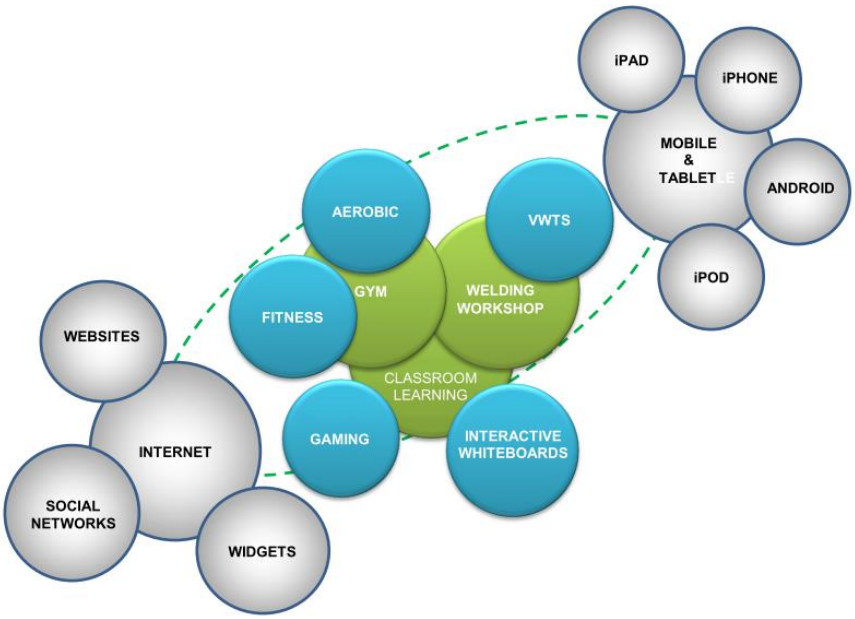
No.7

Document



Integrated interactive system for lifelong education of welders

Slavonski Brod – Porto Salvo – Oberhausen – Basel – Wels - Zagreb

Introduction

The S-K-S system for welder education designed by a team of teachers from the Industrial and Trade School Slavonski Brod was promoted at the 6th International scientific-professional conference SBW 2011 entitled "Modern technologies and processes in production of pressure equipment, welded metal constructions and products" with the paper: "Welder training – a new approach".

The idea for the project is a consequence of several facts related to the profession welder.

1. Welder is a profession high in demand in EU as well as in the USA, and this problem is intensified more and more each year. The fact that there were 12.159 openings for welders in October 2011 at European level (source: EURES), and in May 2015 20.782 openings (source: EURES) speaks well in favor of this.
2. Negative tendencies are also visible through the fact that the average age of professional welders is approaching 50 years, and that less and less young people opt for the profession.
   Here it is important to stress out that a significant number of welders in their 50s quit the job because of health issues caused partially by the job they were performing. At the same time, the number of young people opting for the profession is heavily decreasing precisely for the fact that they believe the job to be "dirty" and health hazardous.
3. Welders in EU countries acquire unstandardized competencies for one and the same welding process depending on the country of origin and implementation of different programs for education of welders.
4. Welder education mostly ends after the training period and acquisition of qualification. After that follows the pattern: welding – attestation – welding – attestation, and it slips everybody's mind that welders are the carriers of product quality in welding.

The S – K – S system offers solutions for these issues. It is directed towards the individual – the welder and their competencies, be it a trainee or a professional welder. During the period of four years, the system has evolved through conducted research and pilot program, involving 348 trainees, 106 professional welders from the real sector, 12 girl students – welding volunteers belonging to mechanical engineering programs and 94 boy students belonging to mechanical engineering programs attending classes compatible with welding, such as: machine elements, electromechanical engineering, technical drawing and technical materials.

Nine scientific professional papers dealing with this topic have been published so far at international conferences, and 4 more have been accepted: 2 papers for the DVS Congress 2015 in Nurnberg and 2 for the 8th International scientific-professional conference SBW 2015: "Design, manufacture and maintenance of welded structures and products". Through the joint activities of partners and silent partners in the Leonardo da Vinci Partnership project 2013 – 1 – HR1 – LEO 04 – 032242, the system has been amended, tested and verified. Four-year research and the conducted pilot program give S – K – S system the relevance.

