Different ways of education in Industrial Automation

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Abstract
One of the profiles in the ICT Department of Fontys University of Applied Sciences is Technical Information Technology. Within this profile the most important specializations are Embedded Software and Industrial Automation. About half of the Technical Information curriculum consists of learning modules (often lectures combined with small practical assignments). The other half is organized in projects. The whole study lasts four years. After two-and-a-half year students choose a specialization. Before the choice is made students have several occasions in which they learn something about the possible fields of specialization. In the first and second year there are two modules about Industrial Automation. First there is a module on actuators, sensors and interfacing, later a module on production systems. Finally there is one Industrial Automation project. In this project groups of students get the assignment to develop the control for a scale model flexible automation cell or to develop a monitoring system for this cell, that supplies information to the "operators" (directly) and to the "management" (via Internet). In the last year of their studies students participate in a larger Industrial Automation project, often with an assignment from Industry. Here also the possibility exists to join multidisciplinary projects (IPD; integrated product development). In this paper the different ways of education in Industrial Automation and our findings with it will be described in detail.

Keywords: Industrial Automation, Production Systems, projects

1. INTRODUCTION

This paper intends to report on the current practice of Industrial Automation education within the Fontys University of Applied Sciences. It can serve as a working paper, provide others with ideas on comparable courses and generate feedback in order to improve our own courses. Since Autumn 2002 Fontys University has a new independent course; Technical Information. The course was realized in co-operation between the ICT Department and the Electrical Engineering Department. It started with 60 students; now around 40 students are attracted each year. The way this course is developed and has been structured (half of the curriculum consists of learning modules half of projects) has been described in detail in [1]. One of the possible specializations within Technical Information is "Industrial Automation". An overview of courses in Industrial Automation at higher educational level in the Netherlands, often part of courses in (Technical) ICT or Electrical Engineering is given in [2]. The Technical Information course in Eindhoven, including Industrial Automation has been developed in close co-operation with industry, where most of our students will find their future employment. Our students can make their choice for a specialization in Industrial Automation (IA) after two-and-a-half years of study in Technical Information. Before the choice is made students take several educational units in which Industrial Automation plays an important role. In the first class there is a module called "ASI', which is all about actuators, sensors and interfaces. This is a rather traditional module; that is to say it consists of a number of theoretical lectures supported by a number of practical assignments. In the second class we have a module called "Production systems", the base again is a theoretical part and practical assignments. The way it is taught differs from ASI. In the third class, before making the choice for specialization all the students have to take part in an industrial automation project. The second half year of the third class is reserved for internship in industry. The assignments will be in the field of the specialization, chosen by the students. The first half year of the fourth class is devoted to the students' choice. Here a large project, often with assignments from industry, is performed, accompanied by modules in the chosen field. E.g. for IA we have Industrial Vision, Control Theory and Mechatronics. In the last half year of the fourth class, students do a graduation assignment, usually in industry in the field of their choice. In the next sections the module "Production Systems" and the third and fourth class projects will be discussed.

2. EDUCATIONAL MODULE PRODUCTION SYSTEMS

The aim of the module “Production Systems” is to give the students an overview of the different systems that are used within production and especially make them aware of the (technical) information technology that is used in or for these systems. The module consists of a number of somewhat independent learning units. Each unit deals with a specific production system or an important part of that (e.g. Numerical Controlled machines, robots, PLC’s, transporting systems etc.) All units are accompanied by practical and theoretical assignments in which also the skills on information technology have to be used. Within the IA-lab of Technical Information a number of small industrial systems, like PLC’s, desk model milling machine, manipulator and scale model flexible production system are present. As industrial automation is about real systems, not all assignments can be performed in this lab. Therefore for some assignments we can make use of the labs of “Mechatronics” (a co-operation between the Fontys Electrical Engineering and Mechanical Engineering departments. Here the students learn to know Industrial Robots, professional vision equipment and a PLC-controlled soldering machine. Besides, there is one assignment that is performed in a company. At Actemium [3] in Veghel (a town close to Eindhoven) students learn to know a logistical system. Use is made of a PLC controlled transporting and sorting system, developed by the company VanderLande Industries [4], that also develops baggage handling systems for large airports throughout the world. The system is meant as a training system both for students from secondary and higher education and for job training. E.g. mechanics and engineers from VanderLande Industries are trained here.

2.1. Production systems – educational structure

Production systems is one of the modules in the second class. Characteristic is, that no theoretical lectures are offered. The theory is meant to be self-instructional. Our experiences show that this is quite feasible. If parts of the theory are not understood well, the students can apply for a lecture on-demand. If there is enough interest this can be organized. It appears that students seldom make use of this possibility and looking to the scores it is not necessary even. The theory is divided into learning units. Each unit consists of two parts:

- a reference to that parts of theory that has to be studied, accompanied by a number of theoretical questions
- the description of a lab-experiment, related to that theory.

