An international seminar for industrial projects with teamwork training

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Abstract: - The collaboration experiences and results of three seminar editions of the "*Pfalzmetall* European Team-Seminar" will be presented in this paper. The duration of each edition of the seminar is one or even two semester terms and it consists on the cooperation between two national student teams (German and Spanish) in order to study an industrial problem for a German company. The students composed an international team and were in charge of different aspects of a given problem. Trips in both ways between Germany and Spain give opportunity to put in common the work of the groups. The seminar finished with a presentation of the students' work and its results to the company engineers. The plan and organization of the seminar is explained in this paper, followed by a description of the technical work covered for each year.

Key-Words: - Collaboration between universities and industry, engineering in automation and robotics, practice-based education, student mobility, problem based study seminars, communications technologies in engineering education.

1 Introduction

In 1997, a collaboration agreement was founded between the Universidad Politécnica de Valencia (UPV) / Spain and the Technical University of Kaiserslautern (TU-KL) / Germany. Within the scope of this arrangement, cooperation between the Faculty of Computer Science in Valencia and the Faculty of Mechanical Engineering and Process Engineering, Faculty of Produktionsautomatisierung in Kaiserslautern was established. In recent years, a series of students and university lecturers' exchanges based on the ERASMUS-Program [1] inspired this cooperation.

In addition to these exchanges, for diploma thesis development in the case of the students and for seminar lecturing in the case of lecturers, in spring 2003 both task groups arranged a common seminar at Valencia. In this seminar, the research activities were introduced one another and educational and research activities were discussed. In the domain of science research results were changed bilaterally on the field of robot programming, micro-assembly and some other robotics related topics. As an example of common research, nowadays, the Faculty of Produktionsautomatisierung acts in the field of programming of micro-assembling systems with a simulation and programming software, *VirtualRobot Simulator* [2], developed by Faculty of Computer Science in Valencia. In doing so, the purpose is to enhance the system for the field of micro-system technology and to initiate a common EU-project for that topic on the long run.

Two years ago, *Pfalzmetall*, the institution *Verband der pfälzischen Metall- und Elektroindustrie*, an association for the promotion of the metal and electrical industries in the German region of Rhineland-Palatinate, decided to found educational activities of the Department of Mechanical Engineering in Kaiserslautern in order to improve the formation of future engineers. In this way, an agreement was established with the Institute for Production Automation, Kaiserslautern University of Technology, in order to promote international, practical and industrial oriented seminars to be reached as part of the academic formation and education of the mechanical and electrical engineering studies.

Taking the best of this opportunity, during the first semester of the 2004-05 academic course, the alliance between the faculties of both universities, Faculty of Computer Science of UPV and Institute for Production Automation of TU-KL, was extended with a new educational seminar in collaboration, entitled "*Pfalzmetall* European Team-Seminar". The objective of this innovative seminar

consisted on the development of a multi-disciplinal and international activity between different teams formed in diverse EU countries. The seminar was designed to consider practical lecturing in similar but complementary topics within robotics and automation, in order to develop a specific project oriented to industry.

For project development and task managing, the groups have to organize themselves. Thus, one of the groups firstly receives the task, specified in different possible forms according to the case (data sheets, drawings, quantitative information …). This team will be in charge to (a) make a first draft analysis of the problem, (b) consider the division of the task in several partial subprojects which afterwards can be worked on by single seminar teams and (c) explain the subproject of the other team in a first meeting. Parallel to the structure of the work, a project manager has to be elected in every group who is responsible to coordinate the works of the seminar teams and maintains the contact as well as the data exchange with the foreign group. The communication between both groups occurs via internet and email, with English as the official language, even considering that according to language knowledge of students, Spanish or German languages could also be used.

Therefore, in this educational seminar, aspects such as internationality, complementarity's background discipline, teamwork mutual aid and communication, as well as industrial applications are dealt with, considering situations more realistic every day, as they occur in industrial world, mainly in multinational enterprises.