PROJECT OBJECTIVES

1. Creation of system for lifelong education of welders – from trainees to professionals, based on the usage of conventional and modern teaching methods.
2. Introduction of Virtual Welding Training System - VWTS into welder education system
3. Introduction of the psychophysical component into welder training (aerobic and psychological training).
4. Harmonizing welder competencies at European level through recommendations concerning their type of education, the training system for both trainees and professionals, and through constant care of the welders themselves and their employers of their psychophysical and psychosocial state.

Specific objectives in education of trainees:

1. to ensure a systematic way of teaching the trainees; encourage and improve their intellectual, physical, esthetic, social, moral spiritual development,
2. to ensure the acquisition of basic (general-education) and professional competencies,
3. to train them to live and work in a changeable social-cultural context according to demands of the market economy, modern IC technologies, scientific revelations and accomplishments
4. to encourage and develop independence, self-confidence, responsibility and creativity
5. to train them for lifelong learning.

Specific objectives in education of professional welders:

1. to ensure continuity in acquisition of new knowledge according to development of new technologies and materials in welding,
2. to ensure continuity in maintaining skills of professional welders using VWTS,
3. to promote physical activity among professional welders for the purpose of their psychophysical stability and longevity in the job they perform.

PRINCIPLES

1. High quality in lifelong education of welders - making provisions for material, technical, IT, hygienic and other conditions for accomplishment of highest educational standards, as well as high professional standards of those acting as carriers of educational activities
2. scientific foundation – the system is changed, improved and advanced according to modern scientific revelations
3. school / training center independence – a degree of freedom and independence in designing the activities, programs and projects for participants as a part of creation of one's own identity; freedom in choice of contents, implementation of methods and organization in implementation of lifelong education of welders.
4. Pluralism in pedagogical work and work in school / training center – a degree of freedom and independence in creation of diversity in pedagogical work
5. the European dimension in education – training for co-existence in European context
6. inter-culturalism – understanding and acceptance of cultural differences in order to decrease inequality and prejudice towards members of other cultures

LIFELONG EDUCATION DIRECTED TOWARDS THE WELDER

The S – K – S system promotes lifelong education directed towards the individual – the welder, a trainee and/or professional. This implies:

1. Adjustment of educational and teaching forms, methods and materials to the individual needs and capabilities of participants, in order to ensure the necessary competence level for European labor market,
2. Introduction of appropriate forms and methods of teaching and learning that will enable active and independent learning and practical application of the acquired knowledge
3. Usage of different and relevant knowledge sources and teaching materials that enable participation, observation, independent research, experimenting, discovering, making conclusions, curiosity and learning how to learn
4. Creation of positive environment that will interest and motivate the participants to learn and give them the sense of assurance and mutual respect

STRUCTURE OF THE S – K – S SYSTEM

Starting from the demands for standardization of welder competence at European level and the need for lifelong education of welders, it was necessary to find a document that would represent the core to build the system around.

The basic document on which the S – K – S system is built is: IAB-089r4-12, IIW-IAB Section: "Minimum Requirements for the Education, Examination and Qualification of International Welder".

The system architecture consists of three main constituents:

Skills – acquisition of skills, i.e. mastering of welding technique

Knowledge - knowledge acquisition, i.e. mastering of welding technology

Stability - in the welding line of work represents the capability of frequent repetition of quality welds under demanded technology using the demanded technique in the demanded period of time on one's own or under supervision.

Why Skills?

Skill is an important factor in welding. It is expressed through work technique in different welding positions. Fluctuations in welding technique lead to defects in welded joints. Welding technique needs to be learned, minimally kept at this level, and then one should stream towards perfecting it. In other words, one needs to exercise.

Why Knowledge?

In today's time, when new materials appear on a daily basis and when technological procedures are getting more complex, welder's knowledge is an important factor in quality of welding jobs. Understanding the welding process during its execution reduces the possibility of defects to a minimum. Those who know more, make fewer mistakes. By repeating, one strengthens the teaching matter, and its upgrading raises the level of quality in welding. In other words, one needs to learn.

Why Stability?