The theoretical questions serve as an aid to understand the theory. Besides, answers can be handed in to be corrected by a teacher. Those students that do this consequently and with sufficient results can already earn points for their exam. Also the questions represent the kind of questions that are put in the written exam. Reasons enough for most of the students to answer the questions on a weekly base.

During the semester each week one part of day (four teaching hours; one morning or one afternoon) is reserved for the module. Each part of day starts with a short explanation of the unit and eventually a discussion on the answers to the questions of last week. Also the reports of the lab-experiments can be discussed. The remaining time (approximately three teaching hours) is used to execute the lab-experiments. In order to be able to execute the lab-experiment properly the related theory should have been studied. The theory is available on the web, sometimes in the form of e-learning (see [5]). There is a total of twelve assignments. Most of the assignments consist of three parts:

- *preparation:* studying manuals and relevant parts of theory. Sometimes some questions have to be answered and handed in before the lab-experiment may start
- *execution:* the actual lab-experiment itself
- *reporting:* from each experiment a (small) report has to be made. Herein should be described how the experiment was executed, what problems have arisen and how they were solved. The students are always encouraged to give suggestions on improving an assignment.

The lab-experiments are carried out in groups of three to four students. As there is no time dependent sequence in the experiments, students can execute the experiments in a circulating schedule. We only have two clusters; one for each quarter of a year.

2.2. Production systems – external assignment

Each semester there is one part of day per group available to perform an assignment with our industrial partner Actemium. The subject of this assignment is controlling a logistical system. An interesting detail is, that the control for this system has been developed with the aid of students from different institutes in higher and secondary education. Also students from Fontys University have taken part in this development. Recently also a process control system has been developed in the same way. The company Actemium, a system integrator, has been co-operating with educational institutes already for a long time. It is regularly involved in projects that aim to develop material and courses for technical education. These projects are also described in [6]. The company attempts to support the courses that are developed by practical assignments on either the logistical system or the process control system. The location of the systems within Actemium is called “Edulab”. A description of this lab can be found in [7]. It is in Dutch but might be interesting for the pictures. The logistical system, called “EdulabXorter” is shown in figure 1.

FIGURE 1. EdulabXorter at Actemium

It consists of a circular transport system on which carriers can circulate. Also an alternative routing is available. The system is controlled by a Siemens-S7 PLC. During the lab experiments students get parts of this PLC-program and have to complete the communication for the systems that route the carriers from one transport belt to the other.

3. THIRD CLASS INDUSTRIAL AUTOMATION PROJECT

The learning module Production Systems is followed by a project on industrial automation. Normally during this project students have to develop a monitoring system for a scale model flexible production cell. At the one hand this monitoring system has to provide operators with information on the state of the production cell (a SCADA-like application), at the other hand the system has to collect data for production statistics that should be available for a manager through the internet. This scale model flexible production system, called “FlexCell” consists of five interconnected units, built with Festo Didactic equipment. [8]. The following units are available: distribution station, testing station, processing station, transporting station and sorting station. The distribution station has a buffer that can be filled up by different types of small cylinders (red, black, plastic and aluminium, all with the same diameter but some with different heights). In the testing station the colour, material and height of a cylinder is determined. Cylinders that are found too high will have to leave the process as garbage, the remaining ones proceed to the processing station where a hole can be drilled in the cylinders. Here also an in-line test is performed; it is traced whether the hole is drilled or not. From here the cylinders are transported to the sorting station, where they will be sorted depending on colour and material. Originally the system was controlled by an obsolete PLC, which has been replaced by a modern version of a B&R PLC. This was done mostly with the help of students that did their fourth class IA project. A picture of the “FlexCell” is given in figure 2.

3.1. Third class industrial automation project – educational structure

As mentioned before this educational unit is carried out as a project. In our view a project means that a group of students (about four) get a problem description. They have to use this to produce a project plan in which we want to find a clear phasing of the project, task division, time schedule etc. Of course this is a form of the old principles of Problem Based Learning (PBL), the way we perform it is highly influenced by the ways described in [9]. For this project the following fixed deliverables are compulsory: URS (user requirements specification), test cases, design, the working program (accompanied by commented code) as well as installation and user manuals. The project is concluded with a presentation and the formal delivery of the programs. Besides each student has to produce individually a learning report with his or her own reflection. This is common for most projects within the course of Technical Information. The project is supervised by two teachers, one has the role of coach, the other plays the role of contractor. A complication for the students is, that the contractor simulates not to be able to speak Dutch, so all communication and documentation has to be done in English. In parallel, supporting lectures in the use of the English language are possible. The contractor requires a management information system for his "factory", making it possible to view production statistics and error logs everywhere in the world by Internet. Besides, an application has to be built, which makes it possible for the operators to see a graphical representation of the factory with the state of the present situation.

