

APPROACH ON THE DEVELOPMENT OF ENGINEERING SKILLS IN INDUSTRIAL ROBOTS PROGRAMMING AND OPERATING

MERTICARU Vasile¹, RIPANU Marius-Ionut¹, NAGIT Gheorghe¹

¹"Gheorghe Asachi" Technical University of Iași

email: v_merticaru_jr@yahoo.com, ripanumariusionut@yahoo.com, nagit@tuiasi.ro

Keywords: industrial robots programming, engineering education, learning outcomes, human resource.

Abstract: The paper presents an approach and the related efforts performed within a Romanian HEI (Higher Education Institution), in the direction of skills development in industrial robots programming for industrial engineering graduates, in order to meet the exigencies of some particular important regional employers from the NER (North East Region) of Romania. A particular application of industrial robot modeling, simulation, programming and operating, designated for educational purposes, is also presented and discussed in the paper.

1. INTRODUCTION. PROBLEM STATEMENT AND APPROACH OUTLINES

The paper presents an approach and the related efforts performed within a Romanian HEI (Higher Education Institution), in the direction of skills development in industrial robots programming for industrial engineering graduates, in order to meet the exigencies of some particular important regional employers from the NER (North East Region) of Romania.

The presented approach is based on a clear identification and synthesis of the present realities in Romanian higher education and particularly in the engineering education, seen from the perspective of European integration and alignment in the process for the establishment of the EQF (European Qualifications Frame) in the EHEA (European Higher Education Area) – as part of lifelong learning.

Some efforts and some results obtained in this direction, particularly for responding to the demands of a new important regional industrial employer, performing highly technological productive activities and demanding high levels of professional qualification, even for execution activities, are presented in the paper.

More explicitly, an educational approach and a range of activities identified as strategic solutions for developing engineering skills in design, selection and exploiting of solutions for technological processes' automation, in integration of industrial robots in flexible manufacturing systems and in modeling, simulation, programming and operating technological processes or operations on industrial robots, are presented.

A particular application of industrial robot modeling, simulation, programming and operating, designated for educational purposes, is also presented and discussed in the paper.

2. APPROACH SUBSTANTIATION

Romanian engineering education have been lately and still are involved in serious efforts for improving the development of graduating engineering human resource and for improving the national and the European market employability of Romanian engineering graduates. In this sense, an improved harmonization of the learning outcomes with the demands of the employers from the labour market and, not at last, the European wide recognition of the delivered qualifications are permanently targeted.

Within this general trend, the alignment to the demands of the Bologna Process, to the terms and stipulations of the Work Programme of BFUG (Bologna Follow-Up Group) [3] and to those of the European Parliament regarding the establishment of the EQF (European Qualifications Frame) in the EHEA (European Higher Education Area) [6] – as part of lifelong learning - is a present imperative.

The national project DOCIS, [2], initiated, promoted and developed by ACPART - a Romanian empowered governmental agency which is responsible with the qualifications redefining process in the Romanian Higher Education and with the partnerships with the economic and social environment – is a very important action to be mentioned within the above presented efforts. The main author of the paper participates in this project as a national expert, being responsible with describing the qualifications for the second cycle programme – master degree – entitled “Robotics in Welding Processes” and for the first cycle programme – bachelor degree – entitled “Welding Engineering” and in such quality supports and aligns himself to the efforts of bringing together specialists from Romanian empowered governmental agencies, from Romanian HEIs (Higher Education Institutions), from important Romanian industrials, research institutions or other companies as employers and from professional organizations to actively participate in the compulsory process of elaboration of the National Qualification Frame for Higher Education, until the end of the year 2010.

From another point of view, particularly in the North East Region of Romania but also at entire national level, there exist real perspectives, in the next period of time, for the development of manufacturing engineering as profession and occupation. For achieving success in this direction, better developed skills and performance for human resource are compulsory conditions.

