Distance Training of Mechatronics and Alternative Technologies in European Industry
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Abstract—Expected economical and demographic changes in European countries require high efforts in the development of human capital in the area of high technologies. Industrial companies expect more effort in the continuing education of elder technical co-workers and in the cooperation between higher education and industries in that area. Researches and expert discussions identified the new interdisciplinary field mechatronics as one of the structural drivers of change in the electro-mechanical industry on the one side, but also a lack of knowledge between professionals on the other side. So there is a high demand of continuous education in that area in the most of European Union countries. To improve the situation, an E-PRAGMATIC network (E-Learning and Practical Training of Mechatronics and Alternative Technologies in Industrial Community), an association of 13 regular and 3 associated partners from seven European countries, was established as a part of Lifelong learning program, Leonardo da Vinci. The network’s partners are educational institutions, chambers of commerce, companies and the associations. The main network’s aim is to modernize mechatronics and engineering vocational training of the employed professionals, apprentices and trainees, by enhancing of the existing or establishing new in-company training approaches of enterprises, network’s industrial partners.

Index Terms—Mechatronics, Technology enhanced learning, remote experiments.

I. INTRODUCTION

European companies face after the last economical and financial crisis a high pressure from the market. A lot of companies are outsourcing their resources to other parts of the world with higher and stable rates of growth. The only way out to hold companies and jobs in Europe are investments in high tech products, which require high qualified human resources. On the other side hand European countries are confronted with aging societies. The part of elder people is increasing and they should stay in the working process longer. To keep these people up-to date with the technological progress, a lifelong process started inside and outside the industries. E.g. the Austrian Federation of Industries started together with the Austrian Labor Market Service in 2010/2011 a series of expert discussions to define the needs of continuing education and qualification in different technology fields like electronics, telemetric, mechanical engineering etc. During these discussions one technology field was named more than others: mechatronics, a technological hybridization, where electronics and mechanics are joined in a new interdisciplinary field, combining mechanics, electronics and informatics, [1]. Many companies see in mechatronics a structural driver of change in the electro-mechanical industry [2]. Despite of the market demands there is a lack of formally educated professionals in that area in most of European Union (EU) countries. In the companies the jobs of mechatronics are often occupied by specialists with either mechanical or electrical professional education, which do not have the appropriate knowledge of mechatronics. As a consequence, the jobs that would call for experts in the mechatronics are often occupied by the experts from the mechanical or electrical engineering, who do not have the appropriate knowledge of mechatronics. Continuous education of those professionals can at least partially solve that problem, but this challenge for change can be met only combining the activities on an international level. Affected from that problem are all levels of professional education, but mostly affected is vocational level. The changes in this area of technology are so high, that normal vocational schools are not able to follow them with respect of the content and also with respect to the necessary technical equipment. Only in educational networks, combining the possibilities of vocational and higher education and industries, are able to master this challenge and at least partially to solve the current imbalance between the supply and demand for suitably qualified professionals in the field of mechatronics.

Human resource departments in high tech companies and educational institutions of differed level are complaining about a lack of knowledge in basic subjects like mathematics, physics between younger people, which are the basis for a high level formal and informal continued education in technology related fields. In Austria this problem is especial relevant for young people, which finished vocational schools. They are as usual highly specialized, but have a lack of basic knowledge, which would enable them to follow the high speed of technological progress e.g. in the field of mechatronics. But one of the megatrends of future technological development is the increasing importance of math, algorithms and simulation.

On the other side the percentage of employees with a medium qualification level until 2020, can increase, especial for the age groups 55-59 and 60-64. This elder workforce will need an additional education to keep up with the increasing demands of their jobs. The participation of adults in the education/training is decreasing in the last years. The EU 2010 target of 12.5 % of adult employees participating in the education and training process will not be reached. [3]. In Austria for example the participation rate in the job related non-formal education, for age group 55-64, is much below the EU average (58.3 % versus the average 70.7 %). This was also confirmed in the discussion of the standing committee for new skills of the Federation of Austrian Industries and the Austrian Labor Market Service for Electronics and Telematic. In some big companies in
Austria about one week per year is formally reserved for training and education, but often not used because of a lack of free time during the working process, a high pressure in running projects or because of family responsibilities.

