EXPERIENCES WITH NEW ONLINE SIMULATOR SERVICES IN PRODUCT ORIENTED TRAINING METHODS IN VOCATIONAL EDUCATION AND TRAINING

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Abstract
This paper reports technical considerations in the development of a new type of simulator to be used in vocational training in mechanical industry. The simulator is designed for easy use on digital blackboards by use of AIR technology. The training environment utilizes evaluation processes where they may “play” dynamically with essential production parameters by using a “what happens if” scenario. In this way students may visually understand the tolerance window occurring in real life production facilities

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1 INTRODUCTION
The modern society is extensively depending on welded products. Unfortunately, no high quality, easy accessible, integrated and multipurpose online welding simulator tools are available on the market in Europe to help Vocational Education and Training (VET) schools, instructors and welders to make up user friendly production process training.

This article describes experiences obtained when using a new type of online simulator tools [1] that are going to offer easy access to the best cost-efficient production process solutions that may reduce manufacturing defects, while maintaining the best tolerances in industrial production parameters. The work builds up on the mecca project [2]. The advantage of online simulator tools is that students and instructors may dynamical play with the essential parameters in order to visually understand the tolerance window occurring in real life production, and make up alternative decision routes that may handle both technical and economical production tasks. Advanced mathematical calculations are hidden, by utilizing advanced online Computer Algebra Systems, such that skilled welder specialists that don’t have any special mathematical knowledge may use them by accessing easy to use high-end graphical interfaces.

Advanced calculations are easily done in high-end graphical interfaces by moving easy to use sliders that vary between a maximum and minimum value. Each slider represents one production parameter. The simulator actions include the following elements:

- Development of simulator services for i) square butt welding, ii) v-bevel welding, iii) fillet welding, iv) x-bevel welding, and v) calculation of production costs for the four welding forms above
- Development of new pedagogical methodologies
- Delivery of training courses to the market

The new simulator and training solutions offer a range of new features. This includes:

- Instructors may utilize new pedagogical methodologies by including learning activities which explore flexible easy to use on-line dynamical and/or interactive services stimulating inquiry and problem based learning
- Students obtain new learning experiences by exploring services for application and inclusion of skills into real-world descriptions.
- The services stimulate students to dynamically play with the essential variables in order to visually understand the tolerance window that occurs in a real life production.
The end user is offered the possibility to create alternative decision routes in real life projects. Such a tool offers the user the ability to select the technical tasks as well as the economical tasks involved in the decision process.

The simulator services contribute to the modernization of the VET system by promoting virtual simulator tools that address the technological needs in industrial training. Furthermore, it involves development of new training methodologies in combination with pedagogical sound implementation of predictive virtual welding simulators. The new training methods provide a new European learning environment and new training paths to VET schools, instructors and mechanical industry.

The simulator tools introduce a new industrial evaluation process both in front of the training and after the practical laboratory work has been completed, by comparing the proposed data with the measured real life results. European Community supports the work presented in this paper as a development of innovation project under the Leonardo da Vinci program.

2 ONLINE SIMULATOR SERVICES

When teaching welding to welders, there is a theoretical basis that is difficult to include in the classroom. The students are not in general interested in learning the theoretical parts of the subject and getting calculations integrated in the teaching is not natural. The idea about letting the blackboard do the calculations and letting the teacher do the storytelling was one of the main ideas behind iQSim.

iQSim can do a lot of the calculations on different parameters related to welding, and how they are related based on [3]. iQSim has been designed for digital blackboard environment. The software was designed such that the teacher can focus on teaching and telling the story, and not run to the computer for a keyboard to do changes in the simulation. This means that everything can be operated using one finger on the digital blackboard or simply by simple clicks and drag movements with a mouse on a regular computer screen. If the design was made such that a keyboard had to be used, this would disrupt the flow in the storytelling and the teacher can easily look control and the students lose focus. The design with several tab sheets is mainly for the purpose of easy access from a digital blackboard. Everything is accessible with a mouse click and not hidden in menus. This philosophy has been chosen to avoid confusion in the classroom when the teacher looks in menus to find what he/she is looking for. Throughout the design a visual communication has been used to simplify the communication with the users. A technical language is replaced with icons and graphical symbols where possible to simplify the communication between users and the software.

The other basic idea is that everything that is online and can easily be accessed in the classroom. That's the reason for developing this welding simulator as a flash application. Adobe flash gave us the possibility to design the software, as we would like to visually, and at the same time allow us to do some simple calculations behind the graphical interface. If you have a web browser with Internet access, you can find the simulator tool online and use it as you want, when you want. An online application also simplifies the development phase where updates were made weekly and the community did not have to download a new version each week. The new version was the one they found online.

This software is not an accurate calculation tool. To be useful in a teaching situation, updates of calculations have to be fast. Even a calculation time of 3-4 seconds will destroy the flow of the teaching and hence the calculations are made light, to keep calculation time low. Any hang-ups would be disturbing for the teacher and should be avoided. This also means that the calculations are not precise, and should only be considered as a tendency. It is mainly a “what happens if I change...” tool to indicate consequences. It may be used in Activity based Training environments [4].

3 MECHANICAL APPLICATION AREA OF THE SIMULATOR

The main layout of the software is seven tab sheets that can be reached from all other pages, such that the user can switch to any page from any other page.

