Innovative Simulator Tools for Quality Management Production Process Training in VET (iQSim)
Project information

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Executive Summary

AIMS
iQSim developed and disseminated a new generation of training methodologies that are applicable to European wide mechanical industry sectors, including fabrication industries, Vocational Education and Training (VET) schools and SME’s.

Within this perspective, an online simulator service has been developed as an online service. It addresses, for all stakeholders involved in the training scenarios, the key question: “What happens if ....” in complex mechanical industrial production processes.

RESULTS
The 6 basic components of the simulator services are:

- Defining material constants
- Selecting geometries
- Fine-tuning the geometry
- Selecting welding method
- Displaying temperature in HAZ
- Performing cost and economical calculations

Picture 1: Comparing the effects of geometry on the economical cost calculation.

Evaluation tools that include the most frequently used welding methods:

- MMA, TIG, FCAW and MIG/MAG
Tools for evaluation of the most frequently used joint configurations or bevels:
  • Square butt (I-bevel)
  • V-bevel
  • Fillet weld
  • X-bevel

Calculation of mechanical and economical production costs for the four welding methods and bevel configurations above.

Online evaluation services provide quality assurance design by including student evaluation with results into the training environment. New pedagogical methodologies improve the quality assurance process of industrial production process training. Instructional video material consisting of **70 new video clips** for demonstration of skills, training methods, and evaluation of tools and services, has been developed. The project has raised awareness of and delivered instructor training to welder trainers in Sweden, Hungary, Lithuania and Norway. Afterwards the instructors have used the methods and services and delivered training courses to welders. The project has arranged seminars, and participated in conferences and exhibitions for transfer of knowledge to stakeholders in and outside Europe.

Almost **150 organizations** inside Europe have tested or used the new online services. Organizations from **35 countries World Wide** have asked for testing the services.

Picture 2: Calculating the production costs.
IMPACT
The Swedish Welding Society (with more than 400 companies), the Schweißtechnische Lehr- und Versuchsanstalt SLV in Germany (70 mill euros in turnover), the Norwegian Welding Society, the Hungarian Association for Material Testing and Welding, and Accredited National Bodies in Serbia, are going to implement the services in 2011.

The services are freely available at http://www.histproject.no/ (select “Products”). They may also be installed and used from a PC without Internet connection.

Welding institutes, VET schools and companies may utilize the new online simulator in their own learning environment, to offer a broad range of specialized courses at a European level. The services are easy to use and may be used it in combination with new pedagogical methods, or within existing methods.

The teacher and/or the students may play with the variables dynamically, using sliders to create "What happens if … ” scenarios, such as:

- What influence will the root gap have on the economy?
- Do tolerances in the bevel angle influence the welding costs?
- Which welding methods give the widest set of production tolerances?
- Which of the welding parameters have the greatest influence on the heat input?
- Which welding parameter is the most important one if the HAZ value is to be maintained?

Picture 3: Practical testing of the proposed solutions from the iQSim online services, in a welding laboratory.

Impact at local level:
The project has enabled CFL, KU and MHtE to raise the theoretical level of training in
the Qualified Welding courses. In Norway, one of the major training providers in the welding sector (Vitec AS with ca 50 employees) has started using the simulator in their welding courses.

Impact at regional level:
The services have given some partners a good argument for a centralization of welding education, e.g. to Söderhamn. This includes the opportunity to introduce the tool in an effort to build a Technology College in Söderhamn (CFL).

iQSim as a brand new training project including the whole system and process, has been developed and implemented by MHtE in their member VET schools all over Hungary. Thus, new generation, modern education methodologies may be used in VET and MHtE practices. They are going to provide cost and time effective transfer of industrial production process know-how (MHtE).

Impact at national level:
For CFL it has been an opportunity to introduce the tool in the national Technology College organisation in Sweden.

The simulator is going to be implemented into the International Welder education that is just about to start in Norway. 400 industrial companies through the Swedish Welding Society in Sweden may use the tool.

For Hungary these services represent use of: new Quality Management System in VET education, simulator service in VET education, new competence in training, and new ABT-based methodologies in VET training. This teaching/learning product is good for further development, not only in welding technology (MHtE).
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7. WHAT HAPPENS IF
1. Project Objectives

Aims
iQSim developed and disseminated a new generation of training methodologies that are applicable to European wide mechanical industry sectors like fabrication industries, Vocational Education and Training (VET) schools and SME’s. Innovative online simulator services, with embedded mathematical calculations, provide easy-to-use graphical interfaces that optimize cost- and time-effective transfer of industrial production process and technology know-how to VET students. The combination of new pedagogical methodologies and simulator services extend existing training methods by offering Quality Assurance of production process training when it starts, during a training session, and when it has been completed.