The teaching seminar described in this paper implies the development of an educational activity in the field of active teaching through collaborative works between international institutions. During the last years, in the Faculty of Computer Science of Valencia, some experiences in this field of innovative teaching methodologies have been carried out. These experiences are included in the progress of adaptation to the European Higher Education Area, according to the Bologna Process [3]. In this context, educational initiatives including *active teaching* [4] have being developed.

After this introduction, in the rest of this paper, the experience of the first three years of this collaboration will be introduced. First, the global seminar planning with its main stages is explained. Then, the specific aspects of industrial problems of the three seminar editions are described. Finally, conclusions of the experiences with future work will be stated.

2 Seminar planning

The seminars have been scheduled in a similar way for all the editions, with four stages:

2.1 Project definition

Every seminar started in the first week of a winter semester in Germany (that is, October). The German team contacted a company and studied a practical problem, preparing its analysis. In an introductory presentation, the basics of the handling, transportation and storage technology are given which are necessary to cope with the task. The German students receive a task in the form of data sheets, drawings, product examples and quantitative information about the production line to be planned. In a visit to the partner company the actual state of the production line and the project purposes are clarified. In this step, the whole task was divided into single partial subprojects, which afterwards were assigned to single seminar teams. The requirements of every single working package were defined. The teaching staff involved in the seminar organized the students into seminar teams. Several visits to the company partner have been done by the German team. During the following three weeks, the students created a rough-cut planning of the production line. The purpose of these first period consisted of defining the boundary conditions for the planning of the assembly line and for the assembly workstations, so that the Spanish group can receive an exact description of the problems.

2.2 Start meeting (Valencia)

A visit of the German team to Valencia is then organized (Fig. 1) in order to present and explain the problem to the Spanish team. In this meeting, the German group presents the task, the planned layout of the production line and the boundary conditions for the configuration of the assembly line. The global task was analysed and partial tasks were detailed. The Spanish group analyses these boundary conditions and develops a rough-cut planning of the assembly line together with the German students. Besides, the layout of the production line provided by the German group is verified and the integration of the assembly cells is discussed in the measures and conditions.

Fig. 1. Students and lecturers during a meeting in Valencia (November 2005)

2.3 Project development

After this meeting, both teams worked parallel on their topics during a semester. The Spanish group developed a simulation of the assembly line. The purpose of this simulation is to verify the feasibility and the measures of the assembly line. The German group carried out a fine planning of the plant with which storage and buffer dimensions are optimized and at last specifications are provided for the single plant components. In addition, a student was named in each group as project manager, who was responsible for work coordination and data exchange. The communication between both groups occurred via internet and email. The official language was English, but some Spanish students did speak German and vice versa. Data management and communication between student groups are supported, as a novelty for the third edition of the seminar, with a learning course management system (CMS), which allows lecturers and students to do file-transfer, chat communication, date fixing, deadline definition, etcetera.

2.4 Final presentation (Kaiserslautern)

The seminar finished with the visit of the Spanish team to Kaiserslautern. The last step in the seminar was the integration of the work done by both teams and the presentation of the final results to the company. Thereby a presentation of the results had been worked out in a first meeting at the university (Fig. 2). The next day, a visit to the factory is organized, giving to the Spanish students the opportunity to learn more about the company and its other production lines. During a meeting at the partner company, both groups performed a presentation of their work to the personnel involved in the collaboration project. A discussion with participation of the engineers of the company, the tutors from both universities and the students puts the end to the technical part of project, extended usually with a social event for cultural interchange.

Fig. 2. Students Preparing the Presentation in Kaiserslautern (February 2006)

3 Industrial Problems of Seminars

In this section, the specific aspects for project development of each of the three seminar editions are described.

3.1 First Seminar Edition (2004/2005)

The first seminar ran along the first semester of the course 2004-05 [5]. Thirteen students, from the mechanical and electronic engineering studies, formed the German team, headed by Professor Detlef Zühlke and three assistant professors. The Spanish team consisted of six students from subjects of Robotics and Computer Aided Engineering of the computer science engineering studies, with two associated professors participating as tutors. Both teams, with different specializations, developed their work through a semester, investigating, realizing and solving a specific problem given by a company. The work, coordinated by the tutors, was exposed finally to the company engineers with a presentation in conjunction of the work done in the project. Then, team collaboration and coordination was a key aspect for seminar success.

