International Cooperation Concept and Learning Environment for Innovation Process of Electro-Mechanical Products

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Abstract - The business environment has changed very much, because of globalization, including that products has become more complex, life cycles of products have become shorter and the delivery times are getting shorter and shorter, etc. Because of all these changes, companies are focusing on their core business, outsourcing some of their operation and also looking for good suppliers worldwide. Efficient global supply chains are needed for future business. Companies does not use only traditional subcontracting, but they are also outsourcing some R&D-work concerning products. This means that more product data is transferred between companies and then application integration plays vital role in the development of the supply chain. If we try to develop learning by doing, we have to arrange learning environments which use same tools as industry and which are some how connected to industry. In our cooperative learning concept the focus is in the development of the supply chain and technologies which made it possible to work efficiently and in the innovation process of the highly innovative product that satisfy various requirements (customer, functional, technological, cost, environmental, etc). Developed platform can be used also as a learning environment of the university student groups. Concept is same time an international cooperation concept between HAMK University of Applied Sciences (Finland) and Technical University of Cluj (TUC, Romania) and important part of the innovation system.

MODERN BUSINESS ENVIRONMENT

Modern business environment has changed remarkably in industrial countries during last decades. This change continues and its direction is clear. Automation and information systems must be used more efficiently in the industrial production to guarantee its profitability. Production systems must be more flexible to response customer needs. Production systems must be fast and streamlined, in order to be able to compete with delivery times without tying up capital to warehousing. Special attention on supply chain management must be addressed, as the products production and even design is divided among many companies. With these methods production industries are attempted to keep in high income countries. Despite this the production industry sector is shifting more rapidly to low income countries, especially to close proximity to its main market areas in China, India and South-America.

As the production systems speed up and become more diverse in terms of producers, the supply chain becomes more vulnerable, if the processes of each link are not inspected in the best way possible. A shift from traditional sub contracting can be seen to part deliveries, were the contractor is a partner, who delivers semi finished products instead of just parts and possibly is partly in charge of designing these semi finished products in accordance with the main producer’s preliminary parameters. As companies out sources their operations and establish them selves in new countries, the target is in many cases in a country with different culture and in correlation different habits, customs and language.

Industrial business service is seen as one possibility for success. Business is increasingly shifting from a product oriented process to solution based thinking. (figure 1).

Fig. 1. From product oriented thinking to solution oriented thinking

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Product features are no longer important, but the ability to create solutions to a customer problems and added value the product generates are in high regard. In many cases it is a question of increasing efficiency in customer processes (information management, production, supply chain, etc.) The customer is not interested in the actual product, but that it increases efficiency in the desired way. This new solution based customer oriented way of thinking is a challenge to comprehend for the traditional engineer community. In the traditional engineer way of thinking the focus has been on machines and equipment and on innovative technical solutions. It has been no problem for engineers to build machines that no one needs or at least no one will buy, if the product is in itself interesting enough. Well, maybe another engineer would buy it. There are actually many real live examples of this happening. More challenges are created by the fact that the solution to a customers problem cannot always be found from the conventional product. In industrial business service the solution is located through new services, which can be based on using high technology products, but the customer is not buying the product, they are buying the service. Typical industrial business service products are being developed among other things, for remote diagnostics – management in production processes. The customer buys a service by which the seller manages and adjusts the customer’s production equipment via a network, so that the equipment performs in optimally, also potential problems can be predicted and maintenance work can be scheduled accordingly with the best possible efficiency.

It would seem that in this new operational environment very different capabilities are expected from engineers than before. Companies operate in an international customer oriented and mostly order directed business environment. In that case the R&D person is most often in direct contact with the customer, not behind a sketch board thinking of the newest technical machine, but thinking for a solution to the customer’s problem with the customer. If this is the world we as we see it, then we must take it into consideration when educating new engineers. The new capabilities must be evident already during the application process and these capabilities must be enforced through out the education. It is not enough that we lecture about these matters, the learning environments and teaching processes must support the development of these capabilities.

