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Use of the ICT in vocational training in the area of industrial robotics and automation

Abstract /Title of the Section (bold, 11pt)

As nowadays many Small and Medium Enterprises (SMEs) need to increase their production quality and efficiency, they have to integrate the existing facilities (purchased from many vendors) with new, innovative Automation and Robotics solutions. To this end, they need proper training on how to select, integrate and operate the A&R systems in order to achieve the highest efficiency and the shortest Return On Investment period. The main problem regarding the successful application of automation in enterprises is the lack of qualified personnel (from less qualified workers to manager level), and in SMEs this problem is particularly evident.
This paper postulates how to combine traditional vocational education with modern multimedia materials (photos, movies, animations, simulations – with distance access) and e-Learning modules.

Keywords: Industrial Robotics, Automation, Education, Vocational training

Introduction

ICT systems have gained a permanent presence in the field of education. They can be found on all education levels: from nursery schools, through primary and secondary schools, universities and colleges, to vocational courses and adult education facilities. Among essential tasks performed by computer tools and applications, there are:

- source of information for students – most educational institutions have their own websites, where they publish news, regulations, learning resources, etc.;
- communication between students / parents and the school and / or the teacher – even on the lowest levels of education, more and more teachers use electronic mail to communicate with their students or their parents; one of the forms of such communication that has been gaining more and more popularity is a so-called electronic teacher's notebook, providing access to the information about grades, attendance, substitutions and other important events related to students;
- Learning resources – intelligent interactive boards, presentation systems, etc.;
- distance learning – majority of universities and colleges offers distance learning opportunities; departments of humanities, economics and foreign languages were the pioneers in this field, but now such opportunities are offered also by technical faculties, such as the Distance Learning Centre of the Warsaw University of Technology;
- e-Learning courses – different training institutions offer e-Learning courses.

In the years 2005 – 2007, the ISAR project [1] resulted in the development of a system of vocational courses in the field of advanced technological, organisational and occupational safety solutions in the automated and robotised production systems. The interest in the training courses elaborated during the project encouraged the team to develop the courses using modern knowledge structures, methodologies, tools and web-based services, as well as virtual reality techniques. Creation of such a virtual training lab is the objective of the VITRALAB project carried out under the Leonardo da Vinci's Lifelong Learning Programme [5].

VITRALAB Project

The VITRALAB project is funded with support from the European Commission for a period of two years: October 2009 – September 2011. It is aimed at the development of an integrated set of vocational training solutions in the field of Automated and Robotized Manufacturing (A&R) systems. General goal is to educate technical teachers in vocational schools and employees of production SMEs about possible utilization of automated and robotized installations in industry Project will transfer and adapt existing education content to the specific environment of SMEs by combining traditional vocational education with modern multimedia material (photos, movies, animations, virtual reality, simula-

tions - with the possibility of distance access) and e-Learning modules. Detailed goals of the VITRA-LAB project are as follows:

- to develop a set of vocational training courses with highly innovative content,
- to increase the educational level of the staff of SMEs in the field of A&R,
- to increase qualification of the target group in the field of A&R and this way encourage the application in the labor market ,
- to facilitate the adaptation of new staff to the production process in the field of A&R particularly at producers and subcontractors of the automotive industry,
- to develop Vocational Skills corresponding to the labour market needs.

The project addresses 3 target groups of beneficiaries:

I. Managers of SMEs – they require appropriate knowledge resources in order to reach decisions that are technically and economically justifiable.
II. Technical staff of SMEs – people from this group should be able to operate, maintain, and troubleshoot A&R equipment safely.
III. Teachers and trainers – Consultant and teaching services in the area of A&RM systems continuously increase, denoting the need for an advanced approach to training material distribution. The VITRALAB vocational training environment will enhance the dissemination of competences and expertise.

Four partners creates consortium which is engaged in Vitralab project realisation: Technical University of Kosice (TUKE – project coordinator), Brno University of Technology (VUT), Industrial Research Institute for Automation and Measurements (PIAP) and Slovak Association for Automation Equipment and Robotics (SAATAR).

Training needs of SMEs in the field of automation & industrial robotics

Automation has an increasingly important role in the global economy and in daily experience. Many companies constantly have to increase their quality and productivity, which in turn forces them to integrate the existing production facilities (machinery and devices purchased from many vendors) with innovative, often highly automated solutions and systems. To this end, they need proper training on how to select, integrate and operate the A&R systems in order to achieve the highest efficiency and the shortest Return On Investment (ROI) period. There are thousands of SMEs that could use automation systems with robots in the production for diverse sectors, but they lack any vision and qualified employees able to apply those new solutions in practice. On the other hand, there are many A&R training courses (including e-Learning solutions) available in the market, but they mainly concentrate on automated or robotised products supplied by a specific vendor and fail to cover complex issues related to integration of A&RM solutions and often fail to answer specific needs of SMEs. VITRALAB project aims at creating educational solutions meeting the aforementioned requirements.