Psychophysical stability is an important factor in any line of work. Psychophysical stability in welding is a big step forward regarding welding quality and prolonging the professional life of welders. Aerobic training raises the aerobic ability which represents the ability of a body to create energy necessary for physical work. This type of training not only provides the strength necessary for easier execution of work, but also the stability in expected results, which increases the quality of living prolongs the personal and professional life of welders. I other words, one needs to keep fit and motivated.

System accomplishments

System accomplishments are reflected in following elements:

1. *Speech and communication:* acquisition of technical terms, encouragement and practice of vocational communication in mother tongue and at least one foreign language,
2. *Individual and society:* group work, encouragement of tolerance and mutual respect during the execution of work, development of individual abilities and responsibility for the work done, professional orientation in discussions among participants based on their joint work on assignments.
3. *Nature and technology:* systematic thinking and development of strategy for finding a solution to the problem, use of modern technology.
4. *Creativity and exploration:* encouragement of creativity and ability to form and shape by individual demonstration of personal capabilities and solution of problems by exploration.
5. *Health and movement:* development of consciousness on health and safety when using tools and machining, and development of fine motoric.
6. *Sustainable development:* waste is created when doing the assignments or in work process and sustainable development presumes continuing living and working at the same location.
7. *Work, discipline, results:* by doing the exercises or performing at work, the participants come to the conclusion that through planned work and discipline one can always accomplish a satisfactory outcome.

System accomplishments are congruent with acquired objectives for development of education in EU in the 21st century expressed in syntagms: education for employment, autonomous actions of individuals and well-functioning society.

S – K – S SYSTEM PEDAGOGY

The S-K-S system leans on the curriculum pedagogy, an important interdisciplinary area that is methodologically, structurally and in terms of contents defined (designed) in relation to practical expectations.

Why the curriculum pedagogy?

The main objective of the curriculum is acquisition of competencies by the individual – in this case, the welder. This means that the applied teaching principle is directed towards the individual. For that reason, the S – K – S system follows this direction.

Curriculum pedagogy takes as its starting point the general established strategy of social development, singularities of modern educational policies and verified pedagogical standards and competency expectations. It includes formal, non-formal, informal and e-learning, as well as media inculturation and socialization process.

Structured and modular model was chosen as a teaching process model here. Namely, in the welding line of work, such a model is closely connected to EQF and provides the necessary horizontal and vertical passageway.

Horizontal passageway is guaranteed through choice of modules for different welding processes, and vertical provides you with the possibility to move ahead in welding profession.

It is important to stress that the objective of this project is not to design the curriculum, but rather to define an efficient system and give recommendations for its successful implementation. For that reason, there is a great need for a European curriculum for each of the welding processes. Such curriculum core would enable further creation of national curricula and subsequently, school curricula. In this way, the welder competencies at European level would be standardized.

S – K – S SYSTEM METHODICS

New and modern technologies are an integral part of private and professional lives of people nowadays. They, among other things, enable the development of new cultures and new forms of learning. Alongside with formal, the informal education and training of individuals to learn independently is gaining on importance (the competence *learning how to learn*). Such new forms of learning demand a different teaching concept. Rapid changes in all segments of society, there is a pronounced need for learning anywhere, anytime, where new technologies make provisions for precisely such learning and corresponding forms of teaching (synchronous and asynchronous). Taking into consideration that most participants, both trainees and professional welders, are not adequately prepared for this type of education, the recommended form is hybrid learning or blended learning. Hybrid learning is learning based on different combinations of classical face-to-face teaching and learning by Internet and using other different technology (audio, video, etc.) with the purpose of creating a learning environment that is more effective and acceptable (enriched) for the participant. Hybrid learning is a combination of the best teaching forms from both traditional and on-line education.

Here it is crucial to form a strategy for introduction of hybrid learning and development of on-line educational materials which meet the following criteria:

- they are an efficient supplement to off-line educational activities;
- they include the most appropriate content for on-line presentation;
- they are time and cost efficient, bearing in mind the available resources;
- they coincide with expectations, needs and abilities of participants;
- there is a low probability of becoming dated too soon
- they are flexible enough to fit in the syllabus that usually changes every couple of years

Implementation of hybrid learning into the S – K – S system

Optimum share of components within the S – K – S hybrid system (off-line and on-line) that was gained through research and pilot program is:

	Trainees		Professionals	
	Off – line %	On – line %	Off – line %	On – line %
Skills[1]	60	40	0	100
Knowledge[2]	50	50	20	80
Stability[3]	50	50	0	100

[1] Off – line: traditionally; on-line: VWTS (Virtual Wlding Training System)
[2] Off – line: traditionally; on – line: EU on - line platform for all welders
[3] Off – line: aerobic training in vocational school; on – line – fitness training according to recommendations

The table makes it obvious that the S – K – S system is different for trainees and for professional welders.

