

# FMS simulator

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**Abstract - HAMK - University of Applied Sciences in co-operation with industry and with public funding is developing a new way to improve the know-how in the area of local metal industry. The whole “package” - InnoSteel - consists of a group of projects which contain support for product development of innovative companies and new learning methods and equipment useful for educational institutes and small or medium size companies. One of the main projects in InnoSteel is InnoSteel Factory Ltd, which is a training factory for sheet metal product manufacturing.**

**The main goal of the InnoSteel project consortium is to increase know-how in companies and educational facilities related to the metal industry. The InnoSteel Factory -training factory is the heart of a diverse research- and learning environment, with the factory being a modern metal engineering workshop with training-, research-, and production capabilities.**

**With a concept known as Virtual Factory, which is included in the same project consortium, an e-learning environment based on simulation and modeling, is being built next to the training factory. The central operating model for this environment is that studying should be, at least within reasonable limits, possible over the internet making studying independent from place, even though this can prove to be difficult to accomplish in a technical field of study.**

**An important part of this environment is a simulator for flexible manufacturing system (FMS). It is based on the same technology as the real FMS in the training factory offering the possibility to design and test drive self made FMS-processes. Together with the real production environment of the training factory it forms a versatile and stimulating learning environment.**

**In this paper the possibilities of the FMS simulator will be presented as well as the pedagogical challenges related to it.**

*Index Terms* – Flexible manufacturing systems, e-learning, simulation

## E-LEARNING

E-learning materials have to justify their existence by offering clearly something more than the traditional, text based contents. This means naturally that useful e-learning environments can not be created just by transferring the information from books to computer screens. E-learning has to offer experiences and clarifying examples to students to motivate them to continuously develop their skills and knowledge. Since e-learning is meant to be - at least partly - dependent of time and place, the materials have to offer a quite extensive collection of on-line support and background information for the student so that the studying process will not be interfered by lack of information.

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A limited portion of the necessary learning environments can be executed by building web-based interfaces for simulation models and other systems [4]-[10].

## PEDAGOGICAL APPROACH

To find the best pedagogical practices for the virtual learning environments is a new challenge. For example the skills of an online counselor operating in a virtual lab environment needs to be redefined. A proposal is offered in the presentation on how remote education and its counseling would be done in the Virtual Factory learning environment. A new pedagogical view point in the presentation is to introduce a blended learning experience into skill based FMS technology distant education.

The meaning of the concept “skill” has to be elaborated in many cases for educational objectives. For example in the ECTS- system (European Credit Transfer System) created to enhance EU’s internal student mobility; educational goals should be assessed according to knowledge, skill and attitude. These should be defined individually within each study module for what they are.

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One of the important aspects which can be attached to the concept “skill” is that the performing a job or a task does not strain a skilled worker on a cognitive level. In the eyes of an outsider, the work performance often seems easy and smooth. In literature skill has been described as a target-oriented and hieratically organized behavior, where a person has an ability to choose the right course of action, according to the situation, from a large group of potential action models.

One of the many authors to describe “skill” is Lisanne Bainbridge. In her studies the concept ”skill” is based on the following three type division:[1]

- perceptual-motor skills
- cognitive skills
- problem-solving skills

Practicing manufacturing skills in Virtual Factory environment is based on using three different approaches to production and being able to mix them together when it is considered necessary. The student will get the first contact to Virtual Factory in web based laboratory demonstrations and learning materials. The materials will typically be small simulations of the real devices in the training factory. This enables the students to well prepare on their visit to the laboratory. This also will save time, since the students will not use the computers in the training factory for learning how the machines work. Instead of that the students – if they really are well-prepared – can quite soon start designing products, which can be manufactured in the training factory.

For evaluating the processibility of a product it very useful to be able to simulate the manufacturing process. In InnoSteel the real production line – InnoSteel Factory – is modeled using different applications [3]. These applications contain for example production simulation tools, CAM applications and robot off-line programming and simulation applications. The applications can be accessed in InnoSteel computer classroom. Hence the InnoSteel environment offers methods for simulated and real production.

