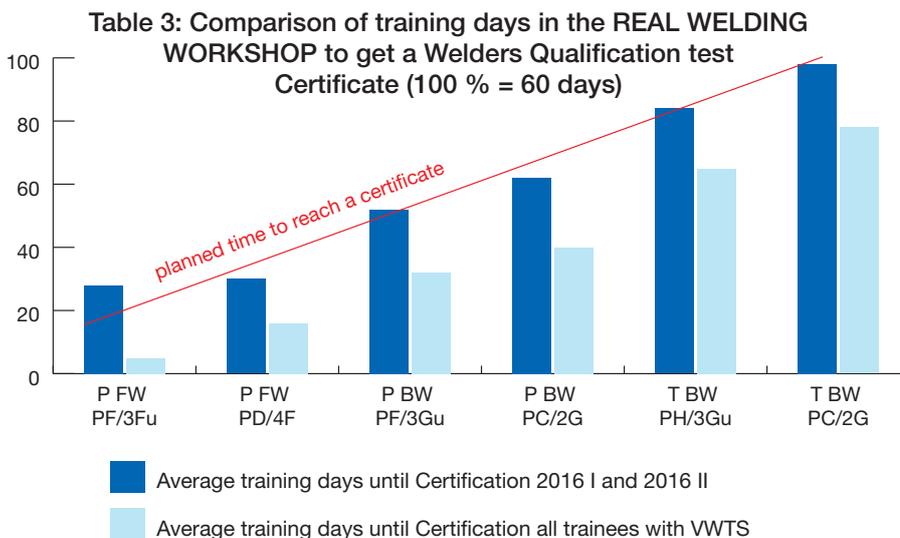
Overall, the training time was reduced by approx. 20 percent while the success rate simultaneously increased by 10 percent. In addition, it is also worth noticing that only 3.5 of the planned 60 days of training were spent in the virtual welding workshop.

Evaluation and outlook

The efficiency of practical training of welders with language barriers is significantly increased by use of VWTS. It can be assumed that these results are also applicable for groups without language barriers.

Considering the practical exercises defined in regulation DVS-IIW/EFW 1111, optimisation can be achieved by developing expedient VWTS and real exercises.

Additional analysis in this direction will take place in 2019, also within the scope of a planned master's thesis. From those data, recommendations for targeted use of virtual welding trainer systems will be deduced for many other measures for welder's qualifications at the SLV Nord.



Explanations and abbreviations

German code	International code	Explanation
P FW PF	P FW 3Fu	Panel, vertical-up fillet weld
P FW PD	P FW 4F	Panel, overhead fillet weld
P BW PF	P BW 3Gu	Panel, vertical-up butt weld
P BW PC	P BW 2G	Panel, horizontal butt weld
T BW PH	T BW 3GU	Tube metal, vertical-up butt weld
T BW PC	T BW 2G	Tube metal, horizontal butt weld

The first letter represents the semi-finished product, i.e. P (panel) or T (tube). The second and third letter represent the type of weld, i.e. FW (fillet weld), BW (butt weld). The fourth and fifth letter represent the welding position; positions in Germany differ from the internationally used positions.

Summary:

VWTS increase the efficiency of practical training of welders.



VWTS in training

Educational facility: Bildungszentren Rhein-Ruhr

Studying together and learning from one another

The Bildungszentren Rhein-Ruhr (BZ RR) are a subsidiary of the GSI - Gesellschaft für Schweißtechnik International mbH (Society for welding technology international) and have been located in Oberhausen since 1993. Since their accreditation as an independent GSI subsidiary in 2006, the central administration of the BZ RR is also located there. With their new training workshops, the BZ RR together with seven other GSI subsidiaries form the largest training and examination body for welding engineering in Germany.

Subsidiary manager Wolfgang Hildebrand-Peters and Training manager Dipl.-Ing. Holger Rautert consider learning at the BZ RR using VWTS to be a unique feature of welding training in the Ruhr area. The virtual welding trainer systems are not only a useful instrument for the participants to practise but also well suited for demonstration purposes at fairs and exhibitions. In this way, the BZ RR position themselves as advanced and future-oriented training workshops.

For more than three years, virtual welding trainer systems have been used in classes at the BZ RR. At the Oberhausen site there are five VWTS, and two in the training workshop in Bielefeld. Although at the beginning it was only possible to virtually train MAG welding, now the trainees are also given the possibility of practising their skills in TIG and electric arc welding. Learning and training takes place 1:1, which means that one participant works and practises at their welding trainer. However, the welders to be are always taught in groups to ensure that they study together and learn from one another.