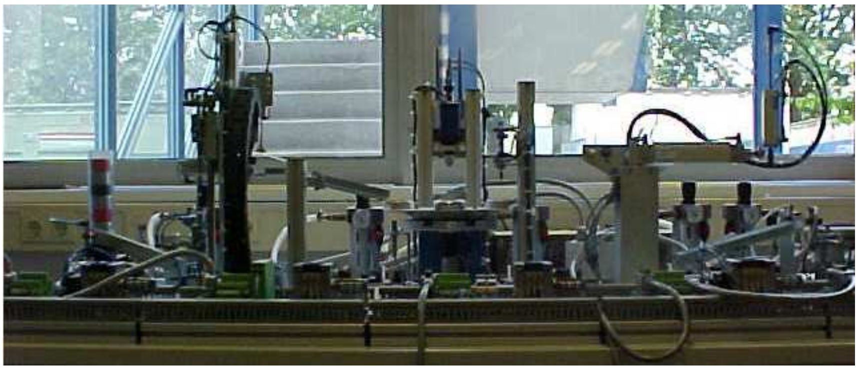

FIGURE 2. FlexCell

In the operators' screen the states of all the sensors and actuators in the system should be presented in a clear way. Also the "Work-in-progress" (products in the cell) should be indicated clearly. It must be possible for the operators to interfere with the process in a simple way and when error situations occur they must have the possibility to input comments in the system. Often two fourth-class students are asked to play the role of operator. This makes it possible for the project group to organize interviews with the operators in order to find out what functionality they want and how information should be displayed. For making the URS the Structured Analysis method of Hatley&Pirbhai [10] is used. To support the documentation and to ensure the correctness of the models the case tool AxiomSys can (still) be used. This tool used to be free available at www.stgcase.com, but is no longer supported. A copy of the software package can be provided by the writer of this paper. For the design, use is made of UML, supported by the case tool TogetherSoft. This tool is now supported by Borland (see e.g. [11]). In order to be able to extract the necessary information from the FlexCell the accompanying program of the control PLC has to be studied and understood. The students can get help from the "operator", as often students, playing the role of operator have performed this project before. The programs have to be developed in C++. As we state that the factory is not always available for testing purposes, the students also have to produce a "stub"; a program that simulates the functionality of the FlexCell. Before the programs are tested with the FlexCell itself they can be tested with the stub. This project lasts a quarter of a year. Within this quarter students have to spend a considerable part of their time on the project.

4. FOURTH CLASS INDUSTRIAL AUTOMATION PROJECT

In the seventh semester (fourth class), right before starting a graduation project, the students of the Technical Information course have to perform a project of half-a-year. This project is preferably, but not always, done together with industry. The contents of the project depend on the chosen specialization, so most projects are either in the field of embedded systems or of industrial automation. Examples of projects in the IA field are:

- an investigation into the possibilities to spray figures on chocolate bonbons,
- the development of a robot against which you can play Yahtzee (popular game with dice)
- an investigation into alternative methods to measure the turbidity of beer etc.

An example of the robot development is shown in figure 3. For the educational structure is the "standard" project way is chosen, however the students get more degrees of freedom in the way they want to perform the project and the aids and tools they want to choose. The fourth-class projects consist of more research aspects. All specializations have supporting learning modules. For IA there is a module about industrial image processing and vision. (This could be applied in the earlier mentioned examples of projects). Also attention is paid to new developments in Industrial Automation. In stead of choosing a specialization project, it is also possible to choose for an IPD-project. IPD stands for Integrated Product Development. In IPD-projects students from different departments come together to do a multidisciplinary project. Assignments usually come from industry and students have to perform either a technology and market search for innovative new products or have to develop a prototype; sometimes both. There have been experiments to let students from secondary technical education (electronic and mechanical engineering) also participate in IPD-projects, but since the funding for this experiment stopped this is only continued on a very small scale. Often students from the at Fontys available (technical) English courses participate. So also here all communication is done in English. (For the "standard" projects companies often ask to make documentation in English as well). In the past many projects have been carried out together with students in institutes abroad; students had to communicate by e-mail, fax and telephone. More about those projects and the accompanying learning effects can be found in [12].