Even though the virtual environment offers efficient tools for studying engineer skills, a new kind of problem arises when using simulation for studying. There is not much research done in the area of simulation based learning. The simulation is just a tool and requires very delicate designing of the learning tasks. On the other hand the definition of assessment criteria has to be done on a new basis since in simulated environment there are no “absolutely correct” ways to accomplish learning tasks.

### BLENDDED LEARNING

Even though e-learning is often an efficient way to study dependent on time and place, it does not offer a solution to all challenges. It is always useful for the learner to have contacts to the other learners or teachers of the course. This, of course, can be offered virtually via the internet, but for some learners a face-to-face contact is the optimal solution. The same way the learner may use different kinds of equipment via the internet up to a certain skill level but still the final evaluation of the learning process is more reliable,

## Learning path; from web to factory...

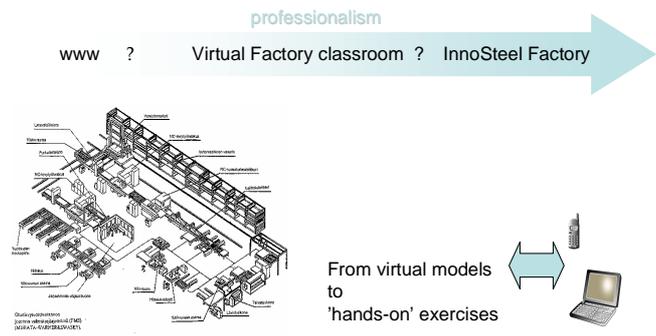


FIGURE 1  
VIRTUAL FACTORY LEARNING PATH.

if at least at the end of the training period, real equipment can be used.

Using face-to-face approaches combined with e-learning if often called blended learning. Virtual Factory is based on the principles of blended learning: virtual approaches are used at the beginning of the learning process and towards the end of courses, learning is more and more based on the real machine environment.

In the InnoSteel- projects learning environments and educational packages are focused particularly for the needs of the metal industry. These packages are mainly based on learning objects, which allows a dynamic way to produce modular course contents. To be able to manage the course contents and the learning processes some kind of tool is required [2]. In InnoSteel the learning object and learning process management system is executed with open source applications.

### WHY SIMULATE

Using simulators instead of real processes has some major benefits. One of them is naturally money. By using simulators instead of real production equipment, the student does not waste energy or raw materials. In case of a failure, no actual harm is done and no machine gets broken. On the other hand the latter sentence contains one of the main benefits of e-learning: things can be tested without the performance stress, dummy questions can be asked and difficult things can be repeated all over again. In addition to cost saving, simulation based learning can be much more efficient than working with real production equipment: idle times can be avoided and training can easily concentrate on some special sections of the manufacturing process and those sections can be repeated without looping the whole process.

Simulating production lines can be done in many ways. Usually commercial simulation software, such as Quest by Delmia, is used. Simulation models may be based on real manufacturing line programs or they use parameters which can be measured from the real production. For example a robot program may be used as it is or the simulation model may just use production times measured or estimated from

the real environment. The former method naturally is not as accurate as the method based on real robot programs but on the other hand it keeps the simulation models lighter and therefore smoother to run. In our case simulation models are mainly based on Quest and on a Finnish simulation software, Visual Components. All simulation models have three dimensional user interfaces which offer the user a feeling of the real process.

### GAME OVER?

Nowadays the students are used to plying computer games. Therefore playing is quite common approach to e-learning applications. Even though game-like learning solutions offer a familiar environment especially for younger students they also cause new kinds of challenges to their creators: playing may be interesting for the students, but there is a big gap between playing and learning. To make the difference between gaming and studying, the students have to offered well planned learning tasks, exercises and support to maintain the focus in training instead of trying to beat the co-students' highest scores. Especially in case of simulation based e-learning environments there is a risk of confusing the students by game-like simulations which contain inadequate tasks and explanations related to the "real life".