Error analysis on screen: Uwe Koppel, welding engineering instructor, explains the welding process to participants using an example.

According to Hildebrand-Peters and Rautert, learning is not only faster by this method but also more efficient. They are much more aware of what they are doing and, what is more, why they are doing it. This is a great advantage, particularly for participants with a migration background, who want to learn or deepen their welding knowledge. In addition, they are offered language courses; speaking German is indispensable for being able to gain a foothold on the German labour market. The placement rate of foreign participants in the BZ RR is nearly 100 percent. This rate confirms the concept of subsidiary manager Hildebrand-Peters in relying on VWTS throughout daily learning within his educational centre.

Interview with Uwe Koppel, welding engineering instructor

In Oberhausen, the welding engineering instructor Uwe Koppel comes into particularly close contact with participants; he has been working with VVTS for as long as eight years. In the following interview, Koppel reveals his estimation of the Virtual Welding Trainer Systems (VVTS) for training and further education.

Mr Koppel, why do you rely on VVTS for training and further education?

In addition to savings in materials, it is particularly the aspects of body posture correction and hazard-free training that provide great benefits. Also, the simple explanations are very good and useful, particularly in the case of the language problems that our foreign participants might face.

What is your experience with this technology as an instructor?

There is no decrease in the overall time when using VVTS. As I said before, the body posture can be perfectly observed and corrected during practising sessions. In this way, beginner's mistakes, such as tense holding and guiding of the torch, can be easily identified and improved.

You have stated some of the advantages. In your opinion, what are the disadvantages in using VVTS in training?

Root welding of butt welds is limited with the systems we use here. The overall graphic representation of the welds is not very realistic, so far. But I think this can surely be rectified by future software updates.

Do you notice increased interest and participation of trainees due to the use of VVTS?

Yes, certainly. The number of participants is increasing due to exhibition of VVTS at job and trade fairs.

Do you think that VVTS will be used nationwide for training and further education in Germany?

That is a definite "Yes"! Through new software developments, the use and the fields of application of virtual welding trainer systems will be extended.

Educational facility: SLV Nord gGmbH

VVTS changes the conventional welders training

SLV Nord gGmbH in Hamburg is renowned as a competent partner in all fields of welding and testing engineering. The educational facility is well equipped in the field of digitalisation. Wi-Fi was established in the entire ELBCAMPUS building in 2008, in 2011 a "virtual classroom" was introduced as an on-line portal for participants, and in 2013 the facility joined the learning management

system of GSI. Since 2014, tablet computers have been available for participants as "folders and documents" for the welding supervisor qualification and in February 2018, SLV Nord opened their "virtual welding workshop". Since then, twelve participants can learn and train with six welding instructors using the latest generation of devices.

Interview with Dipl.-Ing. Sven Noack, General Manager of SLV Nord gGmbH

Dipl.-Ing. Sven Noack, General Manager of SLV Nord gGmbH speaks about the special aspects in learning using the Virtual Welding Trainer System and what the first impressions in training and further education were.

Mr Noack, you have been using VVTS in training and further education since 2018. What is the philosophy that you as General Manager of an educational facility have been following for implementation of these training tools?

All experts of the industry are aware of the special requirements in welding engineering. To overcome such challenges, the basis

prerequisite is highly qualified personnel. With the "appropriate VVTS systems" training of welders to be and also of welding supervisors and other expert personnel becomes more modern, more transparent, of higher quality and economically more attractive. Reduction of training times through more efficient learning seems possible but needs to be confirmed by further experience and studies.

I am convinced that manual skills of welders to be can be significantly improved by integral use of virtual welding engineering training.

Routines for welding parameters, such as welding speed, torch feed and inclination angle, distance of contact tube or electrodes can be trained as individual parameters. The motion sequences can be broken down into individual steps during practice and the participants receive direct feedback from the trainer systems while the “assistance systems” coach the welders to be. The repeatability accuracy of the technical welding sequences is trained under almost real conditions. Everything through “augmented reality”.

What is your experience in using VWTS?

During the few months after implementation, marketing and application, we have only received positive feedback in Hamburg. Open and interested groups of participants for various fields of the industry have tested the virtual welding trainer so far: ranging from trainees to the “classic” welder to be, partly experienced welders, various work groups of the DVS, jobseekers, migrants, company bosses, welding supervisors, instructors, teachers from vocational colleges. Both old and young were impressed by this future-oriented technology.