E-LEARNING ENVIRONMENTS OF ENGINEERING EDUCATION

The use of E-learning environments is continuously increasing and there are precise reasons for this. The internet makes learning not dependant on time or place possible also the distribution of documents and learning objects greatly simplifies using the internet even to different types of terminals. This in itself is not sufficient when aiming for even better learning environments. In the early stages of development typical network material consisted of uploaded text documents. Perspicuity, interactivity and the ability inspire the user are required from the new learning environments and learning objects [1].

I. Learning Management Systems

Learning management systems have been the targets of extensive research and development. They act as platforms for different courses. Through these the learning privileges of defined groups can be governed, material can be distributed and able quick tests to be taken through the internet. Chat rooms or forums also have an important role, where problems are solved together with conversation. Through the forum collective questions can be presented and when answered, everyone in the forum can receive the answers and info. Learning management systems also work as a feedback channel between teachers and students, enabling personal guidance via the internet. Learning management systems have many different applications, some are purely commercial products and others are open source based [2].

II. Learning Objects

Learning objects have been under special interest lately. The goal has been to develop learning objects, which function individually facilitating the learning process of a specific topic. Learning objects can be attached to various courses and learning contents when necessary. In many colleges the situation is that there are educational packages or degree programs, which are associated with various course modules, these modules are comprised of individual learning blocks, which themselves have many learning narrators (lectures or exercises). Various materials including internet lectures, exercises, questioners, animations, simulations, videos, recordings and etc, which are learning objects, can be included in an individual lecture. Another course can directly contain the same lecture as another course; another education program can contain the exact same learning module as another [3]. What is most typical is the flexible use of learning objects. The distribution of learning objects can be facilitated through learning platforms. Applications for this specific purpose have been developed.

III. Considering various target groups

One fact speaks for the flexible use of learning objects and it is that many colleges offer educational programs for very different target groups; youth education, adult education, further education, corporate training, education intended for international distribution and so on. When developing an internet based learning environment one must consider the various target groups and their relationship to information technology. It should be considered that when designed correctly, an internet based learning environment can support the learning of the disabled and elderly [4]. In corporate training internet learning enables education along side work, but could create friction among older employees who might not be accustomed to working with computers. The younger
generation on the other hand is growing up with computers as a normal part of their lives, with computer games creating even overzealous expectations for internet based learning environments. Learning is expected to be as grasping and inspiring as a game and on the best occasions this is achieved.

IV. Features of Engineering Learning Environments

What kind of expectations and features can be found in the learning environments related to engineer education? In many educational facilities the importance of practical exercises is emphasized. The basic conception is that practical work has a fundamental role in learning. The talk is on a concept known as: learning by doing. One can learn by doing for example by operating production- or measurement equipment or by programming a robot or other automatic equipment and testing the program in practice. Typically the learning process starts in a more closed environment and after some experience one can move into more open and complex environments. In the unifying exercise works a problem based learning method (PBL) is used. The system must be achieved into a predetermined condition, the main lines to achieving the problem are there, but there can be many solutions to a problem [5]. In many cases also this is involved with project learning, were in the whole exercise forms a project, which contains many stages [6,7,8]. This is how it is done in industry also.

V. Role of the e-Learning in Engineering Education

How can the internet based learning environment help when the goal is better learning results and the aim is to enhance efficiency in the education process? The way of thinking I described before is still strongly in the open, practical exercises have a substantial role in learning; this does not want to be totally replaced by an internet environment [9]. In blended learning applications e-learning explicitly supports the accomplishment of practical exercises. Good internet based learning environments and learning contents combined to these environments, including interactive learning objects, can replace traditional lectures, which have produced poor learning results. On the other hand this is confined to the topic in hand. Sometimes a good lecture is the best way to relay information and achieve learning. The live-situation in a lecture is definitely more interesting, then again if the learning processes are inclined to be independent from time and place, internet lectures speak for themselves. Still the student has the possibility to review the internet lecture, even though it weren’t that eventful.