National statistics, [4], show relatively encouraging trends in the sense of the need for effective development of manufacturing engineering education for the North East Region of Romania, as following:

- The most important gross investment in the last couple of years has been done, in the North East Region of Romania, in manufacturing industry.
- In the manufacturing industry and in the services, the SMEs (Small and Medium Enterprises) hold definitely the majority in the total of active companies.
- Machining operators and manufacturing engineers are currently nominated as relevant occupations in the offers for employment of many companies.
- The increase of the number of unemployed persons on the labour market has as possible cause some mismatches between the exigencies of the employers and the skills of the unemployed human resource.
- The rate of substitution is super-unitary, being nominated a value of 1.35, which indicates, for the next period an increased pressure on the labour market of the young graduated engineers.
- The weight of population having high level of qualification is needed to increase.
- Higher education at first cycle level – bachelor degree - trends to become a mass feature, which otherwise is desirable in our modern society, highly technological and demanding higher levels of professional qualification, even for execution activities.
- Educational programmes for manufacturing engineering qualifications must be aligned to the demands of social and economical development of the North East Region of Romania.

Another important trend that cannot be neglected is that in the economical landscape of North East Region of Romania and not only, former traditional great manufacturing enterprises have been replaced and still are replaced by SMEs and by subsidiaries of important global companies, bringing new technical and technological demands.

Within this general frame, Delphi Romania, which has other two plants in Romania — two electrical/electronic architecture plants located in Sannicolau Mare and Ineu, trends to become an important participant in the economy of North East Region of Romania, by opening, since 2008, one diesel plant in Iasi, which is expected to employ a team of more

than 1,000 employees, [5], since Iasi County offers a good environment for new business to grow.

The new DDS-R (Delphi Diesel Systems Romania) plant of Iasi produces common rail diesel pumps and injectors and the involved technologies give for employees important opportunities to work with advanced techniques in precise machining and assembly. For being able to successfully operate on a just-in-time basis, DDS-R plant of Iasi as organization must base on dynamic, qualified, and dedicated employees, empowering and encouraging them to strive for excellence in their work environment. For achieving this objective, DDS-R plant of Iasi is looking for top level employing candidates with high technological qualification, specifically listed in the local recruitment portals of the company.

In such conditions, there is obvious that DDS-R plant of Iasi seeks to attract fresh graduates from local and regional technical universities, also developing important efforts for adjusting the professional skills of fresh employed human resource through internal intensive training programs. As a consequence of its needs, DDS-R plant of Iasi have established a strong and long term relationship with "Gheorghe Asachi" Technical University of Iasi, developing a permanent recruiting program for graduates of engineering education programmes. More than that, the company also collaborates with technical high-schools in Iasi, where their undergraduate operators are coming from.

3. APPROACH DESCRIPTION

Starting from the above presented considerations and particularly taking advantage of the wide range of career development opportunities offered by companies like DDS-R plant of Iasi for graduates of manufacturing engineering education programmes, in order to meet the exigencies of such particular important regional employers from the NER (North East Region) of Romania, important efforts have been developed and continue to be developed also in the Faculty of Machine Manufacturing Technology and Industrial Management from "Gheorghe Asachi" Technical University of Iasi in the direction of developing, for its graduates, engineering skills in design, selection and exploiting of solutions for technological processes' automation, in integration of industrial robots in flexible manufacturing systems and in modeling, simulation, programming and operating technological processes or operations on industrial robots.

The efforts of the above nominated HEI (Higher Education Institution) stand under the compulsory need of performing in a hardly competing academic environment and target an appropriate professional development of the students, considering that the main purpose of higher education in manufacturing engineering is to provide adequate competencies to the graduates in order to assure their later performance and professional independence.

More explicitly, the educational development approach have targeted the clear identification and analysis of the need for qualified engineering human resources in the regional area and especially at representative employers such as DDS-R plant of Iasi, followed by the investigation and registration of particular competencies and professional skills demanded for graduated manufacturing engineers at employing moment. Further on, a range of activities identified as strategic solutions for developing adequate engineering skills to fresh graduates have been identified and started to be applied.

4. STRATEGIC SOLUTIONS FOR DEVELOPING ENGINEERING SKILLS IN INDUSTRIAL ROBOTS PROGRAMMING AND OPERATING

Further on, the paper presents a particular, but able to be generalized, set of initiatives and activities considered to represent strategic solutions designated for developing engineering skills in industrial robots programming and operating within engineering education in Romania and more particularly in the North East Region of Romania.

These initiatives and activities have been identified to be necessary and useful to be associated with the three key factors involved in the technical education process, factors presented in the model from Fig. 1, which has been built starting from a much more complex model illustrating the system of relationships for an IEE (Institution of Engineering Education) with its customers and stakeholders, [7].