A survey was carried out in order to identify actual training needs of SMEs. Two sets of questions were prepared: one set was addressed to the employees of SMEs (technical and managerial staff) and the other one was addressed to trainers and consultants. More than 120 people (about 60 in each of the two groups) in Slovakia, Poland and Czech Republic were surveyed. The survey results provided important practical guidelines applicable to designing and organisation of VITRALAB training system.

The results of the survey among the employees of SMEs can be summarised as follows:

- internet-based learning is generally accepted by the staff of SMEs. However, most respondents prefer the course material to be delivered also in the "offline" form, e.g. on a CD,
- the respondents would not be afraid to use a virtual lab and highly value exercises in virtual reality and the use of simulations,
- electronic mail is the preferred form of communication with the teacher. The respondents also indicated the Internet forum and videoconferences as acceptable forms of communication with other learners,
- the respondents expect the training course to focus on the practical applications of A&R solutions.

The main results of the survey carried out in the second target group are as follows:

- most trainers and consultants have certain experience with e-Learning solutions. They are afraid that the preparation of lessons and adaptation of materials from traditional courses to the needs and requirements of the virtual lab will be time-consuming,

- nearly all teachers want to have a possibility of direct contact with their students; as the preferred forms of such contact, they mention electronic mail and the Internet forum. It does not mean the need to monitor the students' work online,
- trainers agree that the course material should be also available in the "offline" form,
- the course materials should contain auxiliary resources, e.g. FAQ or WIKI functionality.

General structure of the VITRALAB training system

The training system developed within the VITRALAB project is aimed at facilitating the acquisition of knowledge in the field of automated and robotised systems used in MŚP. According to the project's assumptions, the system will be based on the innovative training concept and methodology employing state-of-the-art ICT solutions (including e-Learning). The concept elaborated in the first stage of the project assumes that the structure of the training system is to be divided into four parts:

- e-Learning training system;
- exercises in a virtual lab;
- exercises in a real lab;
- traditional (stationary) course with self-learning opportunities using off-line materials.

It is assumed that the training course will be adapted to the expectations, needs and levels of knowledge of particular target groups. Therefore, tailor-made training courses will be offered. The modular structure enabling reconfiguration and its parts (particularly the first two in the list above) make the suggested solutions highly innovative.

e-Learning training system

VITRALAB e-Learning training system is based on the technology developed in the ISAR project and offers new capabilities that extend its functionality. The project's objective was to create a system whose technical requirements for users (SME staff, students, teachers and consultants) would be limited to standard equipment and facilities, such as a personal computer connected to the Internet and web technologies.
The system was developed on the basis of a 4-layer architecture model. The first layer comprises databases that store learning objects, information about the learners and the course and access rights data. In the business logic layer, there is a server with Moodle [4] system applications and functionalities, including internal and external plug-ins for management, storage, searching and restoration of learning objects. The third layer consists of a WWW server ensuring the communication between the business logic functionalities and the Apache server-based presentation layer. The fourth layer is represented by various web clients (e.g. learners, administrators or remote content developers) communicating with the server mainly via the Hypertext Transfer Protocol (HTTP). The architecture and structure of the VITRALAB e-Learning system is presented in Fig. 1.