In general about two fifth of EU companies provide a non-formal education to their employees, in the form of in-company training or by special vocational training institutes like WiFi, a network of Austrian and International Institutes of Economical Promotion, which is serving especial the needs of SME. Big global high-tech companies like Siemens or Infineon are running their own in-house academies of continuing education. In-company training can there be also an efficient method to transfer the mechatronics knowledge from the educational institution directly to the professionals employed in industry. But regardless of the way, how to deliver new knowledge and skills, in formal or non-formal education, the problem of lack of time still persists.

Learning on demand, using technology enhanced learning methods, where the complete training cycle is delivered via internet, can efficiently serve for the training of the professionals from the industry and efficiently solve some of the above described problems. [4] Since the distance training can be time and place independent, it can be easier to meet the needs employed professionals. Such training units easily can be included in the in-company training of many employers. This could be an efficient way toward solving the problem of continuing education of professionals from industry in the field of mechatronics. The pedagogical approach should combine methods from microtraining [15] and actions learning [16]. The material should be split in smaller units, which can be learned each in itself. The active learning approach in such industrial training emphasizes the practical orientation, including remote experiments or access to the remote working station, which should be included in the training plan. This kind of technology is taken from a new trend in engineering, online engineering. [7], [8]. Each such unit should also contain practical tasks and small self-tests.

One of the last studies of distance learning from mechatronics was executed within the MeRLab project [9], an international projects, which was focused on continuous training for professionals from Slovenian industries in the basics of mechatronics. The pedagogical approach already used elements of microtraining, combined with an extensive distance tutor support and special developed remote experiments in mechatronics. [6] So far this vocational training was not a typical e-learning, as we know it by self-study introduction courses in business management or basics of simulation languages (like Open Modelica). The project used a professional LMS. It was co-funded by the European Union in the framework of European Union (EU) Lifelong learning program, Leonardo da Vinci Action [12].

In this paper a new, innovative approach for establishing or enhancing in-company training will be presented. The work builds upon the results of the project MeRLab, but also extends the basic idea to the international level.

This contributions presents first the results from an empirical needs analysis to identify the fields of continuous education in mechatronics in the E-PRAGMATIC network and also as an example first modules and the chosen pedagogical approach, a technology enhanced learning, self-directed, with tutoring support and practically oriented with remote experiments and remote working stations. The training will be organized as an in-house training in the companies, special balanced to their concrete needs.

This paper is a report about a project in progress. It describes the status of a project, mainly dedicated to the implementation of a network of continuous education in the area of mechatronics and technology relevant fields in European industrial companies, based on e-learning and remote labs. The contribution is organized as follows. The second section describes E-PRAGMATIC network: its goals, aims, target groups etc. The third section gives an overview about former projects and describes the role of E-PRAGMATIC Community of professionals. The forth section gives a first outcome from the empirical needs analysis, undertaken in six European countries, while the fifth section gives a short description of the first modules, which were developed for some industrial partner. The last section gives a summary and a conclusion.

II. E-PRAGMATIC NETWORK- GOAL, AMS, METHOD, TARGET GROUPS AND PLATFORM

The success of MeRLab vocational distance education of the professionals from industry triggered the idea to extend and implement that sort of training also to the other EU countries. For this an E-PRAGMATIC network [10] (supported by EU Leonardo da Vinci Program) was established [11]. The network consists of 13 partners and 3 associated partners from 7 European countries and Switzerland (see Fig.1).