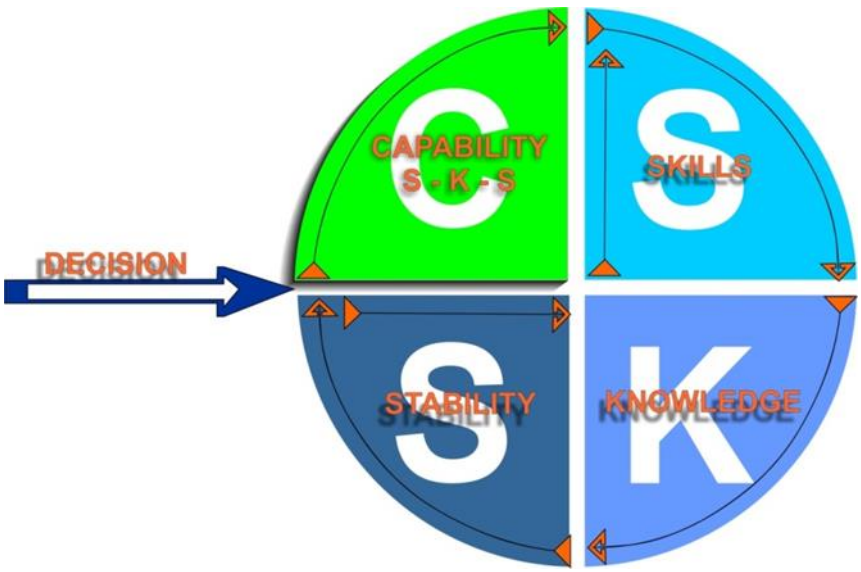
The S – K – S system for trainees is based on:

- interactive skills training as a combination of VWTS and real training, ratio 40% : 60%
- combination of off-line and on-line knowledge acquisition, ratio 50% : 50%, and
- aerobic training in real conditions and on – line fitness, ratio 50% : 50%