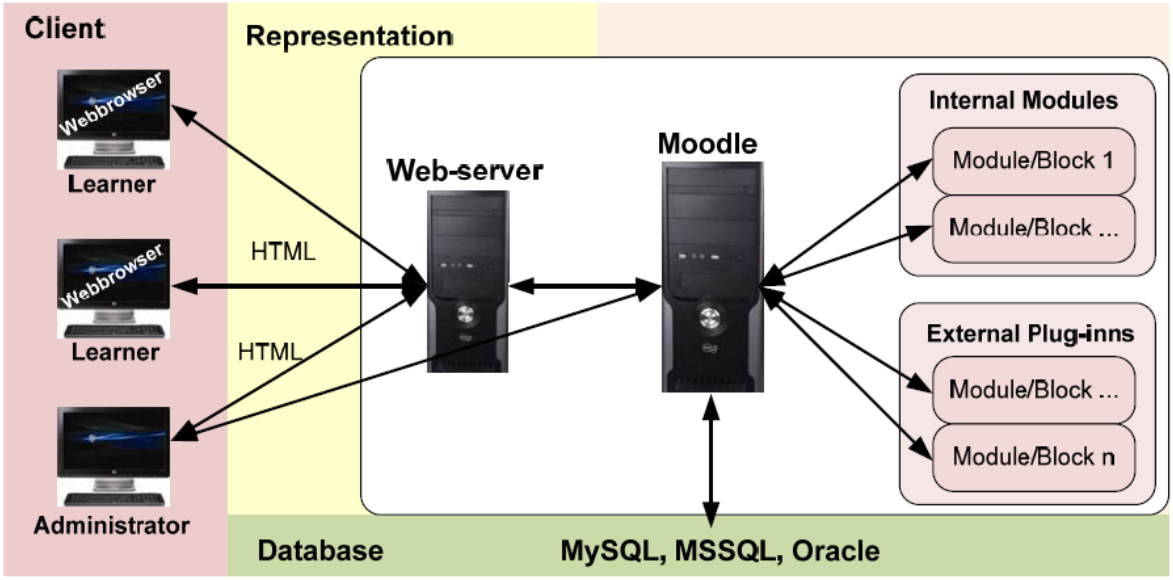

Fig. 1. Technical architecture of the VITRALAB system

The VITRALAB solution comprises the Internet-based services for different target groups offering support in online updating, collaboration and communication, organisation of users in virtual study circles, monitoring of the learning process and time management/planning. All these services will be based on the approach already applied in the ISAR project and upgraded by the latest developments in the Moodle e-Learning system and plugins. The VITRALAB platform provides all the services required for online updating and collaboration between different virtual circles to take place and supports monitoring of the learning process and time management/planning. Table 1 shows system functionalities and services offering those functionalities.

Table 1. VITRALAB functionalities and services

Functionality	VITRALAB service
Online updating	Lesson content creation/updating modules Question Quiz Glossary Survey Workshop
Collaboration and communication	Forum Message board Chat room Whiteboard* Audio/Videoconferencing*
Organisation of users in virtual study circles	User grouping module Hidden lessons/adaptable privileges
Learning monitoring	Activity report Gradebook
Time management/planning	Calendar Forum

Set of lessons in the pilot VITRALAB training system.

In the first phase of the project, so called initial training system was developed. It contains 3 lessons carefully selected and focused on target group I and II – management and technical staff of SME as a potentially most important target groups:

- Lesson no.1 – Introduction to automation and robotics systems,
- Lesson no. 8 – Programming of A&R systems
- Lesson no. 19 – NC machines 1

After tests and some improvement, these lessons are base for preparation basic training e-learning system. It contain 21 lessons, as indicated in the Table 2.

Table 2 Draft of basic course lessons

Lesson No.	Lesson Title:
1	Introduction to automation and robotics (A&R) systems
2	Needs for A&R systems in SMEs
3	Problems by selection, implementation and operation of A&R systems
4	Investment planning in SME for A&R systems
5	Cost-Benefit-Analysis and ROI calculation
6	A&R system configuration
7	Evaluation of offers & procurement of A&R systems
8	Programming of A&R systems
9	A&R systems utilization - examples
10	Safety aspects of A&R systems
11	Maintenance of A&R systems
12	Funding possibilities of innovations in SME – European project, structural funds

13	Visual systems
14	Quality control
15	Sensors
16	Basics of robotics - kinematics, dynamics
17	Tools – effectors
18	Intelligent Manufacturing Systems
19	NC machines 1
20	NC machines 2
21	Database

The VITRALAB Lessons are structured in a way that each lesson includes:

- explanation of the specific thematic part - textual/graphical/multimodal
- example (practical example)
- exercises - practice - test (set of multiple-choice questions, tasks etc.)

It is estimated that for each lesson an 'average student' should spend between 40-60 minutes, to study explanation and example, and to do the exercises [3]. The total number of first draft of lessons is 21. This means that an 'average student' would need for the whole course maximum 20 hours + time for training in the classroom (about 6-8 hours - to be defined). Assuming that a student will spend 2-3 hours per day, he/she may need about 10 ± 1 working day.
According to the VITTRALAB solution concept, not all lessons are intended for all students/users i.e. the lessons are specifically adapted to the target groups identified in the project (managers of SME, technical staff of SME, trainers and consultants). In addition to the lesson content adaptation, also different examples and exercises for different target users are provided. These adaptations will be realised applying generic eLearning tools (as changes in text or graphics).

