

Students Training Through Applied Activities at Department of Automation and Applied Informatics, University Politehnica Timișoara

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Abstract

The paper is focused on the practical knowledge transfer problems in higher education engineering. The objective is to improve the knowledge transfer in order to facilitate rapid workplace integration. The curriculum and the practical training of students at University Politehnica Timisoara, Department of Automation and Applied Informatics are presented and discussed. The implication of companies in the students' practical training is highlighted. A practical knowledge transfer system is proposed, based on logical distribution of the requirements for a single practical application, transversally, to the curriculum courses. The initial changes in the curriculum, introduced after the Bologna Declaration, are presented for the previously mentioned department. Ideas and questions were released which can be clarified, interpreted and criticized, providing a discussion base that can be benefic to the academic and industrial community. The presented changes were discussed with the economical zonal partners (companies: Continental Automotive, Hella, Nokia, Yazaki, Huf, Flextronics, etc.), being appreciated and sustained by the companies.

Keywords: Practical knowledge transfer, curriculum courses, syncretic project, project, higher education.

Introduction

One of the most important problems for every educational system is the knowledge transfer process. The knowledge transfer process includes the development of the student's practical skills. These skills allow the young people a rapid workplace integration. To provide practical skills is the major objective in engineering university education. The University Politehnica Timisoara, over time, has changed the university studies structure, following the previously mentioned major objective. For example, the implementation of the requirements asked by the Bologna Declaration is the beginning of the most recent adaptive process of the educational system for the job market. The educational system before 1989 is not referred due to complete lack of the university autonomy.

We will present the evolution and changes of the educational system in Timisoara after this date. We present, especially, the changes in the curriculum of the Automation and Applied Informatics (A.A.I.) Department at the Automation and Computer Science Faculty from Timisoara. These changes have been made with the purpose of applicative knowledge transfer towards the students. The practical training of students is not taken into consideration incidentally, but due to current demands of the real world.

The rule in the job market is to request skills and knowledge related to specific activities of companies or organizations. For companies and organizations with mainly applied activities and with less focus on research areas, it is important that graduate students coming from universities are possessing aptitudes and skills allowing them to start working immediately.

Many students are employed since the first study years. They adopt a study approach with limited opening for a professional field background. Therefore, they finalize their studies totally skilled depending on the employer. Their motivation relays in the perception that they will accumulate applied information at a future workplace immediately.

Thus, it is mandatory for the University to be preoccupied and to pay attention to solving, in the educational process, the problems involving the students' practical training. In the followings, the paper presents the applied approach at the Department of Automation and Applied Informatics, Politehnica University of Timisoara. The process is obviously dynamic, due to changes in the social-economic environment worldwide and similar approaches take place across the globe in environments that require it [1].

New products and projects, in an enterprise environment, are based on transferring knowledge from one team to another. The time required to do the transfer impacts the outcome of the entire project. Several methodologies and frameworks have been developed to speed the knowledge transfer process.[2] Other models try to optimize the process itself by using state of the art artificial intelligence techniques [3] or furthermore a reinterpretation of knowledge management techniques [4][5]. All of these can be put together in future process management approaches in order to reach an innovative contribution.

The Curriculum Structure and the Knowledge Transfer Process at A.A.I.

Although, before 1989, the curriculum was the same nationwide, for a specific specialization inside a University. After that major turning point, new curriculum was conceived for every Faculty/Specialization. Inside every University, a specific specialization (e.g. Automation and Applied Informatics) implemented different concepts in terms of structure, as well as succession and content inside the current specialization (the 25% framing is quite ambiguous, since the ARACIS policy cannot decide the curricula's content but only the naming of the discipline).

Since the Bologna Declaration, at the Automation and Computer Science Faculty from Timisoara, the curriculum was implemented based on some common core disciplines, optional and independent courses, respectively packages of optional courses [6], [7]. The mandatory practical training takes place during the summer holidays, between the study periods, being independent/individual for each student.