VI. Remote and Virtual Laboratories

A significant role with internet based learning environments is the easing of a student into practical exercises. The exercises are executed via the internet using the even same equipment and through more friendly-user interfaces keeping the sensation to be doing it as in reality. Many solutions have been created for this. The common term in use is remote laboratory, where real equipments are controlled or measurements are taken from real processes using a web camera on-line. The use of these kinds of installations has clearly increased and many advantages can be seen from their use [10]. On the other hand so called virtual laboratories and virtual processes have been created. There is no actual equipment in these laboratories, only a process mimicking a real process ongoing on a server. The student links to the server and is able to control the process according to predetermined objectives and exercises. Virtual processes speak for themselves when a more extensive and complex process is in question [11, 12, 13].

VII. Animations

When illustrating various processes and equipment functionality animations have an important role. By using simple animations relevant aspects can be extracted even from complex systems. An animation works as an illustrator and simplifier. Another advantage to animations is that it can illustrate aspects otherwise invisible in reality; what is actually going on in the process; what is going on inside the machine. In those cases 2D-animation is most often used, which is light enough to use over the internet and serve their purpose concerning perspicuity. Although 3D-animation is being favored more and more. The problem has been their size when used over the internet. Also constructing 3D-models is a larger task than 2D.

VIII. Used Technologies

How have then those learning environments been built and what techniques and applications have been used? Equipment controls in remote laboratories varies, there are programmable logic controllers (PLC) and numerical controls. User interfaces to the equipment have been carried out in different techniques, in some cases customized interfaces are used in others SCADA-programs are used. In many measurement applications has been using MatLab and Labview software as best actual solution to creating interfaces friendly and ergonomic [14]. The same applications have been used in virtual processes or then the functionality of the process has been customized by using VisualBasic, C++ or Java and in some case even a software based programmable logic control (softPLC). The connection to the actual equipment via the internet has been accomplished using a server-client connection or by using remote control programs. WebService-technology enables information security when communicating with the equipment through a browser based interface. Macromedia Flash-animations have been used a lot when illustrating the processes; also some interactivity has been added. The used techniques are as one can see varied, but some commonalities can be found.
Colleges are increasingly aiming to network. These goals are aided substantially with the development of internet based learning environments. Also international and mutually beneficial cooperation in planning and building educational programs can be achieved. The same task does not have to be repeated. The traditional forms of cooperation between colleges have been student- and teacher exchange programs. Many universities want to tighten this cooperation into the direction of combined research, a development that financiers also appreciate. The EU’s 7:th frame program emphasizes the importance of networking. More and more parties; universities, research centers and companies should be involved in research projects. The development is fairly analogous with the development of business environments. If one wants to succeed, there must be a willingness and ability for cooperation. The university to business cooperation is being tightened. Business demands know-how for today’s needs. Education must follow the time as conventional technology is being outdated on an increasing rate. The business community also demands engineers with better capabilities, meaning work experience and ready tools in the beginning of their careers. Then again the aging of technology is comprehended and it is understood that ten years from now the tools that are used might be totally different. So it is important to understand processes and basic concepts on to which the tools are built on. As technology ages the need for further education increases, learning on the job and continues learning are here to stay. One must have the ability to absorb new info and the possibility the train even for new types of tasks. This creates the need to tighten the cooperation between companies and collages.

Companies want universities to join them in developing new solutions, research important phenomena and to make solutions into practical implementations. The conventional research model, were basic research is done and on the basis of this research potential targets for application are thought of and new products are conceived is not very efficient; only a fraction of innovation is born this way. The bulk of innovation derives from sheer necessity, for which a solution is searched for and existing background information is used. Information is applied and tested in practice without forgetting modern computer instruments, for example simulation environments.

Companies see educational facilities as a recruitment channel. Events must be organized were companies can see the practical work of a potential employee in detail. Joint research projects are an ideal environment for this. The movement of personnel between universities and companies has been tried to make easier. This is an advantage for both the universities and companies. So educational – business cooperation is very diversified and deepening, new models are being sought out and tested [15, 16, 17, 18, 19].

HAMK and TUC are in the process of building cooperation concept, which strives to meet the demands set to universities and their educational programs. The cooperation initially materializes between two universities as international cooperation, which aims to meet the demands of business.