A “competitive approach” is spurred through the “HighScore” effect in every welding level, which leads to competition and related improvement in manual skills and welding engineering sequences. Even experienced welders are interested in trying out the new system and train using the welding simulators after a short break-in time.

How do instructors estimate the use of VWTS at SLV Nord?

They are absolutely open, curious and motivated. They are keen on trying out the new technology and successfully weld the

various levels themselves. Also, they want to train further in the use of VWTS and provide that knowledge to their DVS welding works master colleagues and have participants groups benefit from their experience as supervisors. None of the welding instructors at SLV Nord shut themselves off from this virtual world.

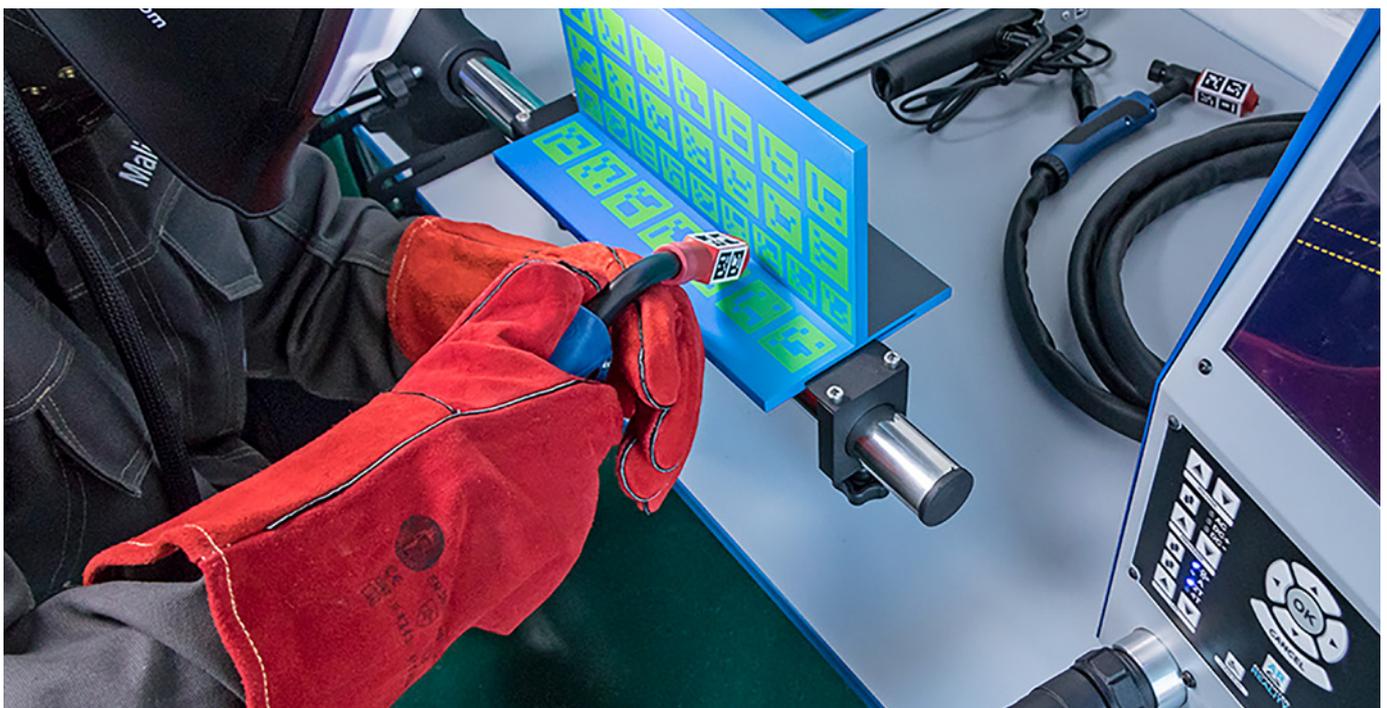
Do you notice increased interest and participation of trainees due to the use of VWTS?

Not yet, but there are initial discussions and cooperation approaches with partners from the industry, who intend to provide virtual, advanced and future-oriented training to their trainees in additional modules.

Do you think that VWTS will be used nationwide for training and further education in Germany?