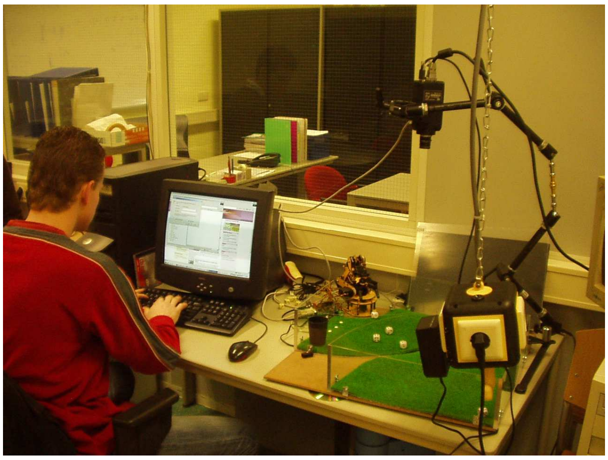

FIGURE 3. Student working in fourth class project

5. CONCLUSIONS AND FUTURE DEVELOPMENTS

In the past few years good experiences have been gathered with the different educational models applied to the specialization of Industrial Automation. Of course they are based on widely accepted methods that are chosen after careful balancing within the course of Technical Informatics. We think that our students are offered not only a wide variety of knowledge and skills in the field of informatics but also in the way they can learn this, as well as the possibilities to interact with fellow students, teachers and company representatives. We are convinced that in this way an important contribution is made towards the development of competences of our students. Although in this paper the present situation on IA education has been described, developments are proceeding. Since September 2007 a start is made in a complete renewal of the curriculum of the ICT department. The curriculum should become more competence oriented, Technical Information should be closer integrated into ICT and companies should play a more important role in education. Consequences are that e.g. the earlier mentioned module "Production Systems" and the third-class industrial automation project have to be fully integrated into one project. For us the problem to keep the benefits of both educational units and the challenge to introduce new developments into the course. In parallel more serious investigations will be done into the concepts of the course. This will be done in several ways: desk research in order to compare and learn from other courses, inquiries for our graduated students in order to find out how their appreciation for the course was and how easy (or not) they could adept to their professional environment. Also the structure of comparable courses at other institutes will be studied and attempts will be made to trace their graduated students in the professional environment. Finally, as we keep noticing that interest in doing technical courses is still decreasing in the Netherlands, we will use the opportunity of renewing the curriculum to introduce more attractive aspects in our course. We are e.g. considering to introduce more (technical) aspects of game design and let students work in projects on the development of competitive robots (and stimulate this by allowing them to participate in contests, like RoboCup, RoboChallenge or Fisrt Lego League; see [13]). Finally an attempt will be made to attract more girls to the course by showing that robotics and other technical information oriented systems can very well be used in social environments, elderly and health care. (e.g. see [14])

References

[1] A. de Waal, “Technische Informatica : *een jaar na de start”*, TINFON 1, p89-91 (2003) (in Dutch)
[2] D. van Schenk Brill, “Industriële Automatisering: *een vreemde eend in de informaticabijt?*”, TINFON 1, p13-14 (2006) (in Dutch)
[3] http://www.actemium.nl/ (only in Dutch)
[4] http://www.vanderlande.co.uk/en-gb/Pages/default.aspx
[5] D.van Schenk Brill, B. van Gestel, “Students’ appreciation of distance learning – two cases”, SEFI Annual Conf. Aalborg: unpublished (2008)
[6] http://www.edu-lab.nl/ (only in Dutch)
[7] http://edulab.actemium.nl/ (only in Dutch)
[8] http://www.festo.com/StartPage/Default.aspx
[9] P. A. M. van Kollenburg, R. M. Bakker, “Project centered competence related education of engineers’, SEFI and IGIP Joint Annual Conf. Miskolc, 2007
[10] http://www.hasys.com/cases/
[11]http://www.borland.com/us/company/news/press_releases/2003/01_15_03_borland_completes_acquisition_of_togethersoft.html
[12] D. van Schenk Brill, K. Kater, M.Ketelaars & J. van der Sanden, “Learning effects of Fontys integrated product development projects”, SEFI Annual Conf. Uppsala: 31. (2006)
[13] http://www.roboludens.com/
[14] http://www.ai.rug.nl/robocupathome/

Curriculum

Ir. Dick van Schenk Brill is senior lecturer at the department of Information Technology of Fontys University of Applied Sciences, where he has been working since 1981. He graduated in Electronic Engineering at the Delft University of Technology in 1978. Besides lecturing, he is involved in many organisational tasks, mainly in the field of Technical Informatics. His research activities are in the fields of Integrated Product Development, Industrial Automation and of Education in Technology. He has been involved in developing the curriculum for Technical Information and especially for Industrial Automation.