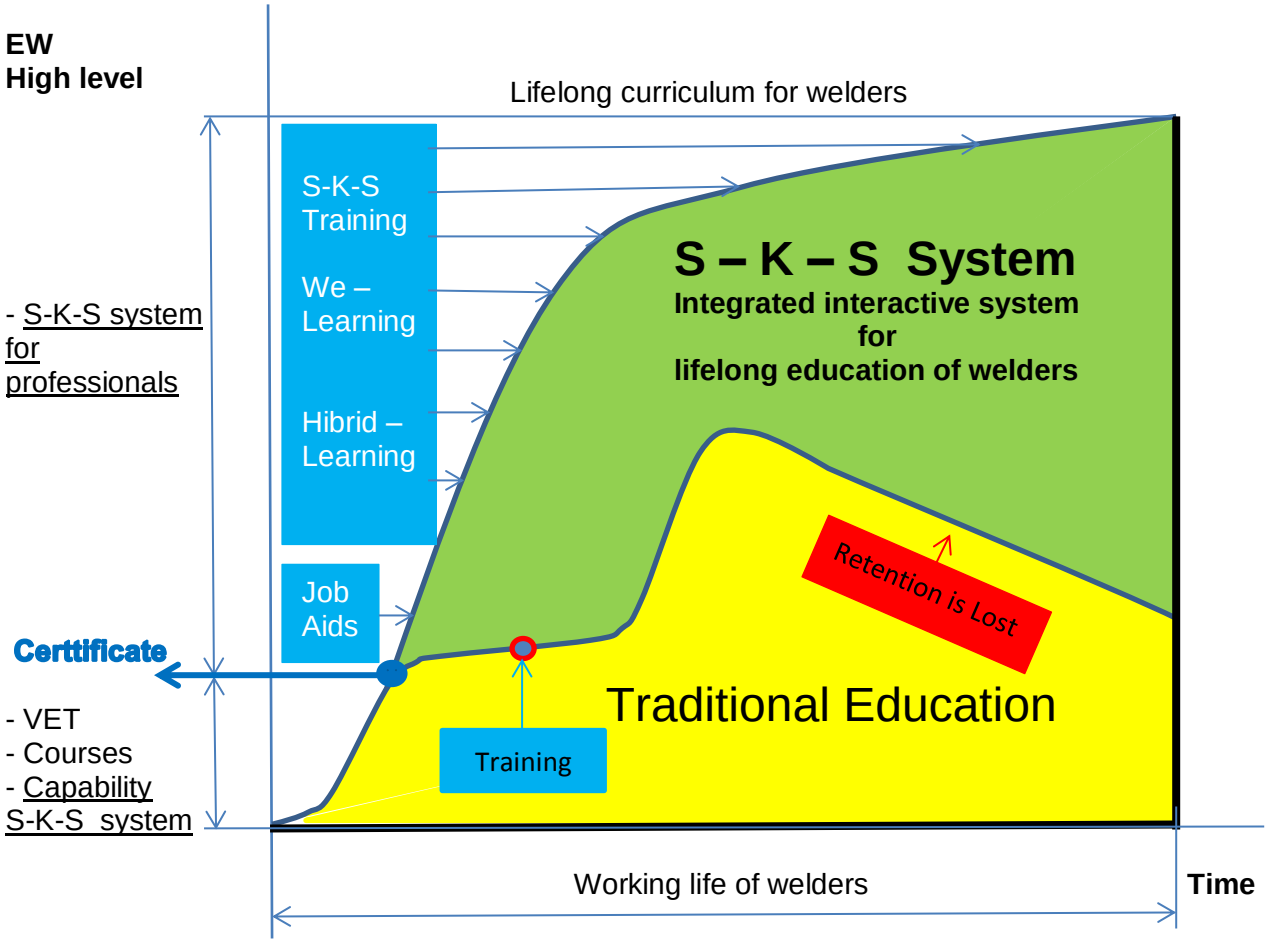
The S – K – S system for professionals is based on:

- correction of welding technique 100% on VWTS,
- combination of off-line and on-line knowledge renewal and acquisition of new knowledge within the lifelong learning process 20% : 80%; This ratio in knowledge acquisition is going to change to 100% on-line in the next ten years, when we have a generation of professionals who went through the S – K – S system education.
- fitness exercises adjusted for welders 100% on-line

After acquisition of basic skills, practical classes for trainees for a specific welding position are carried out at least 50% of the available time in welding companies. Such an approach (traineeship) guarantees easier integration of young welders into production process, and is important for relevance of the S – K – S system. That such practice is efficient can be confirmed through 65-year experience of the Industrial and Trade School Slavonski Brod in cooperation with the industry - Đuro Đaković.



Outline of S – K – S system for lifelong education of welders



Comparison diagram of S-K-S system and traditional education

COMMUNICATION IN THE S – K – S SYSTEM

Social interaction is very important in education. This is why it is not enough that the participants of a teaching process or an on-line course simply obtain information from available literature and electronic resources for an educational process to be successful, but rather get help and assistance in mastering the contents through communication with their teacher/instructor, as well as the feedback on their results and work mode.

Taking part in a group educational process is a chance for participants to make informal contacts and fulfill different social needs. The social aspect in group education is especially important because communication has an impact on participants' motivation. Experience in usage of on-line educational systems has demonstrated that lack of communication with the instructor/mentor is among the most common reasons for participant dissatisfaction.

Starting from the stated facts in implementation of the S – K – S hybrid system through research and pilot program it has been proven that by intensifying the social interaction through application of we-learning system and with support of social networks (Facebook) and e-mail as communication channels, the quality of educational process is increased.

We – learning in the S-K-S system

Learning in its wider sense means interaction. We-learning completely exploits the social component of learning.