The most recent version of the curriculum covers just the common core disciplines, the imposed subjects guiding the optional path of courses (the students are divided in two groups, each of the groups following by choice on of two optional main subjects – Control System Engineering and Programming Engineering), respectively the optional courses. There are no subject bundles. The practical training activity is focused on the third year of study and it has assigned 240 hours. In the fourth year of study there are additional 60 hours dedicated for the diploma project preparation (which includes documentation inside the companies). The 1st and 2nd figured are illustrating the current curriculum, detailing the 1st-VIth semesters and the schematic (because many optional disciplines are involved) for the Vth-VIIIth semesters.

1 st Semester	2 nd Semester	3 rd Semester	4 th Semester	5 th Semester	6 th Semester
Analysis	Computer Assisted Mathematics	System Theory 1	System Theory 2	Management and marketing	Culture and Civilization
Algebra and geometry	Probabilities and Statistics	Fundamentals of Measurement Techniques	Databases	Control systems structures and algorithms	Operating systems
Physics	<i>Fundamentals of Electrical Engineering.</i>	Object-oriented programming	<i>Concurrent Computing</i>	Algorithm design and analysis	Computer security
Computer programming	<i>Fundamentals of Engineering Electronics</i>	Communication	Modeling and Simulation	Optional course 1	Optional course 2
Fundamentals of Mechanics of Robotic Manipulation	Programming techniques	Digital circuits and signals	Event-Based systems	Data communication	Computer networks
Logic and discrete structures	Digital logic	Computer architecture	Microprocessors and Microcontrollers Systems	Embedded systems	Optional course 3
Foreign language 1	Foreign language 2	Data structures and algorithms	Microeconomics	Syncretic Project 1	Syncretic Project 2
Sport 1	Sport 2	Sport 3	Sport 4	Practice (80 hours)	Practice (160 hours)
Facultative course	Facultative course	Facultative course	Facultative course	Facultative course	Facultative course

Fig. 1 Curriculum for the 1st-VIth semesters A.A.I. specialization

5 th Semester	6 th Semester	7 th Semester	8 th Semester
SE	SE	DD	DS1
DD	DD	DS1	DS1
DD	DD	DS1	DS1
DS1	DS1	DS1	DS2
DD	DS2	DS1	PPD
DD	DD	DS2	
PS	PS	DS2	
PC (80hours)	PC (160 hours)	PPD (60hours)	

Legend: SE – social economic disciplines; DD – domain disciplines; DS1, DS2 – specialized disciplines; PS – syncretic project; PPD – diploma project preparation; PC – practice inside the companies

Fig. 2 Curriculum (schematic) for the Vth-VIIIth semesters, at A.A.I. specialization

The following paragraphs are briefly addressing the curriculum in order to explain how knowledge and forming practical abilities are passed to the students.

The practical knowledge is transmitted during:

The laboratories and the projects required by some disciplines (it is known that there is a minimum of 4 disciplines that require realizing a practical project – an ARACIS requirement). The so-called Syncretic Projects are specific for the A.A.I. specialization in Timisoara and will be further detailed;

The practical activity inside companies;

The specific activities needed for diploma project elaboration. Also, inside the A.A.I department, collaboration with companies is developed for:

Facultative courses that are organized by the faculty and lectured by experienced employees from the companies;

Laboratories and punctual activities, diploma theses that are developed inside and with the equipment supplied by the companies;

Organizing specific laboratory rooms that are equipped by the companies in which the students can work on their practical projects. Projects themes are proposed and approved by the respective companies.

During discussions with different representatives from companies and graduates whom are engaged in the curricula elaboration, it has been agreed that one important objective is to increase the number and consistency of the projects as applicative oriented activities. Three types of projects were defined: A- projects that have 7-14 distinct hours incorporated into different disciplines; B- projects that have 42 hours as distinct disciplines (for the Vth and VIth semesters) which were subsequently named Syncretic Projects; C- diploma/license projects.

As already being mentioned, the Syncretic Projects are specific to A.A.I. Timisoara, and we will analyze them here (the other types of projects are generalized and widely known in the university system).