![iQSim](image-url)  
**Figure 1.** The main navigation tab sheets, used to switch pages in the simulator.
First select base material and make changes in the chemical composition, then select a configuration of the weld, work with the selected weld geometry and make changes an look at the weld process and change parameters in the weld process. Then the two last tabs are used to look at what happens with the HAZ and what are the consequences for the economy.

The dockable interfaces make it possible to move one sheet out of the tab rack and dock it on the screen elsewhere. The figure below shows how can be done, showing the economy tab and the final cost together with the geometry tab.

The main purpose of the front page (Tab 1) is to have a welcome page where the user can select language and get some information. The languages available are English, Norwegian, Lithuanian,
Swedish, Hungarian, and Greek. Most of the operations can be performed without the knowledge about language.

The material chemistry page (Tab 2) is where the base material is selected and variation in the base material chemistry is simulated.

In the weld configuration page (Tab 3) the user can select from four different configurations. Buttweld, V-Weld, X-Weld and Fillet weld. The selection made here influence what page is shown in the weld geometry page. The user selects a weld configuration by just clicking on the correct image.

The simulation tool has the capabilities to consider six different weld processes. For each weld process the user has to select weld current, weld voltage, welding speed, ambient temperature and possible preheating temperature. From these values the heat input is calculated based on the efficiency factor of each weld process. The colored lines are used to show what values are used to calculate the calculated values.

![Image of the welding simulation interface]

Figure 4. The welding process tab (no 4).

In the HAZ tab (No 5), the idea is to show the user consequences of their choices of weld process, given material and geometry data set previously in the material and geometry tabs. Here the cooling time and the hardness of the weld fusion line is presented. The HAZ calculation tab uses the plate thickness from weld geometry, material chemistry data and weld process data. In this tab, input is minimal. All calculations here are based on settings from the tabs used earlier.
4 ECONOMICAL APPLICATION AREA OF THE SIMULATOR

The economical tab provides the users a good estimation of the cost aspect of the welding they are simulating. As the IQSim simulator only aims at presenting an approximation of what the actual cost of this welding would be, all the values indicated are to be taken as mere indication more than precise and exact values. But the economic tab offers a good synthetic view of the different parameters and mechanisms involved into the computation of the final cost of a welding and the proportion between the figures displayed and the actual real cost is respected.

The simulator supports six languages (English, Swedish, Hungarian, Lithuanian, Norwegian and Greek) which means that it also has to display different currencies: the euro (the default currency in the simulator), the Swedish krona, the Hungarian florin, the Lithuanian litas, the Norwegian krone. It’s important for each user to be able to relate immediately to the results displayed in the economical tab, so those results have to be expressed in the currency they are the most accustomed to, namely their very own.

The euro being the currency in which everything is computed, a conversion to the local currency is made before display if the simulator is in Swedish, Hungarian, Lithuanian or Norwegian language. The exchange rate between the currencies has been fixed once and for all during the coding process. This decision was taken for three reasons: first, the user is rarely, if ever, going to change the language of the simulator while he is using it and the non-perfect accuracy of the exchange rates is then unimportant; secondly the global proportion between the different currencies will be the same whatever the exchange rate is; finally adding a window in which to input the currency rate would have both cluttered the interface and confused the user, as this is not an information everybody keeps in mind at all time.

The total cost of a welding is computed by taking into account six different parameters:

- The costs for the wire (or of the electrode)
- The gas costs (if necessary)
• The labor costs
• The repair costs
• The heating costs
• The total amount of meter to weld

All those parameters are relevant and important for the final cost, and they are themselves decomposed into some elementary variables. Some of the variables are directly editable by the user with the use of sliders; some others are constant or resulting from calculations occurring in the geometry tab. Such values will be displayed in a slightly yellow box.

The final cost is computed based on many parameters and displaying them all on the screen while still having a very clear user interface was a challenge. The solution we used is to display a color-coded organizational diagram of all the parameters involved in calculating the final costs and to link them to show how they interact with each other in the computations. Of course such a diagram can be quite large (too large for the screen resolutions of most computer screen) and sometimes too detailed for what the users want to know.

The issue we can see in figure 28 is that it’s virtually impossible to display all the details of the calculation in one screen, and vertical scroll bars appear on the right hand side.

So we adopted a dynamic system, where the user can display or hide at will any of the six parameters described before. To hide or show an array of variables, just click on one of the six buttons to the right.
5 DISCUSSION AND FURTHER WORK

The iQSim simulator services may provide flexible online tools that may stimulate reflective cognition processes. The students must first carry out a simulation, before they verify the proposed simulation results in later practical test. By applying such an approach the student is able to simulate the effects of selecting different welding process related parameters, and then carry out the practical welding with the same parameters. After welding test pieces can be created and both non-destructive testing, and destructive examination can take place in order to verify the results. This may be done with the technical parameters, but also the economical aspect of the welding process may be simulated both theoretically and practically through shop welding for verification purposes.

The simulator tools introduce a new industrial evaluation process both in front of the training and after the practical laboratory work has been completed, by comparing the proposed data with the measured real life results. 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. 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.

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REFERENCES

[1] Project iQSim, online at www.histproject.no
[2] Project iQSim, online at www.histproject.no