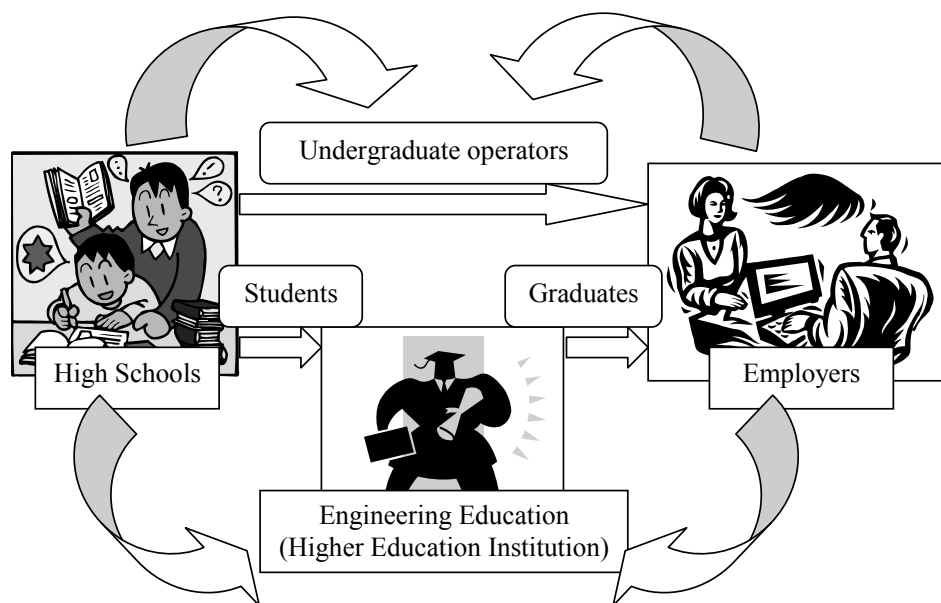


Fig. 1. Triangle of key factors in the technical educational process

As a first very important initiative, there has been identified as being vital to perform a better management of the relationships between the above nominated Higher Education Institution (HEI) and the other two category of factors considered as main partners and stakeholders, of course taking into account the attributes of acting in the new so named Relationship Age, [7], [8].

In this sense, there has been registered the need of the representatives of the regional employers and of the technical high-schools for a better informing about all the information related to the organization of Manufacturing Engineering educational programmes and all the changes related to them.

A second initiative in the same direction has been to more actively involve the representatives of the regional employers and of the technical high-schools in promoting and supporting the profession of manufacturing engineer and in the actions developed by the HEI for promoting their educational offer in Manufacturing Engineering programmes, for helping in marketing and for branding those programmes, as long as such an educational activity must be approached as an entrepreneurial one, [7], [8].

The following set of activities have been identified as being useful for developing engineering skills in industrial robots programming and operating and also have been partially applied by the Faculty of Machine Manufacturing Technology and Industrial Management from “Gheorghe Asachi” Technical University of Iasi:

▪ Acquisition of a system with multi-functional robot IRB140 and IRC5 controller, shown in Fig. 2, for endowing the Laboratory of Automation and Robotics in Technological Processes.