The objectives of the Syncretic Projects are as follows:

To learn the medium complexity projects, which can be found in real word applications or very close to the real-world ones (therefore competences are created for using and practicing the gained knowledge in certain situations);

To assure the multi-disciplinary and interdisciplinary character of education (the purpose of the projects is to use the multitude of gained knowledge from different automation and computer science disciplines);

To develop certain skills/habits and responsibilities for being able to finalize complex activities and then to present them publicly. Each project has a practical completion and therefore not limited to the widely-spread computer simulations;

To create a system that implies teamwork, with the scope of allowing students to cooperate and to auto-organize, aspects that promote communication, defining leaders in the professional activities.

Finally, it must be emphasized that one goal of the projects is to create teaching showcases that aid cooperation between different members of the teaching staff from various disciplines.

The Syncretic Projects were ones of the new disciplines that were included in the new curricula. The students are very determined to participate and solve the tasks required by these projects. Finalizing the subject/theme of the project involves the followings:

to participate at every practical activity that lead to a functional physical model as required by the project;

to create a documentation according to a template (written paper);

to present the projects solution to a committee composed by the teachers involved.

The study years that have 140 students (this is the tuition number at A.I.A Timisoara) are proposing 4 projects in the Vth semester and 4 projects in the VIth semester. The students can choose one of these projects each semester. The distribution of students is made based on the marks obtained in the previous study years. The activation of the Syncretic Projects from the proposed list is done in the descending order, considering the number of options for each project. The projects themes are focusing on microcontroller systems for different applications, positional systems with electric motors, energy measurement, control of mobile robots, control loops for “home automation”, etc. Managing the Syncretic Projects is a complex matter that implies also the management of materials and it involves many members of the teaching staff. From the experience gained in the previous years, with all difficulties involved, it is important that the students gained a big interest for Syncretic Projects and therefore are considered to be an important success.

Aside from the curriculum, but being considered as practical activities, several companies from and near Timisoara (also in cooperation of the student league ¹) organize laboratory type activities with one or two subgroups of students (15 and 30 students) at each company [8], in their own spaces and with their own material resources. Each company organizes a selection process that begins with presenting their activities in front of the students. Then the students submit their CVs and participate to an interview as in the normal company enrolling process. The selected students are participating at the particular activity offered by the company [9].

The Role of Class Teaching in Transmitting the Practical Knowledge

Apart from its importance between departments or teams in corporations or organizations, these approaches can be applied in knowledge transfer and cooperation between universities and between research centers. Analyses of the latter approach was observed [10][11] and argue that academic engagement as knowledge co-production impact strongly depends on sustained knowledge co-producing interactions. The role of class teaching therefore needs to consider these factors before a curriculum is chosen.

As a result of discussions with the students as well as with company representatives, we concluded that the curriculum is good but it requires something to connect the learned disciplines, to prove their utility, to identify the logical succession of courses and the validity of the taught knowledge. The practical activities presented earlier are not sufficient, even if they involve the application of the theoretical information delivered at courses. The proposed idea, which we consider that ensures the mentioned above desideratum, consists in the presentation of a solving model of a practical project (the same for every course) using a transversal approach – with a specific section at each of the common core disciplines. When the students finalize their studies, they have a fully solved project. Therefore, we propose to involve the courses in forming practical abilities of students.

This way, the existing courses from the learning plan of the A.A.I. specialization can demonstrate to students their utility as an ensemble and the existing connection between them. To achieve this, it would be required that one or maximum two applications to be common for every disciplines and the specific implementation stages of those applications to be treated rigorously, fully and concretely with every discipline, respectively to provide the required documentation.

For example, a project that can be considered simple in theory but proving lots of difficulties in practice for students is dedicated for automated opening (via local control or remotely using the internet, phone or radio transmitter) of a swinging gate, fig. 3. The project allows the “discovery” of the importance of every discipline from the leaning plan of the A.A.I. specialization, beginning with the mechanics up to management and marketing. Adding every year the course materials related to the given application/applications, the student will have in the IVth year of study an implemented practical example of how the mentioned application is realized covering all details. The students will notice the utility of the covered courses and therefore the information obtained during the studies will not be considered “useless” (a present idea in the student community related to some courses). If every course would show the practical sense of those presented during the associated laboratory activity, implementing its required part of the project, the student would see the outcome of the course and the whole ensemble. We consider that this would be a real gain. Obviously, different challenges/themes can be proposed for student to be able to find different solution based on the latest findings in the technical domains involved in order to elaborate studies and for research