That is a clear “Yes”! The use of VWTS will significantly change things, especially the traditional methods of welder qualifications. Assistance systems today used in the virtual world will transition into the real world of welding and play an important role e.g. in “real welding helmets” and “real welding machines”. Consequently, the welding parameters defined in a WPS welding instruction will be adopted by the welder transparently and objectively with the help of assistance systems, or the welders receive more support by technological features when performing their welding tasks.

Let’s take a look at cars as a comparative example. The driver receives virtual or acoustic feedback when parking the car, for fastening the seat belt, for keeping the correct distance to the car ahead, when exceeding the speed limit and in many more cases.



Today, welders receive no feedback at all in manual welding. But soon we will experience approaches in the form of assistance systems in welding, similar to those in cars.

In the long run, future-oriented educational facilities will not be able to avoid integral use of virtual systems.

In which sections within the DVS training system is it possible to use VWTS?

Use of the technology makes sense in practically all sections of the DVS training system. They merely differ in aspects, contents and objectives. For example, welding trainees will use the technology more intensively in terms of time and engineering features than welding supervisors to be. But also a DVS welding works master or a DVS welding designer can gain general knowledge of the technology with the help of these systems.

Educational facility: SK Göppingen

Best-practice example for state-of-the-art training

The DVS-approved Göppingen teaching facility for welding technology (SK) is one of the facilities that are increasingly using VWTS in their welding trainings and further education. It has been located within the business school in Göppingen for more than fifteen years. The business school closely cooperates with local companies, professional associations and the chambers of crafts.

Markus Leich is a technical teacher at the business school, as well as deputy head of the teaching facility and a DVS welding instructor in SK. He is convinced that participants achieve a higher training quality within a shorter time thanks to VWTS. Through the use of four welding simulators and the specially established “learning factory 4.0” (see p. 18), trainees are prepared for modern-day welding requirements through digital, modular and virtual processes. VWTS has been used for more than three years both in school education and in the teaching facility, in the fields of E-handheld, MAG and TIG.

For the instructors at SK Göppingen it is important to equally cater for the needs every trainee within a class or a group. This often is difficult to accomplish, especially with group sizes of up to 15 students. There is little time for intensive supervision in “real” welding. Through introduction of simulation welding prior to “real” welding, welding of the actual material can be taught more quickly and faster success is noticeable. This has been observed by Markus Leich and his colleagues. In this way, their expectations for the use of VWTS have been surpassed by far. Leich considers additional benefits to be in the aspects of self-control, self-monitoring, documentation and saving of materials. And, above all, he witnesses the enthusiasm of the trainees when working with state-of-the-art virtual devices. This is a motivation for welding and ultimately for practising.



Markus Leich (left) explains the functions of the Virtual Welding Trainer System to trainees.

The advanced technology ensures state-of-the-art teaching. However, to be able to provide this, the modern SK Göppingen needs to keep up with the fast technical progress.

Future outlook

For Markus Leich, the use of VWTS is a building block for establishing advanced and future oriented training and further education. Based on his experience from the past years, he can see that virtual welding trainers will continue to be established in many areas of training and further education. He assumes that handling will continue to develop. “The use of VWTS will become more realistic and much easier in terms of application and it will be established in the field of training in a multitude of applications,” states the DVS welding instructor. However, in his opinion, increased funds for training and further education must be made available and strong partners need to be taken on board, who are willing to support the constant changes in technology.

SK Göppingen: Report from a trainee

The DVS-approved SK Göppingen teaches various groups of trainees. Ranging from support of migrants to vocational trainees in the fields of metal-working technology, automotive engineering, electrical engineering and manufacturing technology, junior professionals are taught in various welding processes, also using the VWTS. In the previous chapters we have had a look at the opinions of manufacturers and instructors on the use of VWTS. But what do trainees think of welding with a “virtual trainer”? Marcel Brüggemann, trainee at SK Göppingen, answered our questions.

Marcel Brüggemann, 22

Second year of vocational training to become a metalworker at Leonhard Weiss in Göppingen; professional goal: metalworker with a specialisation in construction engineering

What training course do you attend, Mr Brüggemann?

I am currently undergoing the second year of vocational training. I have a training contract with my company and attend the business school in Göppingen in a mini block module, i.e. three days every two weeks where I train to learn the in-depth work as metalworker in cooperation with my training company.

When was your first time working with the VWTS?