The first year, the project was developed for the German company Sensus Metering Systems GMBH Ludwigshafen (www.sensus.com). This company manufactures metering systems for fluids as water meters. The meters, according to their types, are tested in a quality control line (Fig. 3) where they are assembled and then checked using laser sensors. The assembly in this line is made manually and sixteen meters are linked in a serial way to test that they work, that is, measure correctly. A cap with a serial number is put to all the meters that work within the operating limits. The print of the number in the cap is made in some other part of the factory. The serial number is useful to refer to the test results in case of future reclamations.

Fig. 3. Quality control line in Sensus factory

The objective of the project was the analysis of this quality control line for water meters and the study and planning of possibilities to show the company the viability of the optimisation and automation of the labelled and assembly processes. In detail, two features must be considered in the project: the integration of the number printing in the quality control line and the robot based assembly of the water meter.

The seminar finished on February 2005 with the visit of the Spanish team to Kaiserslautern and the presentation of the results in the partner company Sensus. A final discussion finished the project work, followed by an evening social event, with both teams and engineers from the company having traditional food from the region.

Fig. 4. Presentation to Sensus engineers made jointly by German and Spanish Students

3.2 Second Seminar Edition (2005/2006)

The project of the second seminar [6] was the planning of a new production line for seat chassis. The partner company for this year was Keiper (www.keiper.de), a vehicle seating system developer. Keiper develops and manufactures advanced metal seat components and structures for the most important automotive industry suppliers and manufacturers (Mercedes, BMW, Audi, etc.). Keiper has several assembly lines for seat chassis, topic in which the project was focussed in. In fact, the project was defined on the new Keiper assembly line for seats chassis for the new E class Mercedes. The engineers of the company provided all the necessary specifications of the product and the assembly line in order to use actual data in the project.

Students from the Kaiserslautern and Valencia were working in this project together. The German group had to design the new assembly line. This part included, for example, the choice of suitable transport systems, the necessary calculation of the material flow as well as the finishing issue of the system specification. The objectives to cover with this study were:

- The avoidance of transfer cars
- The integration of workstations across the main line driveway without any crossing
- The reduction of the cycle time
- The reduction and control of circulation stock
- The improvement of material flow.

Two versions were developed and compared considering process flexibility as well as investment costs, in order to propose the company engineers two different possible solutions. The results of the best solutions are summarized in:

- Restriction of the assembly process to inner area
- Segmentation of the assembly process
- Improved flow of material due to the implementation of an automatic transport system
- Reduction of the circulation stock to approx. 1/6
- Optimised working conditions
- Whole assembly area is clearly structured.

A third alternative was studied by the Spanish group. In this case, the assembly line was based on the use of a ‘Power & Free’ transport system to the assembly workstations, as shown on Fig. 5. To study this case, the Spanish group worked on two 3D animations in order to show:

- The workflow and transport system of the assembly line
- The verification of the assembly cells for operators (Fig. 6). This animation confirmed that the work places measures are feasible, and that

workers have a comfortable and useful place to work.

Therefore, the animation showed the task development of workers and the assembly line process. The simulation software used was *VirtualRobot Simulator* [7], which is known in both Universities.