¹ <https://labs.ligaac.ro/>

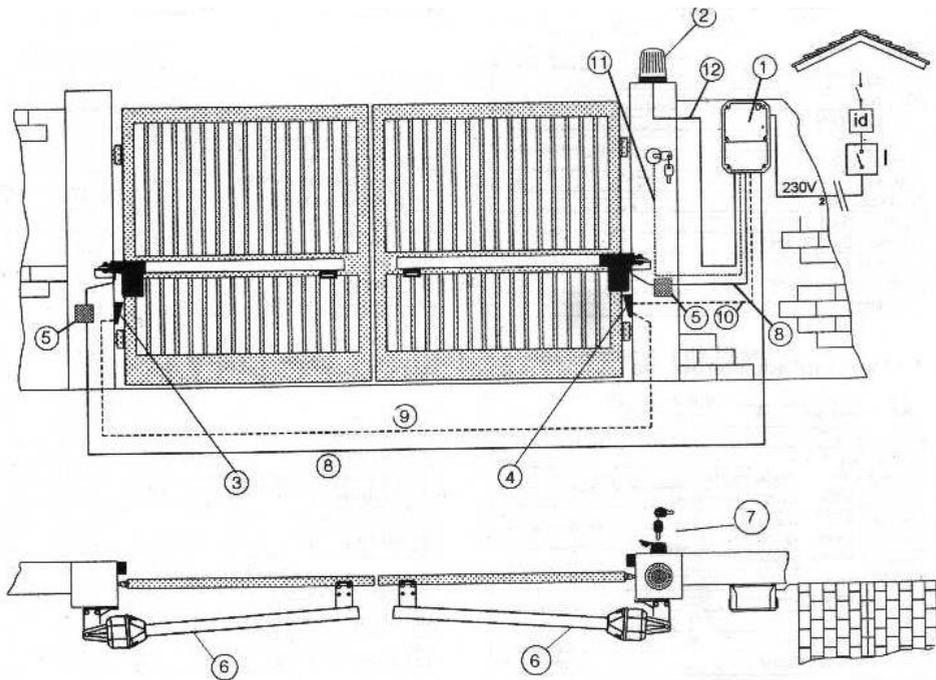


Fig. 3 The access gate with automatic opening system is composed of: 1. command block; 2. warning lamp; 3, 4. Infrared barrier and movement sensor; 5. Terminal box; 6. Electromechanical engaging units; 7. Key button; 8. Power cables for the engaging units; 9, 10. Power cables for the optical barrier, movement sensors; 11. The cable for the key button; 12. The cable for the warning lamp.

A considerable effort for the teaching staff, but not impossible to make, is to correlate the theme requirements to allow the knowledge taught in the curriculum courses to be processed in a way that can lead to a viable project.

As an example, detailing the sub-themes, the project focused on the automatic opening of the access gate, following the compliance with the curriculum from fig. 1, is depicted/structured as follows:

- Physics: the general presentation of the theme/project and the description of some principles that underlie the manufacturing of optical sensors or other types of sensors that can be used to solve the application.
- Mechanical engineering and robotics fundamentals: setting up a mechanical screw system for actuation and head race limiters, finding the maximum speed and extreme positions for the mechanism, calculation of the torque required by the motor, finding the means of actuation (motors) and the measuring method for the revolution/position/speed. The structure dimensions, its mass and the overload due to the wind, are considered known.
- Logic and discrete structures: choosing a working regime [installation regime (I); programming regime (P), working regime (L), service regime (S)] and the discussion of the logical structures that are leading to implementation.
- Computer programming: the program that determines the sense, the speed and the position from the two impulse trains that are out of phase by 90 degrees. This way, the first steps are made in using the positional transducers.
- Electrical engineering fundamentals: the power supply and blocks of electrical components are presented using various sources of energy. The necessary currents for the powering are calculated and static switches and relays are used.