Objectives
The iQSim actions included:

- Development of simulator services for i) square butt, ii) v-bevel, iii) fillet, iv) x-bevel, and v) calculation of production costs for the four joint configurations above
- Develop new pedagogical methodologies by using simulation tools in combination with for instance Activity Based Training, that help to improve the Quality Assurance through industrial risk analysis of production process training by highlighting the total production costs
- Delivery of welding training courses to mechanical industry companies for validation of methodology and the pedagogical benefit of including online simulator tools into instructional training
- Raise awareness of the beneficial impact of (pedagogically sound) implementation of modern simulator tools and use of new training and educational technologies, e.g. by using high quality online streaming video solutions to provide hands-on experiences
- Validation and dissemination of a new competence training model to VET schools and mechanical industry companies offering certification of welders in Norway, Sweden, Lithuania and Hungary, by arranging local and regional seminars and/or exhibitions for dissemination and transfer of knowledge to stakeholders at national level
- Large scale dissemination at European level at events like for instance MACTECH 2009 (Budapest), Computing in Welding 2010 and Online Educa, 13th International conference Transport means’2009 (Kaunas university of Technology), Litexpo Balttechnika’2010, Technical exhibitions, yearly conference of welding coordinators in Hungary, Journal of welding technology (MHtE)
2. Project Approach

iQSim was a Leonardo da Vinci Development of Innovation pilot project that brought together 6 partners from Norway, Sweden, Lithuania, Hungary and Greece.

The services use Flash and Flex; are prepared for presentations on digital blackboards and all mathematical calculations are embedded into the software. The services have the advantage that students and instructors may use learning activities where they use sliders to “play” dynamically with the essential welding parameters in order to observe the tolerance window occurring in real-life production facilities.

It’s possible to investigate the influence of a number of variables in order to figure out which variables have the biggest impact on the quality of the final products. From an instructional point of view, the evaluator helps to reduce manufacturing defects by making up alternative decision routes that include both technical and economical production tasks.

The foreseen main target group is welders working in the mechanical industry, which is the second largest production sector worldwide; their instructors, and the VET schools that need to educate 50,000 welders per year. To evaluate the project results, the consortium will apply the proposed competence transfer models and simulator services to the welding industry, which is part of the wider mechanical industry sector. The following user groups will be involved in the user requirement specifications, as well in the evaluation of project result:

- Mechanical industry welder specialists and welder engineers, who are required to meet high performance standards for the industry, possibly at a remote location, producing for instance components for a large and global company
- Mechanical industry trainers: i) employees within large mechanical industry companies, ii) employees of small training institutions, which typically do not have the capacity to have full-time training employees
- VET schools offering in-company training programs

iQSim develops a brand new solution to the welding sector, by adapting and transferring existing process solutions in mathematics and physics. The solution for the welding sector contains 2 key tasks: development of web-based simulator tools, and deployment and utilization of them in combination with development of new pedagogical methodologies. The new pedagogical methods includes (to some extent) further development of the Activity Based Training methodology developed within the Leonardo da Vinci pilot project MECCA (2005-2007), by adding quality management assurance designs into industrial production process training activities that follows the production schedules by utilizing work orders and work packages.
Picture 4: Training of instructors who are going to use the iQSim simulator services in Hungary, by use of two-way videoconferencing from Trondheim to Hajduszboszló, 11.09.2009
3. Project Outcomes & Results

iQSim developed advanced online simulator tools that display the results of complex mathematical calculations that visualize welding processes, by utilizing easy-to-use graphical interfaces. Embedded mathematics have been used in order to offer welding students, welding instructors and VET trainers web-based access to high-level graphical interfaces where they manipulate the main welding parameters interactively, and immediately observe the results online. iQSim delivered the following outputs:

1. Simulator tools that include the most frequently used joint configurations: i) square butt, ii) v-bevel, iii) fillet, iv) x-bevel, and v) calculation of production costs for the four welding forms above.