From most of the participating countries there is one partner from an educational institution and one partner
from the industry (an enterprise, a chamber or an association of the companies). EPRAGMATIC regular partners are: (1) University of Maribor, Slovenia; (2) B2 d.o.o., Slovenia; (3) ECPE European Center for Power Electronics e.V., Germany; (4) University of Deusto, Spain; (5) Poznan University of Technology, Poland; (6) Carinthia University of Applied Sciences, Austria; (7) Delft University of Technology, the Netherlands; (8) Chamber of small business and craft, Slovenia; (9) Elson Electrónica S.A., Spain; (10) Simulation Research, The Netherlands; (11) Wielkopolska Chamber of Commerce and Industry, Poland; (12) Flowservice (Austria) GmbH Control Valves, Austria; (13) EXENDIS b.v., Netherlands. E-PRAGMATIC associated partners: (14) University of Applied Sciences Bern, Switzerland; (15) Siemens Schweiz AG Industry Automation and Drive Technologies, Switzerland; (16) GAIA, the Telecom Association Cluster of the Basque Country, Spain.

The network’s partners cooperate at two levels. The closest collaboration is established between the working pairs of partner’s frogman educational institution (EDU) and an industrial partner (IND) in the same country. One of the tasks of the EDU partner is the development of two training modules specially suited to the needs of his working pair IND partner. The decision about the subject of these modules is based on the needs analysis and expert discussions between the working pair partners.

The pedagogical approach includes practically oriented learning modules with remote access to training devices and remote workplaces. [12] Based on that approach a basic as well as an advanced mechatronics/engineering knowledge can be delivered. The learning content will be available within the professional learning portal eCampus.

Additional every EDU partner can choose one topic for a third module, which is in the scope of his research interests and delivers practically oriented knowledge about modern trends in alternative technologies such as photovoltaic, hybrid drives and remote technologies e.g. At the end 18 training modules are available and two thirds of them will directly address the concrete needs of an industrial partner in the network.

The languages of instruction of all modules are English and in the native languages of the module’s authors. The training will be executed completely using net technologies. As such it will especially suit the needs of employed professionals. Each training participant will be able to set his own training program in respect of the subjects from the network pool, the tasks and schedule.

It is planned to carry out a pilot training, with at least 100 participants. The training will follow the methodology of personalized learning tracks. Further, trainings of teaching instructors from the industrial partners for in-company training will be delivered.

On a second level, the collaboration between all networks’ partners is foreseen. This level is international and will operate within “E-PRAGMATIC Community of professionals”. It will work toward improving of the cooperation between educational institutions and the industry and is intended for sharing of the knowledge, information and expertise.

Based on the needs of companies and the entire situation E-PRAGMATIC training is oriented toward few target groups:

(1) Employees, professionals (especially from the older age group) from the participating IND partners
(2) Apprentices and the trainees from IND partners
(3) In-company trainers from the participating IND partners
(4) Other stakeholders who have interest in joining the international Community of professionals and participate in the training and other network’s activities
(5) Regular and part time vocational students from the participating EDU partners

![Figure 2. Educational aims and objectives of E-Pragmatic](image-url)

Learning material will be delivered with the E-learning portal eCampus® [13]. This is a content and learning management system, developed by the B2Company; its functionalities are shown in Fig.3. Specific requirements to eCampus® (which are maybe different from other CLMS) are:

(1) To meet the specific needs of industrial distance learning
(2) To provide the functionalities necessary for the international Community of professionals,
(3) To ensure a stable operability of the real-time experiments online
(4) To offer a multi-language environment by the choice of user,
(5) To use the semantic web technologies which offer many advantages in browsing web content enriched with additional metadata.

To achieve a higher degree of learning motivation the learning portal will use:

(1) Hypermedia elements (multimedia capable of the interactions with user),
(2) e-learning conform didactic parts (short quizzes to instant feedback, scored questionnaires),
(3) Real-time experiments (practical experience) and
(4) Available free external tools, connection to the
external social networks as Facebook and Twitter.

