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Development of a multifunctional robotic arm for in-pipe robots

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***Abstract*— The paper presents the development of an multifunctional robotic arm with application for in-pipe rehabilitation and maintenance activities. The robotic arm is the result of one semester work developed in 2015 International Cooperation Project by a multinational students research teams. In the paper the design process and performance evaluation of the proposed solution is presented.**

Keywords— project-based learning; multifunctional robotic arm; in pipe inspection robot

I. INTRODUCTION

The global dynamics in engineering puts pressure on the engineering education programs which are forced to continuously adapt and apply new learning techniques in order to keep up with these changes. The learning programs must provide training in critical and creative thinking skills and problem-solving methods by focusing more on teaching about *real-world* engineering design and operations [1]. In the same time students should be involved in activities that could offer better oral and written communication skills and teamwork abilities [2].

A direction for fulfilling these needs is to develop project-based learning (PBL) in collaboration with the industry. In this paper such an example is presented. The project aimed to involve international teams of students and academic staff in solving a real life problem proposed by an industrial partner. The International Cooperation Project (ICP) is developed as part of the Erasmus - Knowledge Alliances project with the title Reshaped Partnerships for Competitiveness and Innovation Potential in Mechanical Engineering (RePCI) [3]. The RePCI project aims to reshape the collaboration between universities and companies based on a set of novelty factors that will help creating goal oriented and strategic managed collaboration approaches between the two entities [4].

In this context the ICP approach helps creating new opportunities concerning the collaboration activities booth for the company and universities. This framework offers an advantage both to company, by gaining new fresh ideas for their industrial challenges, and universities, by involving academic staff and students in activities that facilitate direct contact with real industrial environment and practice-relevant projects. The project topic and the company partner are chosen by the universities from a list of proposed topics from different industrial partners. After setting the project topic, each university organizes a selection for the participant students. In the 2014 ICP seven Romanian and seven German students were selected to participate in the project. In order to cover the multidisciplinary project theme, the students were selected from different Bachelor programs: Mechanical Engineering, Mechatronics and Business Engineering.

The ICP covers one semester and during this period two intensive weeks are organized at the location of the two university partners. The first intensive week was organized from 22 to 26 September 2014 at TUCLUJ and the second intensive week was organized from 27 to 31 October 2014 at HE.

During the intensive weeks, a mix of teaching, project work, evaluation and cultural activities were planned. The particularities of intensive weeks are:

- the students conducted independent work to gather necessary information for their project, participating actively in learning process;
- within the teams, learning communities were developed, combining the information university partners have;
- the students communicated in English and had to cooperate and tolerate other opinions;
- the project teams benefited of the opportunity to see in practice and collect experiences in robotics, as well as to concentrate on modern technology.

Between the two intensive weeks as well as after the second intensive week the students worked independently under the supervision of Romanian and German teachers. The communication between team members was conducted using emails and video conferences. At the end of the each week the teams prepared a report with the project evolution during that time. At the end of the semester a final presentation was organized in 9 December 2014. The German and Romanian students presented the project results in a videoconference meeting. At the presentation the company representative and the supervisors from TUCLUJ and HE were present. After the final presentation the project results from both groups were analyzed and assessed by the university and company supervisors and the winner team was selected.

At the end of each intensive week and after the final presentation the students were asked to answer questionnaires regarding the activities from the ICP Project. The results are used to continuously improve