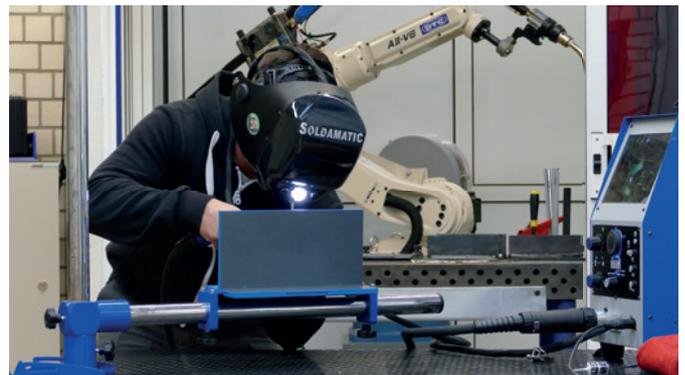
I have been working with the VWTS since my first year of training. In e-handheld welding at first, now I am learning the basics of MAG welding and have undergone introduction with the simulator.

What was your impression of the VWTS when working with it for the first time?

It was particularly useful to learn and practise the correct angles, distances and speeds with the help of the simulator; and digital welding alone and beating the high-scores of my classmates was a huge motivator.

What is your impression at the moment?

It is great for getting to know the handling and as a preparation for reality. But of course, for permanent and in-depth working, reality is unbeaten.



Marcel Brüggemann during training at the VWTS.

How do you feel about working with a virtual welding trainer?

There is still something missing when trying to come as close as possible to a natural weld joint by real welding.

What are the advantages/disadvantages of working with the VWTS in your opinion?

No risk of accidents for beginners, all materials and material thicknesses are available, angle guidance is very accurate and meticulous, you can watch your own mistakes in a film.

But there is still a difference to reality. You need to burn your fingers to become a proper welder.

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Learning factory 4.0 at SK Göppingen

The concept of working with the VWTS in welding engineering training is a good match with “learning factory 4.0”, which is used by the business school in Göppingen for training of mechatronics and automation technicians to be. Learning factory is located within the centre of competence for automation technology and mechatronics, which is operated in cooperation with FESTO Didactic. At the core of the learning factory are the two laboratories for “basic mechatronics” and “applied mechatronics”. In the basics laboratory, basic sequences of automated manufacturing are trained at MPS stations and cyber physical systems. The trainees practise sorting, distribution and testing, as well as basics in robotics. Depending on the task, the stations can be programmed for practising the work steps either individually or in an entire process chain. At the end, the individual processes are completely vertically linked.

Supplier: Fronius International GmbH

“Real” training benefits from virtual learning

Fronius International GmbH is an Austrian company with their headquarters in Pettenbach in Upper Austria. Fronius is globally active in the fields of welding technology, photovoltaics and battery charging technology. As the manufacturer of the VWTS Fronius Virtual Welding, the company is also highly active on the market.

In 2009, Fronius presented their virtual welding simulator to the public at the world's leading fair WELDING & CUTTING and found that with their VWTS they were in line with the current trends in welding engineering training. The in-house device offers four functional packages and three process variants for trainees to practise virtual welding.



Interview with Nikolaus Zauner, Product Manager Virtual Welding

For Fronius International GmbH, the virtual welding trainer is the logical consequence of an increasingly digital world. Nikolaus Zauner, Product Manager Virtual Welding, explains why VWTS plays an important role in training.

Mr Zauner, what was the reason for developing a VWTS?

Fronius is renowned as technological leader. This does not only include innovative products but also concepts that allow our customers to use such innovations in various devices. Ranging from correct operation and parameterisation for every weld task to welder's training. If trainees are made familiar with our products as early as in their vocational training, they benefit from that when using our devices in practice.

What is the objective that you pursue by the development of VWTS in training?

Training and education is subject to constant change, particularly in these modern times, since you have access to information through mobile devices at any time and any place. Acquisition of information is becoming increasingly digital - videos, animations and applications help trainees to familiarise themselves with topics faster and better. In particular, virtual reality contents and motion sequences, for example, can be trained more intensively.

Who are your customers in VWTS?

With our portfolio (apps, documents, simulators) we address various fields of training and education, such as schools, universities of applied sciences and universities, but also train-the-trainer schemes and adult education and/or re-education.

What aspects do you appreciate in training using a VWTS?

Preparation for the REAL training can be implemented better. The trainees can watch their progress on the simulator and can develop independently without the physical presence of a trainer. Since

the elaborate preparation phase (preparing panels, spot-welding, ...) is no longer required, this time can be used for other things. In contrast to that, the trainer is less involved in the intensive “introductory phase” of the trainees and can thus spend more (individual) time with the trainees during the real training.