Learning materials in eCampus® are presented in
the form of small learning units. Each learning unit gives
textual and graphical explanations and includes a
motivational question, which should be answered
immediately. Navigation through the material is easy by
using index and tags. The learning portal is interactive and
can be personalized for each user. Tools necessary for
the management of the learning process are available.
Until now it is not planned to deliver the material as
microtraining on-demand, but if the companies will
require such an approach, it can be taken in consideration.
TABLE II. RANKING BY COUNTRIES

<table>
<thead>
<tr>
<th>Country</th>
<th>Rank</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>1</td>
<td>Emerging/alternative technologies</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Electrical Control Theory</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>PC based measurement and control</td>
</tr>
<tr>
<td>Germany</td>
<td>1</td>
<td>Power electronics</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Engineering Software: C, Matlab, etc.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Emerging/alternative technologies</td>
</tr>
<tr>
<td>Poland</td>
<td>1</td>
<td>Emerging/alternative technologies</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>PLC Controllers and industrial networks</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>PC based control and measurement</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1</td>
<td>Emerging/alternative technologies</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Introduction to Robotics</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Fundamentals of mechanical engineering</td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td>Microcontrollers and embedded systems</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Engineering Software: C, Matlab, etc.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Emerging/alternative technologies</td>
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<td>Netherlands</td>
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<td></td>
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<td>Microcontrollers and embedded systems</td>
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<tr>
<td>Austria</td>
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<td>Emerging/alternative technologies</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Manufacturing technologies</td>
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<tr>
<td></td>
<td>3</td>
<td>Material sciences</td>
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</tbody>
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TABLE I. RANKING OF THE SUBJECTS

<table>
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<th>Subject</th>
<th>Rank 1</th>
<th>Rank 2</th>
<th>Rank 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emerging/alternative technologies</td>
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<tr>
<td>Power Electronics</td>
<td>2</td>
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<tr>
<td>Microcontrollers and embedded systems</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Engineering Software: C, Matlab</td>
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<td>2</td>
<td>0</td>
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<tr>
<td>PLC Controllers and industrial networks</td>
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<td>0</td>
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</tr>
<tr>
<td>Applied control theory</td>
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<td>0</td>
</tr>
<tr>
<td>Introduction to Robotics</td>
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<td>1</td>
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<td>Material sciences</td>
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On the basis of the results of the country specific needs analysis for Austria and expert discussions the EDU partner Carinthia University of Applied Sciences and the IND partner Flowserve (Austria) GmbH agreed to develop three learning modules. One module focuses in alternative technologies and is named Remote Application and Trends while the other two are named Introduction to LabView and Material Sciences.

At the current stage of the project two modules were already implemented and will be described in the following paragraphs.

The Remote Applications and Trends module focuses in describing the state of the art in the field of online engineering with a special focus in online laboratories. Online Engineering can be defined as an interdisciplinary field utilizing the areas of engineering, computing and telematic; where specific engineering activities like programming, design, control, observation, measuring, sensing and maintenance are provided to both remote and local users in a live interactive setting over a distributed, physically-dispersed network (for example: an intranet or the internet). Remote technologies and their application is an emerging field in engineering today and the demand for engineers with this specific knowledge is growing. This broad field spans different areas that go from the development of online laboratories to telemedicine. The following use-cases outline the importance of the described field:

by the Chamber of craft and small commerce, Section of mechatronics and electronics. Also

many professional journals are available.

Another question was devoted to the most required subjects for professional training. A list of 25 subjects related to mechatronics and the business of the involved companies was suggested and the professionals could rate them between 0 (= not interested) and 5 (= very interested). The professionals from all included countries rated “Emerging/alternative technologies: Photovoltaic technology, Wind power, Fuel cell technology, Hybrid drives, Nano-robotics, Nano-materials, etc.” on the first place. On the second place was rated the subject “Power electronics”, on the third place follow Embedded Systems, Engineering Software and PLC controllers. This rating corresponds to the main trends in technology now, alternative technologies are in the focus of interest, also questions of energy saving. Hardware and software related questions are also of great interest. (See Tab. II). The ranking was calculated on based on a weighted relative ranking by participating partner countries (Tab. I). With respect to the participating countries there are some differences. In countries, which traditionally already use alternative energy technologies (e.g. wind power) like Spain and the Netherlands the interest in a training in such technologies is not so high like in other countries. The high interest in mechanical engineering and materials in Austria can be explained with the business subject of the participating companies.