   The simulations handle the following main critical parameters in an industrial production process environment:

   I) The volume that must be welded depends on the angle and the thickness of the plate
   II) The added material depends on the number of layers
   III) The number of staff hours and the total production costs are affected by I and II
   IV) The maximum hardness in the Heat Affected Zone (HAZ) and the extent of this zone

   The web-based simulator service offers stakeholders i) activation of prior experiences, ii) demonstration of skills, iii) application of skills and iv) inclusion of skills into real-world descriptions. They provide quality assurance design by including risk analysis into the training environment. They are available for free use at http://histproject.no/node/7.

2. New pedagogical methodologies offer Quality Assurance to industrial production process training in VET schools by utilizing interactive simulator tools, in combination with for instance Activity Based Training (ABT). ABT follows the industrial production processes, by utilizing work orders and work packages. The final result of the training is a finished product. The training method may be utilized in a blended learning framework consisting of face-to-face on-site training, e-learning solutions, high quality video streaming, and video conferencing. ABT may be utilized in Skills Upgrading Processes where theory and practice are closely connected.

3. The iQSim training delivery uses simulator tools to add Quality Assurance (QA) to an industrial training production process, as well as QA of the final welded product.

4. High-quality instructional video material (streaming or DVD) consisting of 70 video clips for demonstration of skills, training methods, simulator tools etc. It will have an orientation towards a train-the-trainer approach in order to
motivate VET schools and instructors to look into the new proposed training environment.

5. User requirement specification report

6. Pedagogical Methodology report

7. Simulator tools and services technical implementation report

8. Project web-site for dissemination of project results available at www.histproject.no/node/50

9. Use of simulator services in industrial welding courses in Norway, Sweden, Lithuania and Hungary

10. Two leaflets and one poster for dissemination of project results

11. Evaluation strategy outline report and Evaluation report

12. Produce a quality management handbook specification

13. Author 18 scientific articles that were published in proceedings from international conferences or in journals

14. Arrange national seminars for instructors and welders in Norway, Sweden, Lithuania and Hungary

15. Large scale dissemination of project results at major international conferences in Europe: MACTECH, Computing in Welding, International Institute of Welding General Assembly, Online Educa, e-learning conferences, Lietuvos suvirintoju asociacijos konferencija arba Ilteexpo Balttech’2010, etc.

- 148 organizations and companies in Europe have tested and used the simulator services during the project lifetime.
- The project reports more than 140 dissemination activities all over Europe.

Some screenshots of the iQSim simulator are shown below:
Figure 1: Defining the geometry

Figure 2: Selecting the welding method
Figure 3: Displaying the Heat Affected Zone

Figure 4:Calculating the economical costs
MHtE, which is the Accredited National Body in Hungary, reports that questionnaires were used to evaluate the pilot training courses (part of WP 5 – for "External evaluation of iQSim simulator in real-market conditions" – in the Appendix of the Hungarian contribution). The same questionnaire was used in all classes, for reasons of consistency and statistical significance of the reported figures. Only the average values have been reported from the pilot courses. In general are all values in the range from 67% to 100%. This means that the students appreciate the iQSim welding simulator services as a useful tool.
Figure 5: The iQSim poster outlines the main components of the simulator services.
4. Partnerships

The consortium consists of:

- The Coordinating organization Sør-Trøndelag University College, Trondheim, Norway
- HiST Contract Research, Trondheim, Norway
- Centrum for Flexible Learning, Söderhamns kommun, Sweden
- MHiE, Budapest, Hungary
- Klaipeda University, Klaipeda, Lithuania
- University Thessaly, Volos, Greece

The consortium had a strong industrial presence and included partners with strong ties to the mechanical industry and industrial networks. These partners have experience in training standards with regards to VET in the welding industry, as well as experience in interacting with the European Welding Federation, of which MHiE is a member. The participating welding training organisations have a large number of contact points throughout Europe. This industrial approach ensured that the results were and are going to be implemented into practical industry cases, as well as in additional knowledge transfer programs.