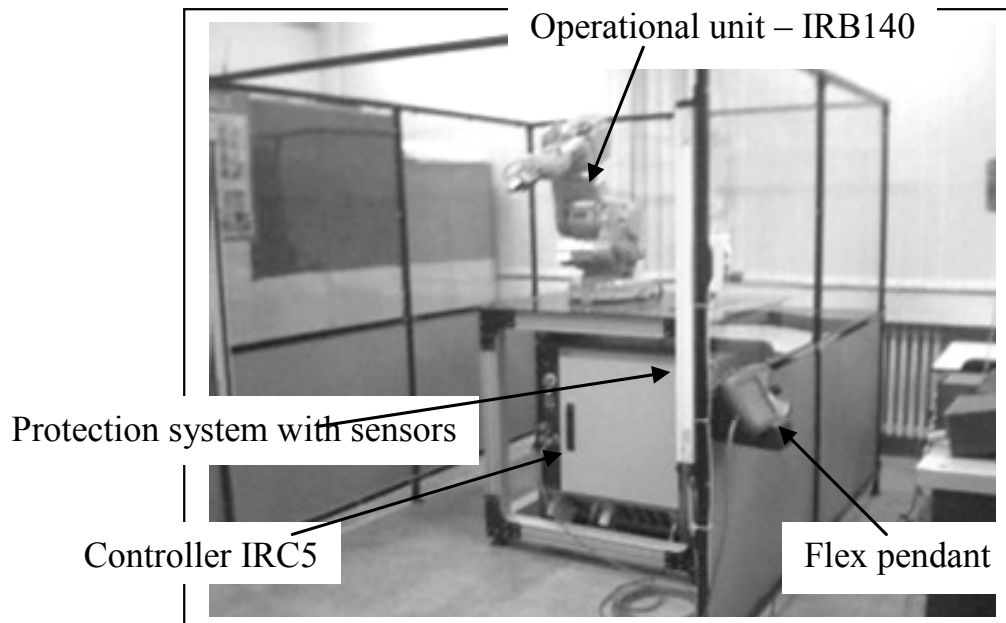


Fig. 2. System of multi-functional robot IRB140 with IRC5 controller

- Providing of RobotStudio 5.12 software for the above mentioned laboratory.
 - Developing educational applications of industrial robot programming and operating.
 - Adapting the educational curricula and teaching subject's syllabus to the demands of the employers regarding the need for skills in industrial robots programming and operating.
 - Organizing of meetings of employers' representatives with students from the second grade, before the procedure of their repartition on specializations, for presenting them the opportunities of the occupations and jobs available in industrial robots programming and operating, for manufacturing engineers, in order to orient better students toward the Manufacturing Engineering programmes;
 - Organizing of meetings of employers' representatives with students from the final grade, for presenting them the employment offer of their companies for manufacturing engineers, the specific activities of their companies and the job positions in industrial robots programming and operating, available for manufacturing engineers.
 - Presentation of some just graduated manufacturing engineers to several companies and discussions with those management representatives for employing them;
 - Maintaining the contact with new employed manufacturing engineers in their first few working years and providing for them technical consulting advisory any time it is asked for;
 - Involving teachers from technical high-schools in specialization, research and life-long learning activities in the area of industrial robots programming and operating.
- Another set of activities, as following, have been identified as being useful to be provided by regional employers, in direct collaboration with HEI, for the students and for the just graduated manufacturing engineers, in order to support their employment and integration in the labour market in the area of industrial robots programming and operating and also their later professional independence and performance:

- Sponsorships awarded by employers to students from the Manufacturing Engineering programmes, for scientific activities such as: research activities within Student Scientific Workshops, publishing in the specialty magazines, participation of students in specialty conferences, participation of students to national and international fairs and exhibitions concerning robotics technologies and equipment;

- Participation of employers' representatives in mentorship programmes organized by HEI for students from 3rd and 4th grades of Manufacturing Engineering programmes, offering industrial practice stages and consulting advisory and collaboration for coordinating the students in the elaboration of their final graduating projects;

- Scholarships and employment offers for mentored students, provided by employers. In this direction, a few such activities and initiatives have already been adopted and partially applied by DDS-R (Delphi Diesel Systems Romania) plant of Iasi, for students and fresh graduated manufacturing engineers coming from the Manufacturing Engineering programme from "Gheorghe Asachi" Technical University of Iasi, respectively as following:

- Presence of DDS-R representatives at each opening festivity at the beginning of academic years.

- Monthly informing campaign within TU Iasi regarding career opportunities in DDS (Delphi Diesel Systems).

- "Open gates" days in DDS-R for students and for teachers.

- Technical workshops organized together with TU Iasi teachers for students in the final grade.

- Scholarships program for selected students or for winners of the organized technical workshops.

- "Fresh Graduate Program" – training program developed at DDS-R, for just graduated manufacturing engineers employed by DDS-R.

Some other initiatives specific for Delphi company policy, applied in other subsidiaries, are intended to be particularized and applied in the future also for DDS-R plant of Iasi, as following:

- Delphi student programs, which include co-operations and internships at Delphi locations around the world. Throughout the experience, selected students will have the real opportunity to enhance both their academic training and personal skills. The components and features of Delphi student programs vary regionally, so they will be particularized for Iasi plant specific.