I. Cooperation Concept as a Part of Innovation System

HAMK has several ongoing projects with the purpose of initializing companies’ innovative activities. Despite the high level of education and investments in research, a big concern in Finland is the small amount of new products launched to the market. The purpose of these innovative projects is to find new innovation objects together with companies from a demand perspective. TUC has strong experience in QFD-process implementation in various companies being a substantial part of the innovative process. A possible approach concerning innovation is presented bellow (figure 2).

![Figure 2: Market orientated innovative product planning](image)

The goal is to create an environment into which innovative objects can be fed and processed forward from the product conceptualization, definition, design, validation, fabrication, inspection, to promotion, selling, service, recycling. Especially in the first phases of innovation the modules identify the product opportunity gap (POG) of the specific environment,
the customer oriented new product performances planning, the quality performances, the anticipatory failure determination (AFD), the failure mode and effect analysis (FMEA) for product and process, and a cascade QFD (Quality Function Deployment) analysis. Special emphasis is on increasing the innovative actions in food- and packing industries and also agriculture. The concept includes the product innovation, product design and product simulation, also production design and simulation and production and product diagnostics. Innovation system development, web-meeting technology use in outsourced design, product-, production and supply chain simulations, system- and application integration, integration between operations and quality control and also quality control for the whole concept and its sub processes are a few examples of the research topics and development targets (figure 3).

II. From Simulations to Prototype Production

Modern digital machine building applications and production equipment for electro-mechanical products are in use. The latest web meeting environments are used in cooperation and the distribution of documents can be handled via a database. As the innovation process proceeds computer assisted mechanical and electrical design environments are in use with simulation applications. Modern CAD environment provides virtual models for product, process and resources. Data sharing enables manufacturing, tooling and systems to be developed in the same time with the product design. The benefits are mainly sharing the work load between teams, better communication and reaching the solution faster. The validation of the solution is made using simulation software (partly own applications) for the manufacturing process as well as for the whole manufacturing system, using discrete or stochastic simulation. Virtual simulation enables evaluation of different scenarios, favoring innovation, reduces resources and shorten times. But there is more than virtual products in virtual plants.that mainly in Rapid prototyping, with it’s three areas: reverse engineering, rapid manufacturing of shape and post processing offers the possibility of generating prototypes from a CAD project without specific tooling. Modeled prototypes can be tested digitally and mechanical models can be built using TUC’s rapid prototyping- equipment (SLS Sintersation 2000 - a system of laser sinterisation).

For simulating the products supply chain separate applications are in use. Simulations can be benefited from in the various stages of product development and production. (figure 4).

Programs ment for mechanical part production equipment can be constructed using CAM- software, even over the internet by using a virtual class concept in the terminal’s remote use [20]. Simulation tested machine tool and robot software can be uploaded directly to the machines, also through the internet. The same protocol applies to the electronics related to the product (circuit board construction). The final prototypes can be manufactured using the universities own training plants; InnoSteel, EleForrs (figure 5). Own applications exist for production- and product data collection, which can also be used over the internet. Participants can follow the development of production orders, the actual production and the state of the production equipment all online.

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III. Application Integration

In the system integration related to the concept a new type of relay server technology has been invented, which makes use of standardized interfaces and web-service technology. The GEDAT- system guarantees information security between different applications and user interfaces, without making any distinction between a real or virtual machine (figure 6).

CONCLUSION

The concept we have developed is in its early stages and it is being tested piece by piece. The goal is to be able to use the concept as an integral part of the education offered by both universities. The concept describes quite well the operations of a networked customer oriented international business environment, where R&D- data is shared among different parties. The hope is that students already during their studies would operate under the same conditions as in real business environments, using modern applications. System integration development and testing is not the only matter when building environments, even though it is an important part in practice. The goal is to create a cooperation concept, which can be used diversely also in corporate cooperation. Through the concept the aim is to better understand the importance of human cooperation in today’s information society. Solely by developing systems one cannot survive. This is also a message to develop engineer education.

REFERENCES