How do you estimate the application options of VWTS in the future?

Technology is developing at a fast pace and simulators become more real both in terms of haptics and in terms of software - this is something trainees will benefit from. Nevertheless, real welding will always remain an integral part of the training while the various approaches provide support to the trainees.

Do you think that VWTS will play a greater role in future than at the moment?

I think that in the future there will be more variants of simulators, since the fields of application strongly deviate in some major points. Similar to computers, the decisive factor for its power is the application; with simulators, this factor will be the scope of learning contents and tasks that the simulator covers.

What needs to change for VWTS to be extensively used in German educational centres?

The generation using these systems for training often has a different technical understanding than the trainer. However, the complexity of the systems in many cases is in the creation of contents, i.e. exactly where the trainers are needed. In my opinion, VWTS providers must ensure greater support in implementation and at the same time ensure easier configuration of the systems. Usability is an important topic in this scenario!

Supplier: WeldPlus GmbH

Digital comprehensive solution for tomorrow's experts

Providing qualified training for specialists in welding engineering through innovative technology and state-of-the-art didactic and methodical concepts - that is the objective of WeldPlus GmbH from Müschenbach in the Westerwald. They have been selling the "Soldamatic" developed by the Spanish company Seabery since

2014. This is a training solution based on augmented reality (AR). In addition to sales operations, professional consulting, education and training with regard to implementation of digital media in the environment of training and further education are among the core competences of WeldPlus.

Interview with Dipl.-Betriebsw. Anke Richter, General Manager

Ms Richter, since when has the first Soldamatic been available?

In 2009, the software company Seabery from Spain started development of the AR-based Soldamatic training concept as a complete solution. In Germany, this VWTS has been available since 2014 and is constantly being developed further in close cooperation with the manufacturer.

Why did Seabery develop the VWTS?

The goal was to provide a tool to instructors to make training and further education more efficient, future-proof and digital. The focus was on utilisation of AR technology.

Who are your customers?

All players in the field of training and further education of welding professionals who are active in the metalworking professions are among our customers. These include industrial companies, vocational schools and colleges, external educational centres, training facilities and training centres in the field of metalworking. The system is also used by universities in their lectures.

What are your objectives with regard to sales of the VWTS?

There is a large number of support and incentive schemes available to get digital transformation on the road in all business environments - also in the field of education. Our goal is to support and foster this development by means of cutting-edge technology and the latest didactic and methodical concepts.



What aspects do you appreciate in training using VWTS?

In contrast to the 3D systems, AR-based systems operate with "mixed reality" where only the workpiece is animated. This ensures near-reality welding, to provide practical knowledge in welder's training faster, more cost-efficiently and more effectively - referred to as "augmented training". But not "only" practical welding is at our focus but also the complete teaching and learning concept, including integrated e-learning platforms and learning management systems. Through AR technology in combination with teaching and learning materials closely based on the DVS, new digital educational concepts will be included in the qualification of welding specialists.

How do you estimate the application options of VWTS in the future?

The readiness and willingness to ensure comprehensive implementation of digital media is ruled by the competitiveness of the training system. The use of VWTS is the logical consequence and development that corresponds to the requirements of modern training and further education.

Do you think that VWTS will play a greater role in the future than at the moment?

AR-based technology develops at a high pace: As early as this year, there will be an option available for integrating company-specific individual modules into the simulation. Also in the field of robotics it is possible for the first time to train future robot operators by means of the latest AR technology and at the same time teach the basics of manual welding. Through combination of AR technology with automated systems, further benefits will be generated in "research and development". This opens another path for successfully implementing the DVS 1184 regulation "Operation for fully mechanical and automated welding systems".

What needs to change for VWTS to be extensively used in German educational centres?

The qualification of instructors and teaching staff in the field of digitalisation and application of digital learning media must be continuously actively supported, to achieve successful change in the field of professional training and education in Germany and thus comply with the market requirements in times of globalisation and assurance of skilled specialists.



Supplier: Panasonic Industry Europe GmbH VWTS as an element of Industry 4.0

Panasonic Industry Europe GmbH is part of the globally acting Panasonic Group and provides industrial products and services in Europe. The portfolio of Panasonic includes electronic and electro-mechanical devices, chargeable batteries, displays, semi-conductors and finished automation solutions for a great number of industries, such as automotive and mobility, building and infrastructure, or residential and personal.

