Abstract - The collaboration experiences and the results of the second “Pfalzmetall European Teamseminar” will be presented in this paper. The duration of the project is one semester term and it consists of the cooperation between two national student teams (German and Spanish) and a German company in order to study an industrial problem. The students composed an international team and were in charge of different aspects of the given problem. The project finished with a presentation of the students’ work and its results to the company engineers. The subject of the seminar was the planning of a new production line for seats chassis. The partner company Keiper has provided all the necessary specifications of the product and the assembly line. The German group had to design the assembly line. The Spanish group did a 3D animation in order to show the workflow of the assembly line.

Index Terms - Collaboration between universities and industry, engineering in automation and robotics, practice-based education, student mobility.

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 projects 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 project in collaboration, entitled “Pfalzmetall European Teamseminar”. The objective of this innovative project consisted on the development of a multi-disciplinary and international activity between different teams formed in diverse EU countries. The project was designed to consider practical lecturing in similar but complementary topics within robotics and automation, in order to develop a specific work 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 project 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 project 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 project, 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 project 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 two years of this collaboration will be introduced. First, the experience of the first year, which was published in ICEE 2005 conference [5], will be summarized. Then, the development during the current academic course will be explained with more details. Finally, conclusions of both experiences will be stated.

**PREVIOUS EXPERIENCE**

For the first year, during the first semester of 2004-05 course, two teams were considered, one from TU-KL and one from UPV. 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 conjuction of the work done in the project. Then, team collaboration and coordination was a key aspect for project 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 (Figure 1) 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.

The teaching project 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 two years of this collaboration will be introduced. First, the experience of the first year, which was published in ICEE 2005 conference [5], will be summarized. Then, the development during the current academic course will be explained with more details. Finally, conclusions of both experiences will be stated.

**PREVIOUS EXPERIENCE**

For the first year, during the first semester of 2004-05 course, two teams were considered, one from TU-KL and one from UPV. 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 conjuction of the work done in the project. Then, team collaboration and coordination was a key aspect for project 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 (Figure 1) 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.

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 project was developed in four steps:

- The German team contacted the industry company and studied the practical problem, preparing its analysis. In this step, the whole task was divided into single partial projects, project teams were built and the dependence of the single working packages was defined. Several visits to the industrial company partner were done.

- A visit of the German team to Valencia was organized in order to present and explain the problem to the Spanish team. In this meeting, the German group presented the task, the planned layout of the production line and the boundary conditions for the configuration of the assembly line. The Spanish group analyzed these boundary conditions and developed a rough-cut planning of the assembly together with the German students. Besides, the layout of the production line provided by the German group was verified and the integration of the assembly cells was discussed in the environment of the transport and storage facilities.

- After this meeting, both teams worked in parallel on their topics with strong relationship and communication between them. A web site was implemented for the project to facilitate the intercommunication (http://robotica.isa.upv.es/eutor).

- The project finished on February 2005 with the visit of the Spanish team to Kaiserslautern. The presentation of the results was worked out in a first meeting at the university and presented during the following day 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.
**PROJECT DESCRIPTION**

The collaboration experience and the results of the second “Pfalzmetall European Teamseminar” is presented in this section. The duration of the project was one semester term and it consisted of 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 the given problem. The project finished with a presentation of the students’ work and its results to the company engineers.

The subject of the second “Pfalzmetall European Teamseminar” was the planning of a new production line for seat chassis. The partner company for this year was Keiper (http://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 University of Technology (TU-KL) and from the Universidad Politécnica de Valencia (UPV) 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 the 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. Figure 2 shows an example of material flow study. 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 Figure 3. 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, as shown on Figure 4
- The verification of the assembly cells for operators (Figure 5). 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 [6], which is known in both Universities.

---

**FIGURE 2**

**MATERIAL FLOW STUDY**

**FIGURE 3**

**DESIGN CONCEPT OF THE POWER & FREE BASED ASSEMBLY LINE**
The collaboration project was scheduled in a similar way to the previous year experience, with four stages:

I. Project Definition

The seminar started in the first week of the winter semester in Germany, October 2005. The German team contacted the company and studied the 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 the 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 projects, which afterwards were assigned to single project teams. The requirements of every single working package were defined. The teaching staff involved in the project organized the students into project 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.

II. Meeting in Valencia

A visit of the German team to Valencia in November 2005 was organized (Figure 6) 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.

III. Project Development in Parallel

After this meeting, both teams worked parallel on their topics. 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. The web site (http://robotica.isa.upv.es/eutor) was updated for this year project in order to facilitate the intercommunication.
**IV. Project Results Presentation in Kaiserslautern**

The project finished at the end of the semester term (February 2006) with the visit of the Spanish team to Kaiserslautern. The last step in the project was the integration of the work done by both teams and the presentation of the final results to the company Keiper. Thereby a presentation of the results had been worked out in a first meeting at the university (Figure 7). The next day, a visit to the factory of Keiper was organized (Figure 8), 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 (Figure 9). 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 that evening with a social event for cultural interchange.

The activity involved 8 German students and 4 Spanish ones, with five lecturers acting as tutors (the authors of this paper). The project provided the opportunity for the exchange of cultural aspects between the teams, as shown in Figure 10.

**FIGURE 7**
The Students Preparing the Presentation in Kaiserslautern

**FIGURE 8**
The Visit to Keiper Company Facilities

**FIGURE 9**
The Presentation of Project Results in the Company

**FIGURE 10**
Social Activities Occurred in Both Countries

**CONCLUSIONS**

An experience consisting on a practice-based education project including student mobility in automation engineering has been described in the paper body. Mainly, the project consists in the cooperation between two national student teams (from Germany and Spain) and a German company to study, analyse and work out an industrial problem of the company. The subject deals with a production line at the company for seat chassis assembly.

In this project, 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 8 German students and 4 Spanish ones, with five 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 real industrial and company problems and points of view. In addition, some other aspects have been pushed, such as internationality, group working, cooperation of diverse engineer disciplines, etcetera.
After two successful experiences, there is an intention to organize the same kind of project for next year and some work is in progress to search for a new sponsor company.

**ACKNOWLEDGEMENTS**

In addition to particular funding from both Universities, this project has been partially funded by the German institution *Verband der pfälzischen Metall- und Elektroindustrie*. The authors also want to thank Keiper and its personnel for the help to develop this project.

**REFERENCES**