- Internship positions for students from "Gheorghe Asachi" Technical University of Iasi, in order to develop future potential skilled employees for the company

- Scholarship support for current internship employees with high potential for further growth and development.

Activities like the right above mentioned have been only punctually and occasionally applied, being particular initiatives of some representatives of DDS-R plant of Iasi and of some other employing companies from the North East Region of Romania in co-operation with Faculty of Machine Manufacturing Technology and Industrial Management of Iasi, but they have demonstrated that this can be a way to help young graduated manufacturing engineers, at least at the beginning of their activity as professionals in the field of industrial robots programming and operating.

5. EDUCATIONAL APPLICATION OF INDUSTRIAL ROBOT PROGRAMMING AND OPERATING

A particular application of industrial robot modeling, simulation, programming and operating, designated for educational purposes, is further on presented and discussed in the paper.

The application refers to solving the programming and simulation in virtual environment, using RobotStudio 5.12 software, for a writing operation on the robot system IRB140-IRC5 above presented and existing in the Laboratory of Automation and Robotics in Technological Processes from the Faculty of Machine Manufacturing Technology and Industrial Management of Iasi and then the implementation of the program and operating on the real robot system.

The work-object for the writing operation above mentioned has been a plate with text entity created using SolidEdge as CAD instrument and it is shown in Fig. 3.

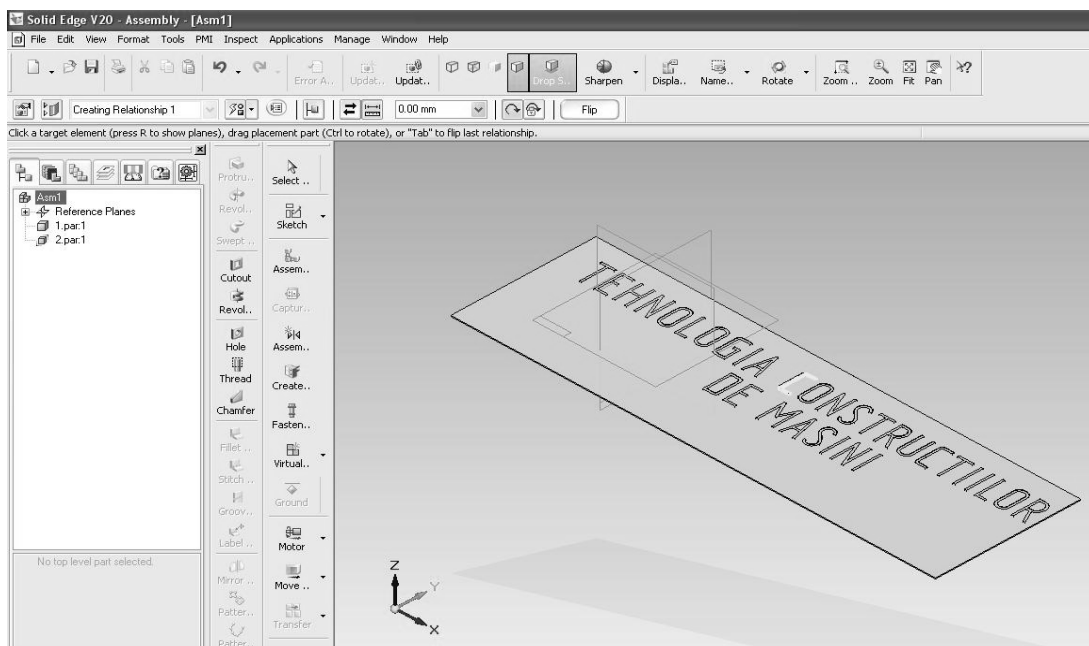


Fig.3. Work-object for the writing operation, created in SolidEdge

The work station created in RobotStudio 5.12 contains the following main components:

- Multifunctional robot IRB140;
- Controller IRC5;
- Pen instrument, imported from the internal tool library existing in RobotStudio.
- Work-object representing the plate with text entity.
- Operator;
- Additional entities: laptop, table.

The created work station is presented in Fig. 4.

After getting through all the steps of the modelling and programming algorithm, the simulation of the writing operation on the virtual controller, in RobotStudio, has been done, as it is illustrated in Fig. 5.