As a partner of the industry, Panasonic performs research and development and produces technologies contributing to easier and more convenient living. The corporation can look back on more than 100 years of technical know-how in the field of electronics. In customer management, the technology partner focuses on highly locally oriented concepts.

Interview with Dipl.-Ing. Peer Schumacher, Head of “Robot & Welding Systems Europe”

Virtual Welding Trainer Systems have also been used by Panasonic Industry Europe for many years. They are an integral part of the everyday work. In the following interview, Dipl.-Ing. Peer Schumacher, Head of Department for “Robot & Welding Systems Europe”, explains where VWTS are used within the company.

Mr Schumacher, why do you use VWTS in your company?

Virtual Welding Trainer Systems, such as the DTPS (Panasonic Desktop Programming & Simulation System) are mainly used in the fields of application and in training. Simulated welding of workpieces is also used for support in the calculation of quotations for our customer contacts. We use our DTPS, which simulates the robot sequence programme at the PC and optimises the robot movements off-line through the appertaining welding parameters.

What is the objective that you pursue in using VWTS in training?

It is important for our trainees to familiarise themselves with the Panasonic welding robot and its operation. This is performed with the help of VWTS.

What aspects do you appreciate in training using VWTS?

The use of virtual welding trainer systems is fairly easy and straightforward for all users. In addition, it is a cost-effective option since real components are not needed.

In what areas is VWTS used within your company?

As I said before, VWTS is used as supporting technology in training. But it also is applied in preliminary analyses or for the creation of quotations and off-line examinations of technical customer requests in welding.

How do you estimate the application options of VWTS in the future?

VWTS will definitely play a major role in future. Even now, it is used in preparation and support of sequences within “industry 4.0”.

What needs to change for VWTS to be extensively used in German educational centres?

All in all, training in the field of welding engineering should be performed using VWTS, everywhere. In addition, it is also necessary to be open to the topics of “digitalisation” and “automation”.



Future-oriented training

The MESA project: A contribution for implementation of digital learning options

On August 1st, 2015, the “Use of media in welder’s training” project (MESA) was started and ran until July 31st, 2018. It was supported by the German Federal Ministry of Education and Research (BMBF) within the “Digital media in vocational education” scheme. MESA dealt with integration of welding trainers and other digital media into qualification processes in welding and with realisation of a comprehensive didactic concept by means of blended learning, where attended sessions are combined with virtual learning.

To ensure near-application design and structure of project contents, the DVS and an extended circle of metalworking companies collaborated with educational institutions in a partnership. On behalf of the DVS, it was mainly its affiliate company GSI mbH that was involved in this project.

What is this actually about?

The MESA project dealt with the use and consequences of virtual welding trainer systems. But not only the trainees or students were in the focus but also the teaching staff and the design and structure of the learning process. The goal of MESA was the creation and testing of a didactic concept for application of VWTS in the welding industry.

The foundation for this didactic concept was the blended learning approach (see image 1). This means that attended sessions and self-learning phases are combined in the learning process and in addition, the benefits of different studying locations are used.* Classes and/or seminars, the PC workplace, the welding

simulator and the welding booth or the workshop were defined as studying locations.

The focus of MESA was on the welding simulator for practical application and in the form of a welding app for learning of the basic terms and for language support, with regard to students with a migration background. Moreover, an e-learning platform for autonomous learning of the specialist basics and for practising purposes, as well as for expert exchange, was realised.*

Trial phase

For testing the concept, companies involved in external professional training as well as educational centres of the DVS developed a bicycle stand using the blended-learning approach as a basis (see image 2). Consequently, testing of the concept corresponded to an actually existing customer order. With the help of previously defined learning and practising tasks, various competences were required and encouraged throughout the different stages of the project. In this way, the participants got to know various welding processes and their differences at the beginning; they had to deal with ergonomic aspects and body posture as well as hazards in welding. Subsequently, they defined welding parameters, weld thicknesses and welding positions and developed a welding sequence plan. The information and planning then helped the students in simulating various weld joints at the VWTS and subsequently in welding the bicycle stand. After completion, testing methods were applied and the welding simulation was reflected and discussed.