The iQSim project results have been presented at all the main welding events during the first and second year of the project. This includes the European Welding Federation General assemblies, the International Institute of Welding General Assembly, the 2 major international welding conferences in Europe, two times at the major e-learning conference in Europe, the two largest industrial exhibitions in Northern Europe in 2010, and at several other welding and e-learning conferences all over Europe.
5. Plans for the Future

The international welding society has shown a lot of interest for the iQSim project. Organizations from approx. 35 countries in America, Europe and Asia have got information and possibility to test, exploit and use the simulator services. The services are available for free use at http://histproject.no (Select "Products")

Due to the limited size of the project, we have to reduce the number of companies that was followed up, and keep it to Europe as shown in the list below. The following 148 organizations from the welding sector in Europe, which have not been part of the project, have been testing and/or are using the iQSim simulator:

<table>
<thead>
<tr>
<th>Country</th>
<th>Organization</th>
<th>Comment</th>
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<td>Austria</td>
<td>Fronius</td>
<td>Large provider of equipment</td>
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<td>Canada</td>
<td>CWB</td>
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<td>Czech Republic</td>
<td>CWS-ANB</td>
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<td>Denmark</td>
<td>Force</td>
<td>Large research and training provider</td>
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<td>Finland</td>
<td>Satakunta University, Pori, Finland</td>
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<td>CIMTEAM</td>
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<td>Esa Tikka. Leader of the ANB</td>
<td>Accredited National Body. Link from their portal to their members from industry, and to VET schools</td>
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<td>Tallinn technical school</td>
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<td>AS Merketex welding centre</td>
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<td>Germany</td>
<td>Schweißtechnische Lehr- und Versuchsanstalt SLV</td>
<td>Accredited National Body. 470 employees and a turnovr of 70 mill euro. Are going to implement the services in 10 branch offices all over Germany from 2011.</td>
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<tr>
<td>Hungary</td>
<td>Distribute iQSim services to 70 VET schools and companies all</td>
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<td>over Hungary</td>
<td>University of Miskolc</td>
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<td>VET school in Visonta</td>
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<td>VET school in Dunaújváros</td>
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<td>Lithuania</td>
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<td>Vilnius Gediminas Technical University Institute of welding</td>
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<td>VET school Klaipedos laivų statybos ir remonto mokykla</td>
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<td>• Public enterprise The Technical Supervision Service</td>
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<td>Sweden</td>
<td>Svetskommissionen</td>
<td>400 companies in Sweden may access the iQSim simulator through a link from their member organizations webpage</td>
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Trulstech
ThyssenKrupp Marine
Sensavis
Volvo
KTH, Stockholm

Plans for using the results from iQSim within the partnership:

**CFL:**
Local and regional level:
Use the tool in welder education at Upper Secondary Level and Advanced Vocational Training.

National level:
Reach out to new users, with the help of The Swedish Welding Institute and the Technology College.

**HiST and HCR**
At regional and national level:
Develop and extend the iQSim services further by adding more processes, and implement the services into IWSD education in Norway.

- Arrange together with University of Huddersfield the international conference CELMA 11 in the Lake District, June 1-2 2011: [http://srs.hud.ac.uk/conference/](http://srs.hud.ac.uk/conference/)
- Arrange together with VuZ-PI SR (in Bratislava, Slovakia) an international 2 day workshop in Prague in week 24 or 25, 2011 that target use of new training methods in Vocational Education and Training in European mechanical industry
- Help implementing the services and methods to Schweißtechnische Lehr- und Versuchsanstalt SLV in Germany. SLV is a large training provider to welding schools in Germany with more than 70 mill euro in turnover per year.

**MHtE:**
At regional level:
MHtE is preparing contracts for using iQSim-welding simulator in the VET schools in Visonta and Dunaújváros, and for the University of Miskolc. MHtE will also distribute 70 pieces of iQSim services on a CD to VET schools and companies.

At national level:
MHtE plans to write new articles focusing on experiences obtained by using iQSim in VET practice, which will be published in WELDING TECHNOLOGY. MHtE will take part in a new project if there will be an extended project of iQSim. The booklet for „Teacher use cases” will be enlarged according to the experiences gathered in practical education.
6. Contribution to EU policies

iQSim addresses the development of innovative ICT-based content by developing brand new type of simulator tools that improve existing training materials and study paths by handling both technical and economical production tasks, in combination with development of new pedagogical methodologies. iQSim offers easy access to the best cost-efficient production process solutions that minimize welding defects, while maintaining the best tolerances of the welding parameters. The innovative content means developing state-of-the-art tools that help to improve and carry out quality assurance of mechanical industry training programs development in VET institutions. iQSim provides the management and quality assurance of vocational training in mechanical industry with an effective tool, such that VET schools, instructors, students or welder professionals select and obtain the most time- and cost-efficient production methods and processes.

iQSim supports improvements in quality and innovation in VET systems by promoting a new type of training and learning environment that utilizes the advantage of online simulator tools, where the students and instructors improve the quality of their work by dynamically playing with the essential welding parameters in order to visually understand the tolerance window occurring in real life production facilities, and make up alternative decision routes that handle both technical and economical production tasks. It is very important to reduce failures related to cracking due to increased hardness in the material, which usually must be followed up by expensive repair procedures.