Exercises in a virtual lab

Another essential component of the VITRALAB training system is a virtual lab enabling the operator to create a custom robot control algorithm in the virtual environment without the need to obtain physical access to the robot [2]. The concept of virtual lab access and functionalities in the VITRALAB system is presented in Fig. 2.

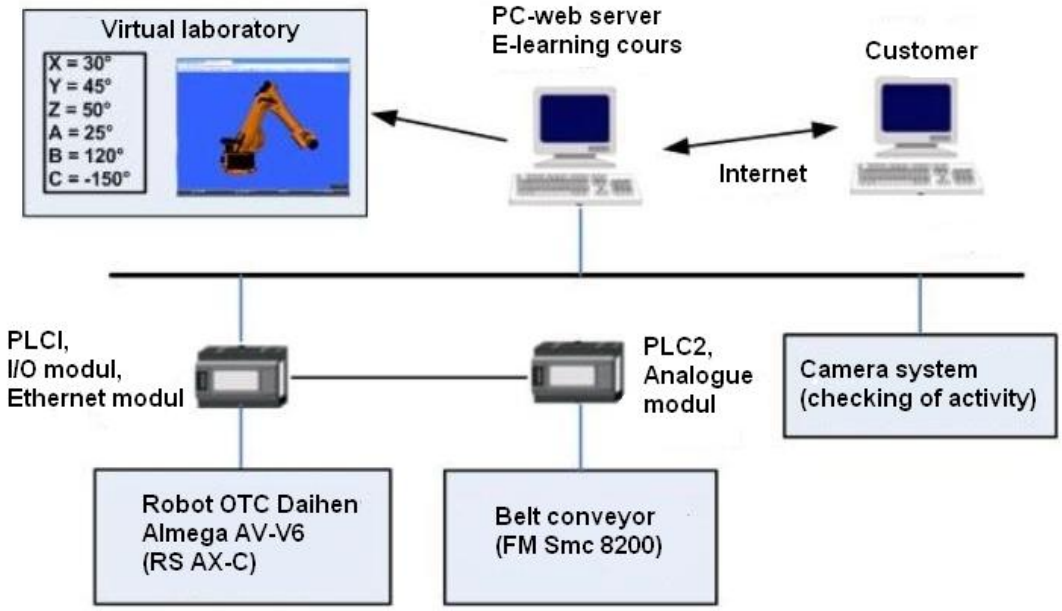

Fig. 2. Access to the virtual lab

In order to guarantee proper safety, the access to the robot must be password protected. Every user logs in to the virtual environment for some time and the learner's activities are monitored in real time. After the end of each lesson, the user is asked to complete an exercise checking her or his knowledge in the fields covered by the lesson. Such an exercise may involve:

- moving specific parts from one place to another;
- moving specific parts from/to a pallet to/from the belt conveyor;
- programming the robot for arc welding of a specific part;
- searching for parts on the belt conveyor using a camera, etc.

In order to prevent unauthorised access, the robot will monitor the virtual environment; therefore, the following requirements have to be met:

- every user must have a unique username and password;
- every user must have her or his own personal account on which all the information regarding her or his activity in the virtual lab are recorded:
    - the log-in and log-out time is recorded;
    - programmes and simulations are stored;
    - information about any other types of activity is recorded.

Summary and conclusions

The development of tools or ICT systems is not the main goal of the VITRALAB project. The task of the project developers is rather to employ the available modern ICT solutions to create an innovative vocational training system.

It must be emphasised that the virtual reality environment is becoming more and more popular in the field of education, but the development of a vocational training lab based on this concept is a pioneering undertaking. It seems that a capability to create virtual learning facilities simulating technological process related to, for instance, automation and robotics, will support the learning process, making it more effective.

The lab should enable the simulation of laboratory exercises in real time, under specific pre-defined conditions and in the most precisely simulated environment. It is essential that the learner understands the goal of each exercise and is able to repeat the exercised activities in real situation, formulate the results of the experiment and draw conclusions from the completed exercise. The e-Learning training course is supposed to support such tasks.

The advancement of information and computer technologies constantly expands the ICT-based education system design and development capabilities. Manufacturers of hardware and software continuously improve their simulation tools that enable more precise modelling of relations present in the simulated environment. The functionality of multimedia effects has also been rapidly improving. The works are being carried out on the simulation of force feedback technology in the virtual reality. Therefore, we might expect that such systems as the one developed in the VITRALAB project will be gradually improved and popularised.

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