On the one side, these results will now be the basis for the choice of the training modules, which will address directly the needs of the IND partners. The concrete topics will be defined on the basis of the empirical study and expert interviews with the IND partners. On the other side, they also serve as hint for the choice of the topic of those modules, which can be developed by the EDU partners for a more general auditory of vocational training.
Examples of good practices - implementation - some cases this is a mandatory part of continuous education in the company, or it is organized on the basis of agreements between the collaborators and the Human Resources Department of the company. All kind of in-house training is also a subject of agreements between the management of the company and the so called works council of the company (in case of Austria e.g.). People, who wants to participate in their free time, as volunteers, are also welcome, if they participated in the survey action.

This module will introduce the basis pertaining the learning in online labs, different technologies to deliver online labs as well as several examples of good practices of running online labs around the world.

The LabView module was developed in deep cooperation between the EDU partner Carinthia University of Applied Sciences and the IND partner Flowserve (Austria) GmbH. The target group for the module is high school of applied sciences alumni who are starting their carrier at the company. This group of learners has basic knowledge in programming but no experience with a graphical programming language like LabView. LabView stands for “Laboratory Virtual Instrumentation Workbench” and is a platform developed by National Instruments that features a development environment for a visual programming language, a kind of engineering software. Typical applications developed with LabView usually involve data acquisition, industrial automation and control as well as others. The outline of the module content was proposed by the industrial partner. The basis of the module is built in the following way: Content, questions and tutorials. The aim of the course is to allow the learners to develop their own LabView applications and to be able to understand and further develop existing applications in LabView.

The first pilot test will start in the second half year, the participants will be chosen mainly by the company. In some cases this is a mandatory part of continuous education in the company, or it is organized on the basis of agreements between the collaborators and the Human Resources Department of the company. All kind of in-house training is also a subject of agreements between the management of the company and the so called works council of the company (in case of Austria e.g.). People, who wants to participate in their free time, as volunteers, are also welcome, if they participated in the survey action.

Any additional data can be reported only after finishing the next steps of the project.

VI. CONCLUSION

In the paper the state of distance industrial education is presented. Further, a new E-PRAGMATIC network is described. Its main goal is to improve the industrial education provided in the form of in-company training. The network will work toward enhancement, modernization and establishment of the in-company training methods of electro-mechanical industry. It will introduce practically oriented distance learning and modern learning modules with the remote experiments and practical exercises from the mechatronics, general electro mechanics and alternative technologies.

The methods developed within the network and tested in this manner will be universally applicable in the in-company training of the enterprises in related fields throughout Europe. During the phase of pilot training they are open also for other participants.

Further, a new practical experiences and knowledge at using of the innovative hypermedia e-content and advanced learning environment both for the industry and the educational institutions will be gained.

User-friendly distance learning and applied educational methods will provide an additional motivation for the target groups, specially the older professionals with vocational education, to acquire new knowledge. Discussions with companies showed, that also young graduates from vocational technical schools are a possible target group. The training will be also at time and location independent and can be as such easily incorporated into their everyday activities. Positive experiences in e-training can also increase interest of the target groups in consuming other e-learning content and thus contributing to the extending lifelong learning paradigm.

The international cooperation, complementation and exchange of knowledge, experiences and good practices encouraged. Already now industrial clusters in several participating countries are interested to use the results.

An undertaken needs analysis gives an empirical background for the choice of the topics of the training modules and finally two already implemented modules were introduced as a demonstration.

ACKNOWLEDGMENT

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