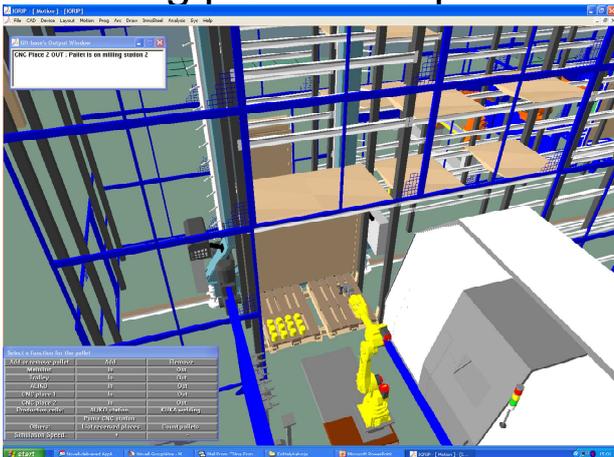


FIGURE 2

FMS-TRAINING ENVIRONMENT: LOOKS LIKE A GAME BUT CONTAINS DETAILED LEARNING TASKS FOR KEEPING THE FOCUS ON MAIN ISSUES

### FMS-SIMULATOR AS A LEARNING ENVIRONMENT

Since FMS in a versatile process containing the whole chain from manufacturing execution system (MES) to separate workcells, it offers a good way to explore the whole manufacturing process. In our approach we have three main approaches to FMS:

- Basic materials:
  - The general level, which clarifies the main parts, functions, data flows and communications of FMS

- MES view, offering tools to test optimizing a simulated FMS based production line
- Medium level materials:
  - FMS simulator, which is a virtual model of a real environment. It is operated with the same user interface as the real FMS system in InnoSteel. Instead of the real system it operates an accurate simulation model of the FMS system.
- The final step in learning process is the use of the real environment in our training factory.

A typical course carried out in this environment contains contact lessons held in InnoSteel and distance lessons based on remote use of the FMS simulator. All these stages prepare the students to be more responsive in the training use of the real FMS.

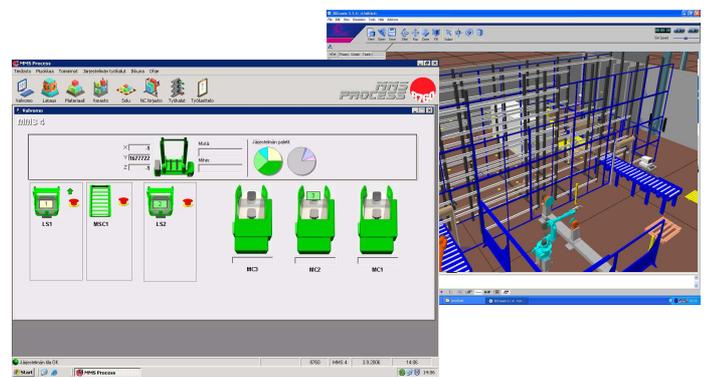


FIGURE 3

FMS-SIMULATOR SHARES THE SAME USER INTERFACE THAN THE REAL SYSTEM IN THE TRAINING FACTORY. IN ADDITION TO THE CONTROL VIEW THE SIMULATOR ALSO HAS A 3D MODEL SHOWING THE RESPONSE OF THE SYSTEM.

### CONCLUSIONS

InnoSteel and its' e-learning environment – Virtual Factory – form a versatile and flexible infrastructure for training. Since it contains various mixtures of real equipment and simulation models, the possibilities of utilizing new educational methods are wide.

In this presentation we have introduced one of InnoSteel's learning tools: FMS simulator. The first versions of it have already been tested with student groups and the feedback has been encouraging.

Some parts of the FMS simulator package are created together with a national network of training organisations in metal branch, called eTRIO.

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