In the S-K-S system for trainees, the social component is evident in the informal (on-line) component of learning through interaction (on-demand, social and embedded learning) that is methodically expressed through work in small groups, mentorship (coaching) and communication on social networks (Facebook) and e-mail. Smartphones and tablets are the recommended aids implementation of such learning methods and retrieving of information. The social component of practical teaching (off-line) at school and in welding companies is evident in interaction while working in groups and indifferent social surroundings. At school this would be group work with peers, and in welding companies working with a mentor - a professional welder and in a group among professional welders.

In the S-K-S system for professionals, the social component is evident in interaction in the working environment. However, this interaction is not sufficient to raise and maintain the level of quality in welding. The employers are a crucial factor in stimulating the interaction directed towards the lifelong education of welders. They are required to create the conditions and positive environment by creating team building programs for welders according to their own needs. It is desirable that such programs, depending on the quality level, be organized at least once in two years. As is already known, the team building programs accomplish following: increase in communication among employees, stress release, creative resolving of problems, higher self-esteem and development of initiative, taking on risks and responsibilities, creation of groups, socializing, fun and recreation, mutual tolerance and self-criticism. With all of the above, specific quality of such programs for welders is that with the help of VWTS one has the possibility of designing serious games that would serve the purpose of correcting the welding technique and raising the quality of knowledge concerning technology.

CHARACTERISTICS OF THE S – K – S SYSTEM

Characteristics of the system are: uniformity, quality, continuity, compatibility, flexibility, dynamics, openness and availability.

Uniformity:

The system is based on the harmonized document IIW: IAB-089r4-12 IIW Guideline International Welder: Minimum Requirements for the Education, Examination and Qualification.

Quality:

Quality is assured through two dimensions: personal and institutional.

Continuity:

The concept of lifelong education of welders ensures continuity in skills and knowledge and at the same time raises the level of their stability.

Compatibility:

The system is compatible with all welding processes and all VWTS.

Flexibility:

The system is flexible because it allows for adjustment of trainings to the demands of individuals or organization for who it is carried out, without the negative influence on quality.

Dynamics:

Individuals and organizations chose their own dynamics according to their own assessment.

Openness:

The system is open to trainees, professionals, hobby welders and the business sector. It is also open for all the new technologies and techniques that will in any way contribute to progress in welder education and to raising the quality of welding in general.

Availability:

Upon the completion of the project, the system is going to be available to all interested parties without any restrictions whatsoever.

QUALITY IN THE S – K – S SYSTEM

Analysis that preceded the research and pilot program concluded that welders in EU have different competencies for one and the same welding process and working conditions. Such situation renders welder mobility more difficult and complicates the situation on the market that is high in demand as it is. This is result of following facts:

- Training and upskilling programs for welders do not lean on European harmonized recommendations, but are rather defined at national and school levels as one sees fit,
- Institutions implementing the programs may or may not possess quality educational equipment.
- Different methods for competence evaluation are applied that in the end cannot yield reliable results.

The first fact is resolved with the S-K-S system.

Quality is one of the basic properties of learning outcomes, and as such of the whole qualification with which one expresses reliability of all the other learning outcomes properties or the qualification (level, volume and profile). Quality of learning outcomes indicates reliability and trust in what is stated on the public document (or any other documents) on which all the other learning outcomes are stated as well. Quality is demonstrated through two dimensions: personal and institutional. Personal dimension of quality of learning outcomes describes the reliability of existence of stated learning outcomes (corresponding level, volume and profile) as a property of the individual and is expressed through grades/marks, and institutional quality speaks of the reliability of the institutions that were responsible for acquisition and formal evaluation of learning outcomes, including issuing of the public document at hand.

The level of learning outcomes is determined by using the measurable level indicators. Volume level of learning outcomes is indicated by ECTS or ECVET credits (or any other), and profile is represented by the learning outcome name.