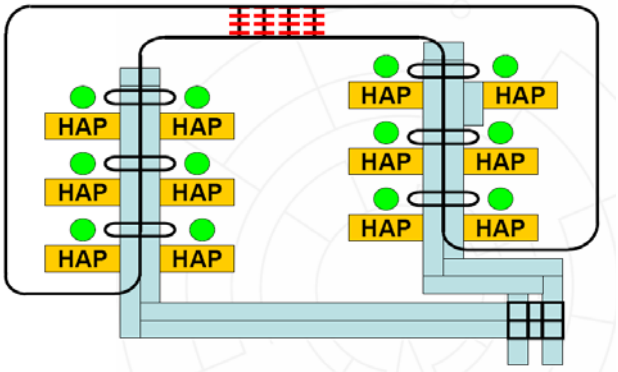

Fig. 5. Design Concept of the Power & Free Based Assembly Line

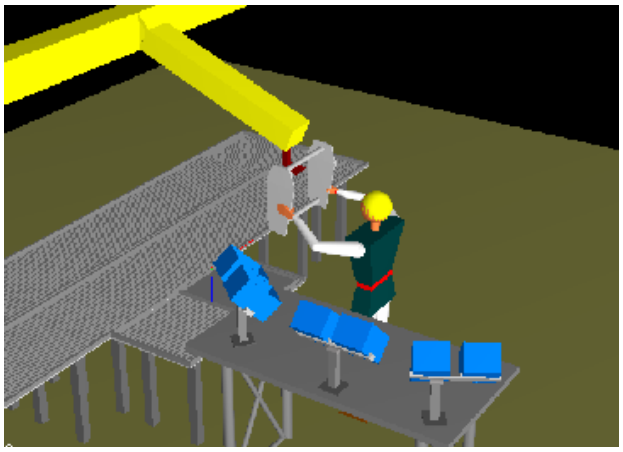

Fig. 6. Simulation of the Assembly Workstation

3.3 Third Seminar Edition (2006/2007)

The subject of the team-seminar is the optimization of a production line for telescopic mobile cranes. The partner company Terex-Demag has provided all the necessary specifications of the product and the assembly line. The German group has to redesign the assembly line: this includes for example the choice of suitable transport systems, the optimization of the material flow as well as the finishing issue of the system specification. The Spanish group will do a simulation in order to compare different solutions developed by the German students. Therefore, the field of responsibility for the working team is on three main topics: the optimization of material flow, the organization of storing and the assembling of the cranes, including the simulation of the line in order to verify the suitability of the solution.

The first analysis of the actual situation in the company gives as main features the following ones:

- Miscellaneous type of telescopic cranes at the same assembly line
- Customer-specific product design
- Cycle time of 11.5 hours
- Picking of component parts
- Little used high rack storage area

The main issues to be covered in this project deal with:

- Inefficient division into compartments
- Insufficient assembly structures
- Individual requests lead to delays
- Numerous assembly delays due to missing parts
- Unreliable picking
- Non-uniform refill system for small parts
- Circumstantial material flow
- Cabin-sub-assembly not sensibly integrated in material flow
- Number of employees at stations not optimally adapted to assembly times
- At reworking employees get removed from stations
- No precise responsibility assignments
- Documentation of assembly progress merely verbal until now

This seminar is still on progress, but it will be concluded for the Conference, because it will finish at the end of the second semester term (May 2007) with the visit of the Spanish team to Kaiserslautern and the presentation to the company engineers involved in the project.

The activity is involving 12 German students and 5 Spanish ones, with five lecturers acting as tutors.

4 Conclusion

The collaboration experiences and results of three seminar editions of the "*Pfalzmetall* European Team-Seminar" have been presented in this paper. The experiences consist on practice-based education seminars including student mobility in automation engineering, as described in the paper body. Mainly, the seminar consists in the cooperation between two national student teams (from Germany and Spain) to study, analyse and work out an industrial problem of a German company. The subject is different for each year, covering companies manufacturing water measurement equipments, seat chassis and mobile cranes, but is always around the optimization of production line at the companies. A

web site (http://robotica.isa.upv.es/eutor) is used to disseminate the seminars.

In fact, in these seminars, the involved students have faced situations with design and analysis of real automation applications, in addition to get use of developing work in international teams, with the obvious implicit advantages. The activity has involved in three years a total of 38 German students and 16 Spanish ones, giving a total of 54 students and seven lecturers acting as tutors.

From the point of view of an educational activity, the students have benefited of an innovative training methodology, quite different from the traditional education, with the opportunity to profit of a closer vision to industrial problems and company points of view. In addition, some other aspects have been pushed, such as internationality, group working, cooperation of diverse engineer disciplines, the use of a learning course management systems for communication, etcetera.

After three successful experiences, funding to European Community has been asked in order to become an Intensive Program for nest year with participation of a new university partner from another country.

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