- Electronic engineering fundamentals: a power supply is defined that allows the automatic switch between the main electrical network to the battery, or designing the power supply of some modules (power supply of the displays, the signaling light, the key switch and the radio receiver/emitter).
- Programming techniques: the software architecture schematics that includes discussions about the techniques that can be used for implementation/development of different tasks.
- Digital-logic: the automated device for implementing different working regimes.
- Systems theory: the systemic concept of the application, the mathematic modeling of elements of the application, of the electro-mechanic structure actuation.
- Principles, techniques and measuring devices: practical aspects that involve utilizing the transducers for measuring current, position, torque, the optical barriers, the digital-analogic and analogic-digital conversion.
- Object oriented design: the implementation of the working regime.
- Dedicated digital circuits design: the design of a positional decoder for TIRO transducers and displaying/writing the information on "7 segments" or over a data bus.
- Computer architecture: memory blocks EPROM, RAM and FLASH and addressing systems.
- Data and algorithms structures: data organizing (code areas and data areas).
- Systems Theory 2: processing/interpreting/analyzing the characteristics of the systems.
- Databases: developing a database application for storing some access related information, maintenance time and data/parameters for testing the system.
- Concurrent programming: developing human machine interface (choosing the working regimes, display) and the application that uses the webcam.
- Simulation, modeling and recognition elements: to use information from Systems Theory 1 and 2 for implementing a mathematical model for the access gate in a simulation environment (e.g. Matlab-Simulink), to extract the resulting conclusions, to present a parameters identification technique.
- Discrete events systems: designing the application using a discrete event system.
- Microprocessors and Microcontrollers based systems: the microcontroller module architecture that corresponds to the application, the sensors interface.
- Microeconomics: Costs related aspects, supplying logistics / manufacturing.
- Management and Marketing: market prospection, banners for promoting the product, sales organization.
- Algorithms and structures for automation of the processes: an algorithm for controlling the position and speed according to real data includes a demonstration using a simulator.
- Programming environments and technologies: choosing a programing environment and technology that assures the application development/testing.
- Control engineering (one of the imposed optional disciplines): the driving/the control algorithm with time optimization of closing/opening the access gate
- Programming engineering (the other imposed optional discipline): development and implementation of the service regime.
- Data communications: the wireless communication block with the remote control, the photocell connection, the USB communication
- The incorporated systems: connecting an embedded system available on the market with the application hardware components and the software implementation.

- Operating systems: the configuration of the operating system, installing the software/drivers/tools used for developing and using the application.
- Information security: securing the wireless communication and the Internet access.
- Computer networks: web server communication [a. installing the network on a computer: IP, netmask, DNS, gateway; b. installing and configuring the webserver; c. designing a PHP/Perl/C++(CGI) program that can access directly or indirectly (based on the programming language used) the serial line of communication with the microcontroller. The commands sent to the microcontroller are simple: OPEN, CLOSE, STATUS, etc.; d. Installing webcam via webserver (if the webserver and the camera are compatible); e. configuration of the access lists for accessing the webcam and CGI (via webserver).
- PLC applications (optional discipline 2): utilizing a PLC for creating an application for closing/opening the access gate.
- Mobile systems programming (optional discipline 3): developing an app for control/view using the mobile phone.
- Standards, graphic design technics, and intellectual property: the documentation related to the design, execution and utilizing the power block.

The above presented information reveals the correlation and covering of disciplines from the curriculum of the A.A.I. specialization. To consolidate the theoretical knowledge together with the practical one (the major objective) we consider that equipment can be built (in miniature and with reduced costs) and can be used in every laboratory activity associated to courses. Every laboratory class can be dedicated for applying the practical side of the theme taught at the course.

The advantage will be that the students know better, year after year, the laboratory equipment and they can connect/use the previous knowledge.

Instead of the access gate application other themes can be approached (robots, thermal processes, etc.) and the requirements of these application can be adapted to the disciplines.

Other Methods that Pursue the Learning Process towards the Applicative Knowledge

As a necessity of young people skill adjustment to the workforce market requirements or as a permanent learning structure, the companies developed training systems for their employees, strictly oriented towards certain competences and abilities. In the last years, several directions have emerged:

With their own resources, the companies organize training courses for future employees. When the courses are finalized, if the attending candidates are passing the exams, they are hired inside the company (ex. Continental Automotive).

Some companies have established the so-called Personnel Training Academies (ex. Alcatel, Hella) inside the company and it involves some professional trainers or even university staff.