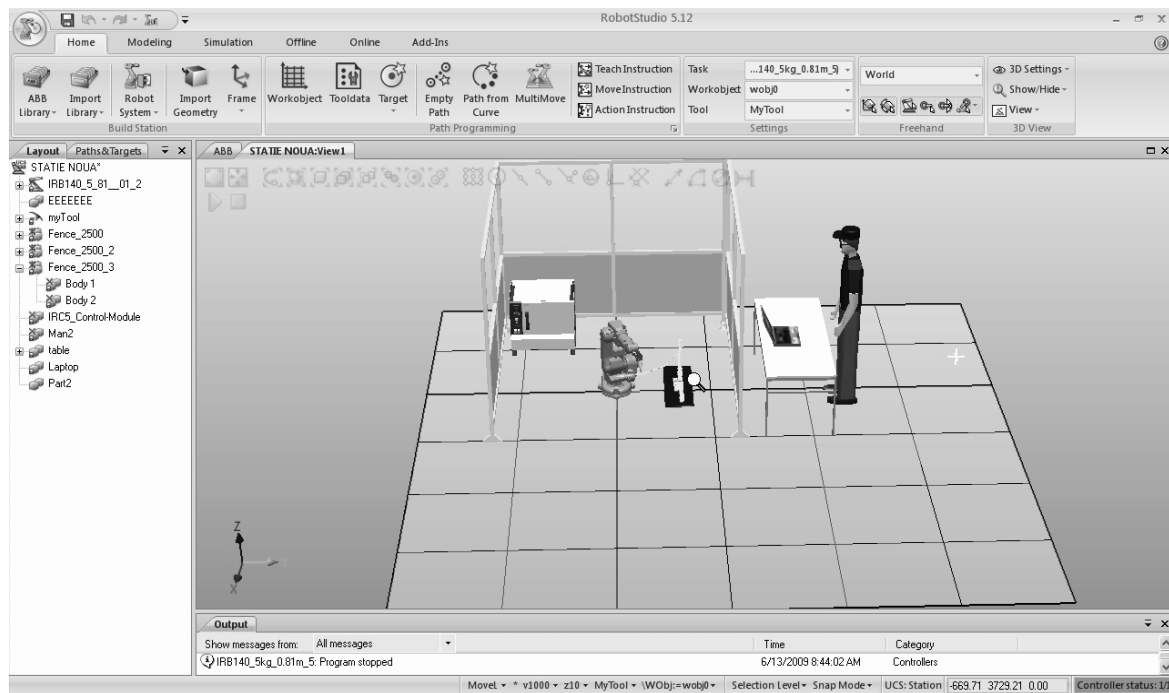


Fig.4. Work-station for the writing operation, created in RobotStudio

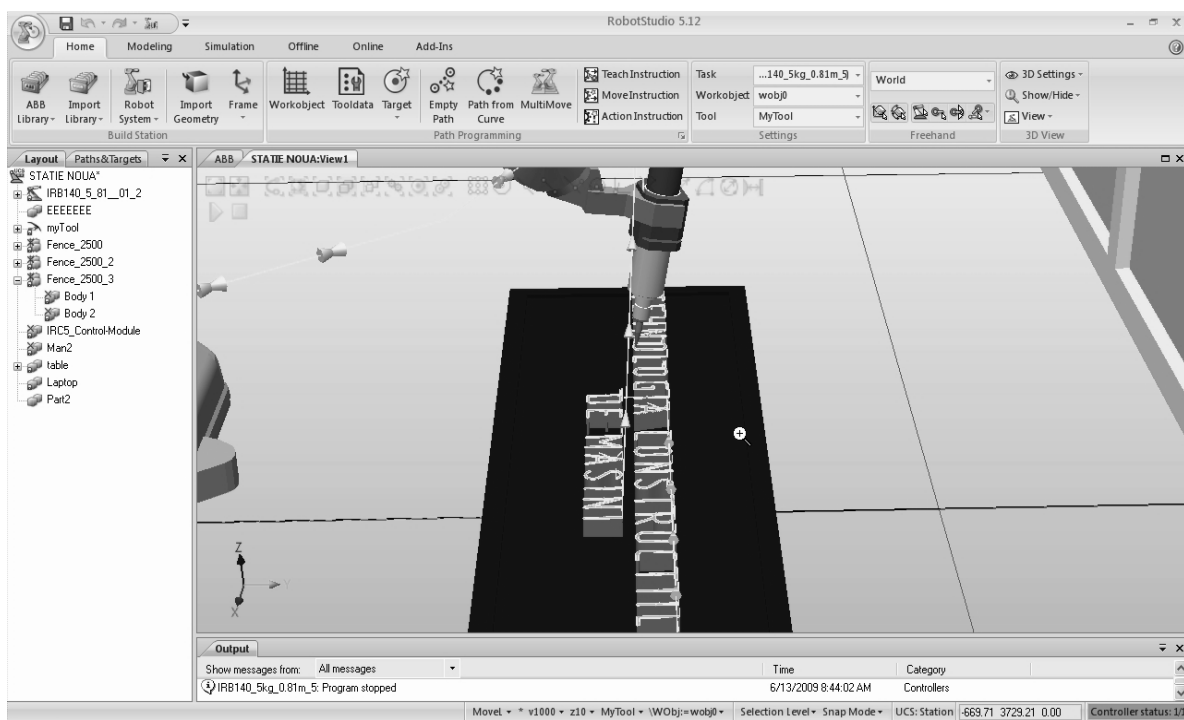


Fig.5. Simulation of the writing operation, created in RobotStudio

When the results of the simulation have become satisfactory and all the problems involved by generating moving paths of the robot final element, following such a complex profile, have been solved in the virtual environment, the final programming application has been implemented and operated on the real robot system from the laboratory. An image of the writing operation on the real robot system is shown in Fig. 6.

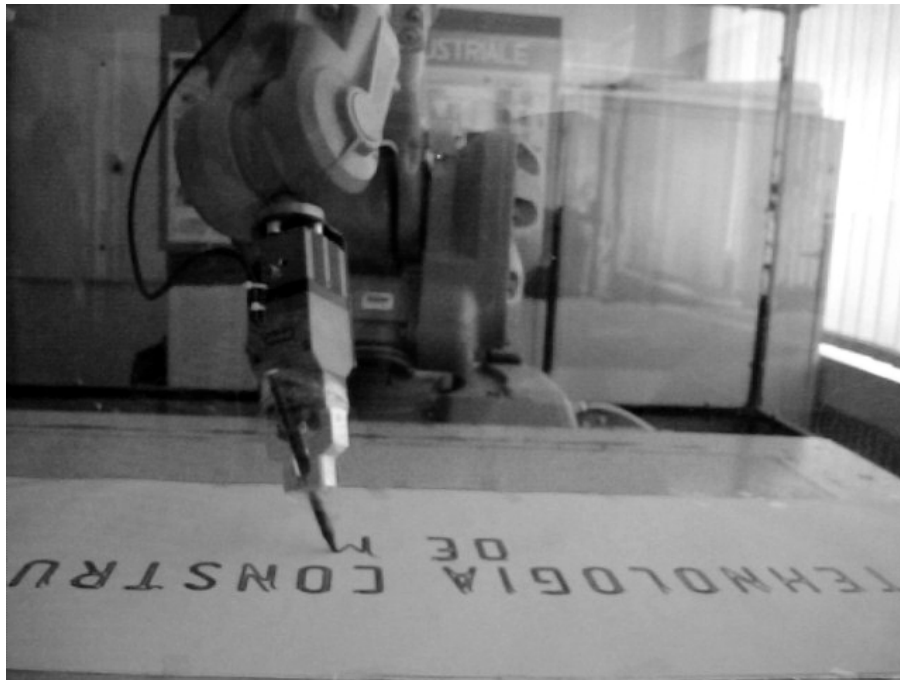


Fig.6. Image of the writing operation on the real robot system

The above presented application has been developed and selected for educational purpose because it is easy to be adapted on the existing robot system and has an important complexity of the profile of work-object, bringing problems to be solved in virtual environment for defining the target points and paths.

This application has been considered as adequate as educational one because it develops for the students professional skills in the following particular activities related to industrial robot modeling, simulation, programming and operating:

- Creating of virtual model for the work station and work process with robot system:
 - Work-object creating in virtual environment;
 - Work station creating in virtual environment;
 - Creating of target points and paths, in virtual environment;
 - Verifying of the tool object position towards the target points;
 - Verifying of reach-ability conditions;
- Simulation of work process in virtual environment:
 - Synchronizing the virtual model with the virtual controller;
 - Collision detection;
 - Simulation testing and validation.
- Implementation of robot programming and operating on real system.