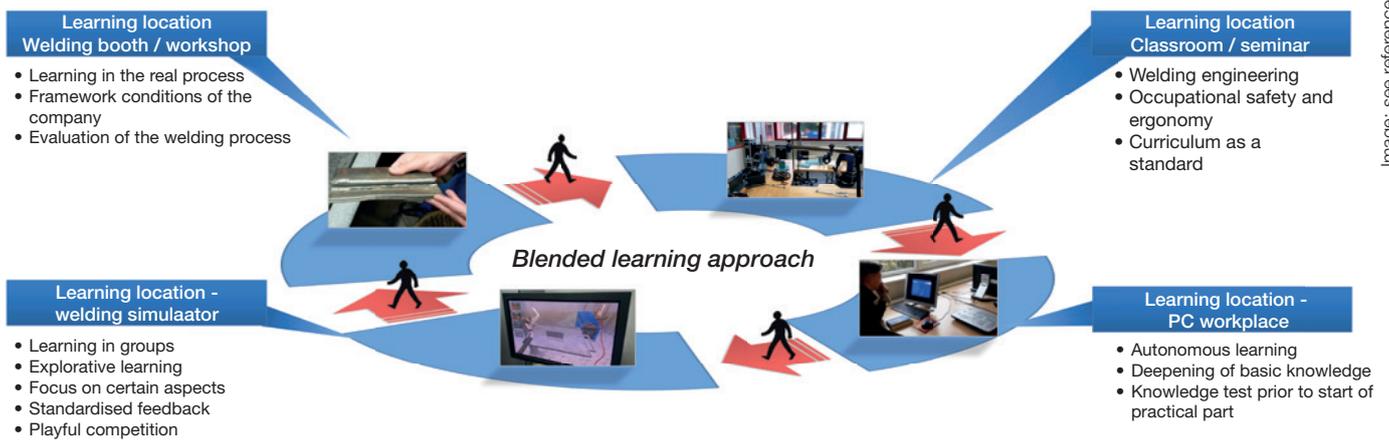


Image: see reference*

Image 1: Blended learning approach

Result

It could be demonstrated that the use of VWTS is a useful instrument for training and further education. Students can concentrate on performance of the welding process while the elaborate steps prior to real welding are not required. The “replay function” is also an important aspect. It saves the achieved results and allows for subsequent analysis of the welding process. In this way students receive direct feedback on holding and guiding the welding torch and on the welding result. Overall, through the use of virtual reality the teaching and training staff are given a number of starting points for a more innovative, motivating and work process-oriented design of the learning process, which also results in a more sustainable learning effect for the trainees and students.*

The targeted use of the learning locations could also be observed as a result of the trial. This ensures situation-based handling of special teaching contents and of the trainees’ requirements or framework conditions in training and further education.

Summary: The didactic concept developed by using digital media is a contribution towards a comprehensive and sustainable welder’s training.*

Image: see reference*

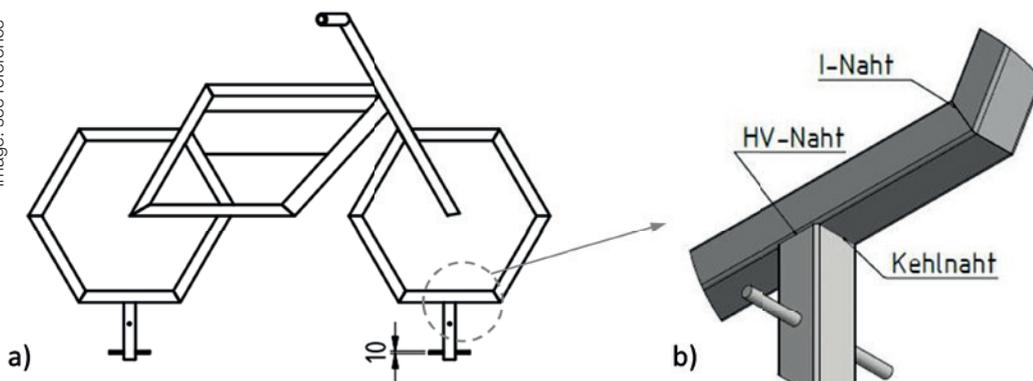


Image 2: a) Side view of the bicycle stand

b) Different weld types

Information and contact for the MESA project:
<http://mesa-projekt.de>

*Information and charts from the presentation “Learning to weld through simulator support - digital learning options and didactic potentials of a teaching-learning situation for training and further education” by Dr-Ing. Christian Daniel, Dr Sven Schulte, Prof Dr-Ing. Maren Petersen.

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References:

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