It is of major importance to support the development of innovative ICT-based content and services by providing a new type of training and learning environment where the simulator tools hide advanced mathematical calculations. iQSim utilizes new Flex- and Flash-based online services where the mathematical calculations are embedded. In this way, skilled welders who don’t have any special mathematical knowledge may use the tools by accessing easy to use graphical interfaces. This ensures that European VET institutions may enter the competitive education market through a quality approach guaranteeing that the simulator services conform to explicit international guidelines and quality standards in welding.

iQSim develops a learning environment that provides a European single point of access to innovative web-based simulator tools, which is suitable to improve the teaching quality management of the learning environment of VET training programs and training materials targeting mechanical industry. The simulator services will support the application of quality assurance services for institutions dealing with vocational training within the welding sector, whereby it promotes the establishment and development of quality management control culture into industrial production processes training. The principles for designing and utilizing the simulator tools as quality assurance designs in practical oriented industrial production process training are generic, whereby they may be transformed to other fields within skills upgrading processes. Thus the proposed new learning environments and simulator tools will have the potential to help transforming education and skills upgrading processes in Europe according to the Lisbon strategy. They improve the quality and effectiveness of EU education and training systems.
It is expected that the iQSim learning environment will improve the quality management of welding education, by providing new simulator tools that help students obtain a deeper theoretical knowledge within basic industrial fabrication processes without getting into complex mathematical calculations. The tools and services are online and offer easy-to-use, vivid high-end graphical interfaces, whereby we expect that it will contribute and motivate students to become more interested in technical education, and welding in particular. The tools may be used for both welder specialists and welder engineers, whereby they may help boosting the participating rates in technical education.

Thus iQSim provides a new learning environment for improved transfer of theoretical knowledge and competence within welding sciences by offering welders and their instructors a new training environment where they may play dynamically with the essential welding parameters. From the industrial fabrication process point of view, it’s very important to improve learning environments that reduce failures related to cracking due to increased hardness in the material, which usually must be followed up by expensive repair procedures.
7. **What happens if ……**

Teachers and students are currently unable to create "What happens if ….." training scenarios as they cannot dynamically “play” with the variables of complex industrial production processes. Examples of such scenarios may be:

- What influence will the root gap have on the economy?
- Does tolerance in the bevel angle influence production costs?
- Which production methods give the widest set of production tolerances?
- Which of the production parameters have the greatest influence on the Heat Affected Zone?
- Which parameter is the most important when heat input must be maintained?

iQSim has been a Leonardo da Vinci Development of Innovation pilot project. It aimed to provide real-time, online and embedded mathematical calculations of complex industrial production processes that are:

- **Flexible**: Easy to use Flash-based interfaces that can be used to simulate «What happens if» scenarios which are hard to do in a lab.
- **Integral**: Work seamlessly with digital whiteboards by using a Flash and Flex-based point-and-click interface and sliders to adjust the parameters.
- **Adaptable**: Can be adapted to any number of teaching methodologies, including Activity Based Training methods.

The Target groups consist of

- Mechanical industry training providers
- Providers of Vocational Education and Training (VET)
- Higher educational institutions

Students and instructors may use learning activities where they employ sliders to “play” dynamically with essential industrial production parameters in order to observe the tolerance window occurring in real-life production facilities. It’s possible to investigate the influence of a number of variables in order to figure out which variables have the highest impact on the final products. From an instructional point of view, the methods and services help optimizing the production by developing alternative decision routes that include both technical and economical production tasks.

The simulator services include:

- Defining material constants
- Selecting geometries
- Fine-tuning the geometry
- Selecting welding methods
- Displaying temperature in Heat Affected Zone
- Performing cost and economical calculations

The simulator services include the most frequently used welding methods: MMA, TIG, FCAW and MIG/MAG
Tools for evaluation of the most frequently used joint configurations or bevels:

- Square butt (I-bevel)
- V-bevel
- Fillet weld
- X-bevel

Calculation of production costs for the four welding methods and bevel configurations above.