6. CONCLUSIONS

Within the particular circumstances of present social and economical development in the NER of Romania, which show that higher education at first cycle level trends to become more and more a mass feature, there is found that the skills of fresh graduate engineering human resource only partially match the exigencies of the employers, mainly those of important new subsidiaries of powerful multinational industrials. As consequence, the need for aligning the educational programmes for engineering qualifications to the demands of social and economical development of regional labour market and not only, becomes vital.

The above educational approach also evidenced that the premises of efficiently forming engineering skills in industrial robot programming within a virtual environment are based on the following conditions:

- adequate level of technical knowledge for accomplishing the tasks for the main steps in the algorithm of modeling, simulation and programming of industrial robots;
- well established motivation of the students by co-interesting and mentorship in the field of industrial robots programming and operating.

Some malfunctions in such an educational process of skills implementation may be caused by different factors such as:

- still insufficient abilities in the CAD/CAM areas for the students;
- differences between the students individual performance regarding the knowledge level, which lead to difficulties in collaborative activity.

Another important conclusion is that the relation established between students and the teaching or training staff must be a partnership one, each of the parts having to assume the responsibility of accomplishing the learning outcomes. In this sense, the learning outcomes must be explained to the students from the perspective of their relevance for their future professional development.

Finally there can be concluded that all the formative and collaborative features of the above presented approach target to provide the increase of development, creativity and competitiveness for the organizational culture within engineering education in general, but also for the human resource, engineering and research-development departments from productive enterprises.

REFERENCES:

- [1] ABB (2010), *Operating manual RobotStudio 5.12*, available at: [http://www05.abb.com/global/scot/scot352.nsf/veritydisplay/abcbd1fe4256d9a0c125766d003a4706/\\$File/3HAC032104-001_RevB_en.pdf](http://www05.abb.com/global/scot/scot352.nsf/veritydisplay/abcbd1fe4256d9a0c125766d003a4706/$File/3HAC032104-001_RevB_en.pdf), Accessed: 02/02/2010
- [2] ACPART (2009), *DOCIS - Development of an Operational System of Qualifications from the Higher Education in Romania*. Available from: <http://docis.acpart.ro/>, Accessed: 09/09/2009
- [3] Bologna Process (2009). *Communiqué of the Conference of European Ministers Responsible for Higher Education*, Leuven and Louvain-la-Neuve, 28-29 April 2009, Available from: http://www.ond.vlaanderen.be/hogeronderwijs/Bologna/conference/documents/Leuven_Louvain-la-Neuve_Communique_April_2009.pdf. Accessed: 09/09/2009
- [4] C.R. N-E (2008), *Plan Regional de Acțiune pentru Dezvoltarea Învățământului Profesional și Tehnic 2008-2013*, Available from: http://www.adrnordest.ro/index.php?page=REGIONAL_REDAP, Accessed: 02/02/2010.
- [5] Delphi Romania (2010), *Delphi Presence. Career Opportunities*, Available at: <http://delphi.com/careers/international/romania/>, Accessed: 02/02/2010
- [6] European Parliament (2008), *Recommendation of the European Parliament and of the Council, of 23 April 2008, on the Establishment of the European Qualifications Framework for Lifelong Learning*, in *Official Journal of the European Union*, C 111/1, 6.5.2008, pp.1-7, Available from: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:111:0001:0007:EN:PDF>, Accessed: 09/09/2009
- [7] Merticaru, V.jr. & Demirbag-Kaplan, M., (2009), *Some CRM principles and strategies applied in branding an institution of engineering education*. In *Proceedings of The 13th International Conference ModTech 2009 (Modern Technologies, Quality and Innovation - New face of TMCR)*, 21st-23rd May 2009, Iasi, Romania, ISSN 2066-3919, pp. 395-398.
- [8] Nagiț, Gh., Merticaru V. & Iosub A., (2009), *Quality Management as Integrated Part and Strategic Instrument for Branding and Sustainable Development in Technical Higher Education*. In *Proceedings of The International Conference „New Technologies in Manufacturing”-NewTech2009* and in *The Annals of “Dunărea de Jos” University of Galați, Fasc. V, Technologies in machine building*, 2009, ISSN 1221-4566, pp.347-352.