Determining the level of learning outcomes in S-K-S system

Measurable indicators of levels of learning outcomes are demonstrated through the complexity of following competencies:

Knowledge:

- factual
- theoretical

Skills:

- cognitive
- psychomotor
- social

Stability:

- independence
- responsibility

Knowledge levels:

- Factual

Knowledge level	Description
1	Remembering general facts
2	Understanding basic facts in execution of simple assignments from the work or learning field
3	Application of basic facts in execution of simple assignments within the work or learning field

- Theoretical

Knowledge level	Description
1	Remembering general theoretical information
2	Understanding basic theoretical information in execution of simple assignments from the work or learning field
3	Application of basic facts theoretical information in execution of simple assignments within the work or learning field

Skill levels:

- Cognitive

Skill level	Description
1	Simple, specific logical thinking (necessary for execution of simple and specific assignments) in familiar conditions
2	Specific logical thinking (necessary for application of relevant information in execution of a set of simple assignments) in familiar conditions
3	Simple, specific creative thinking (necessary for choice and application of relevant information in execution of a set of complex routine assignments) in familiar conditions

- Psychomotor

Skill level	Description
1	Execution of simple routine movements in familiar conditions
2	Simple use of methods, instruments, tools and materials in familiar conditions
3	Complex use of methods, instruments, tools and materials in familiar conditions

- Social

Skill level	Description
1	Accomplishing of general rules of conduct in familiar conditions
2	Accomplishing simple communication and cooperation with other individuals in familiar conditions
3	Accomplishing complex communication and cooperation in a group in familiar conditions

Stability levels

- Independence

Stability level	Description
1	Execution of simple assignments under immediate professional and constant guidance in familiar conditions
2	Execution of simple assignments under immediate professional and occasional guidance in familiar conditions
3	Execution of complex assignments and adjustment of one's own behavior within the set guidelines in familiar conditions

- Responsibility

Stability level	Description
1	Taking responsibility for execution of simple assignments in familiar conditions
2	Taking responsibility for execution of simple assignments and relationships with others in familiar conditions
3	Taking responsibility for execution of complex assignments in familiar conditions

CONCLUSION

The S – K – S system emerged from the needs and demands of the European labor market and harmonization of welder competencies at European level. It also accepted the need for lifelong education of welders that followed the speedy and dynamic development of new materials and technologies in the area of welding.

For this reason, a system was designed that would cover the needs of all welders, from the start of their education until the end of their professional career. All throughout this period, the system covers three important elements in education, development and maintaining of welder competencies: knowledge, skills and stability (and among other things, health).

In the first cycle of welder education, up until the certification of their competence, the S-K-S system for trainees is carried out. Upon completion of this cycle, the participant is awarded a certain number of ECTS or ECVET credits or a certificate and becomes a welder. During this cycle, apart from obtaining the title welder, they also acquire key competencies for lifelong learning recommended in 2006 by the EU (Recommendation of the European Parliament and of the Council of 18 December for lifelong learning (2006/962/EC).

The education within the S – K – S system is continued after the acquisition of welder qualification and entering of professional waters with the help of acquired habits from the first cycle and cooperation with employers. Through team building programs at least once in two years the welders correct their skills, knowledge and stability. In case there is a need for it, the system can be used more often, e.g. through continued use of VWTS (at least once a month) in welding companies, one can ensure continuity of the welding technique, and at the same time significantly lower the occurrence of welding defects.

Through research and the pilot program, problems have been observed that need to be dealt with through new projects:

1. EWF needs to initiate the procedure of alignment of professions in the area of welding at EU level. The connection between the EWF qualification and the Level in EQF needs to be defined at European level as soon as possible, in order to influence the national levels when defining their National Qualification Frameworks. This means that following needs to be approached as soon as possible: development of profession standards, qualification standards and curriculum based on qualification standards.
2. In the basic document: IAB-089r4-12, IIW-IAB Section: “Minimum Requirements for the Education, Examination and Qualification of International Welder“, it is necessary to ensure the curricular approach. It needs to be adjusted to the competencies and learning outcomes. In other words, it is required to start working on curricula for specific professions in welding.
3. The need for a quality on-line platform for welders of all profiles is indisputable. The platform should offer welders quality and verified on-line materials for education/upskilling, information on newest development in welding, forum for exchange of opinion, blogs, magazines, different welding literature, etc.

4. It is essential to design a marketing strategy to promote professions in welding for the purpose of changing the current and unfavorable structure concerning the average age of welders and attracting the greatest possible number of young people to welding.
5. It is also necessary to set a relevant standard that would define a minimum level for institutions engaging in welder education of all levels to satisfy concerning equipment and staff, in order to solve the problem of incompetent institutions in a very competent profession.