The companies that develop products of a certain type/level (Vector from Austria for CAN/CANOE systems that are used in the automotive industry) organize training courses that are finalized with a certification.

Aside the companies, there are organizations that include authorized trainers and offer nationally certified/recognized courses (the POSDRU programs offer such examples).

Offering diploma project themes with a practical component that are financed by the companies. There are companies that finance not only the project implementation, but even the students and teachers that are involved and also their own employees (ex. Saguaro Technology applied such a method for the A.A.I. specialization from Timisoara).

The universities need to consider this trend and involve the teaching staff in the mentioned activities to teach these courses or even to obtain their own certifications. Often the companies are not interested in obtaining a "graduated engineer" but a guarantee that a student will acquire some practical knowledge and abilities. The steps made in this direction are already known, confirming and acknowledging the merits and the orientation of some faculties/universities.

For example, following this trend, the Automation and Computer Science and the Electronics and Telecommunications Engineering Faculties have realized a laboratory sponsored by Vector (~250000 euro) used for CAN/CANOE

communications training. The courses are held by the Austrian firm specialists with remuneration provided by various companies and free of charge for professors inside the University.

Prof. Ioan DUMITRACHE was coordinating during 2010-2013 the POSDRU project named "Increasing the competitiveness of the companies by improving and specializing the human resources in the new technologies areas, in a society based on knowledge for a durable development" – COMHIGHTECH¹, which laid the foundation for training activities organized by universities from Bucharest, Cluj-Napoca, Iasi and Timisoara, through courses accredited by the Ministry of Research and Education and certified. A network of training centers was created but maintaining this activity requires permanent efforts interacting with the companies by offering consistent technical and scientific materials oriented on the present issues.

The automation (PLCs, HMIs, industrial networking equipment, frequency converters, programming software for all levels etc.) and SCADA (especially licensed SCADA software, interfacing software, but also equipment for control rooms) equipment used in real industrial applications are difficult to be provided by the University. The equipment is of various producers, the equipment prices are high and a real application is even harder to implement because of all needed process components, respectively the evolution of the equipment is high-sloped (e.g. new products and technologies are released by different producers and old products are cancelled). In order to examine real applications, respectively to work with real data, the A.A.I. department approached a partnership with the local water distribution company (Aquatim S.A.) that possesses a large amount and various types of automation and SCADA equipment and solutions. Permanently updating and extending its facilities, Aquatim S.A. is able offer state-of-the-art equipment for analysis/development. Starting from SCADA projects, the partnership was extended in 2016 through a bridge grant, allowing groups of graduate students to analyze/implement SCADA/ automation/ communication solutions using modern hardware/software equipment in real scenarios. Groups of maximum 5 students are tutored by a company employee as well as by the grant staff. This way, the students are able to correlate theoretical knowledge, laboratory equipment and real industrial applications and modern solutions. Also, the accumulated knowledge is extended towards a larger variety of products/solutions, offering the students more possibilities for future employment or start-ups.

Conclusions

The methods used at the A.A.I. department from Timisoara together with new suggestions were presented in the paper to train students for being able to cope with the very dynamic workforce market that is oriented toward industrial applications. The current transformations were discussed with the economic partners from this area, being appreciated and sustained by the industry.

Companies like Vector, Hella, Continental Automotive, Alcatel – Lucent (Nokia), and others, cooperated efficiently with University Politehnica Timisoara. For elaborating the curriculum, boards of domains and specializations were gathered, consisting of company representatives interested in graduate students along with teaching staff and students. The involvement of companies in student training will be continued, not only through sponsoring various didactic, scientific and research activities, but also for the punctual didactic activities.

Because of the high volume of information available in all domains, it is required to acknowledge some curricular paths, by increasing the number of projects and laboratories together with the transformation of the courses content. A proposal was that all courses shall focus on the same practical application, in a transversal manner, so that at the end of studies the graduates will have a complete example that was studied in all details.

The changes made in the A.A.I. specialization were presented, together with some ideas and questions that can be further clarified, interpreted, criticized, etc. Based on the mentioned ideas, debates can be initiated with benefits to the academic and industrial community.

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¹ <http://www.comhightech.ro>

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