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Web-based Learning in Engineering and Management Education: an IIDSP for Teaching of Inter-disciplinary Study Modules

ALGIRDAS BARGELIS
Department of Manufacturing Technologies, Kaunas University of Technology, Kestucio 27, LT-44025 Kaunas, Lithuania. E-mail: algirdas.bargelis@ktu.lt

RASA MANKUTE
Department of Manufacturing Technologies, Kaunas University of Technology, Lithuania

DALIA CIKOTIENE
Department of Mechanical Engineering, Siauliai University, Lithuania

This paper deals with a Web-based Integrated Knowledge-based Inter-discipline Study Portal (IIDSP) for teaching/learning of inter-disciplinary study modules in engineering and management education. A portal has been developed on an integrated knowledge-based approach within engineering, computational sciences and management domains. A due regard is focused on preparation of labs, exercises, simulation procedures and case studies applying the newest achievements of multimedia techniques and the means of visualization. The experience of six European Union countries has been used. Each partner as an informative agent represents his/her own development integrated via the Internet Web and forms the entire common educational system. Within an individual site, the site controller controls his/her own activities and communicates with other sites via the portal through the network interfaces. It is a multi-user method which combines the techniques of HTML, Java/Tapestry application framework and Web server Apache Tomcat. The presented development is intended to update the educational process in universities and colleges and to raise the vocational qualification of company engineers. It is being implemented both in university education process and in industry for employees re-training.

Keywords: engineering and management; inter-disciplines; portal; study modules; web-based education

INTRODUCTION

NEW MANUFACTURING ENVIRONMENT demands from the employees not only perfect knowledge of their core education but also good orientation in the neighbor inter-discipline fields. Companies of global and national manufacturing can buy new machines, computers, technologies, but the main asset of each organization is its people and their competence. The latter task, in general is left to companies because they have to prepare employees in accord with their requirements using the life long learning and other methods. Universities have a mission to educate students for meeting the labour force market requests.

Unfortunately, the differences of academia and industry tasks frequently spring up [1]. A possibility of eliminating or minimizing these differences lies in an improvement of study programmes and development—implementation of modern teaching/learning technologies in universities seeking to educate the broad minded specialists in engineering and management areas. Improvement in an engineering and management study programme has to be oriented into development of products, processes and systems as their nature is related to organization productivity and competitive ability. These factors are crucial for the survival of organization in this competitive age.

During the last decade, the globalization of people activities has also involved the field of learning/teaching in universities and various organizations. University people need much time for their research and administrative work thus leaving fewer slots for their work with students. As such, the imperfect interaction results in discussions with students and outside classroom communication. In fact, the effective learning requires active participation, peer support and interactions among lecturers and students. The diminishing traditional face-to-face interplay makes them contribute less towards the provision of an active and efficient learning environment [2]. This effi-

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ciency can be improved by using the Web-based and distance teaching/learning technologies [3, 4]. The related developments of these education technologies and pedagogical techniques are given in the next section.

The main objective of this paper is to present the Integrated Knowledge-based Inter-discipline Study Portal (IIDSP) for teaching/learning of inter-disciplinary study modules in engineering and management education. Here an integrated knowledge-based approach has been used for development of inter-discipline study programme on the Website within engineering, computational sciences and management domains. The due regard is focused on preparation of laboratories, exercises, simulation procedures and case studies applying the newest achievements of multimedia techniques and means of visualization. The proposed development is intended to update the educational process in universities and colleges and to raise the vocational qualification of engineers in companies.

RELATED DEVELOPMENTS

Global competitive strategies are increasingly becoming technology driven. Technology has turned to be a great equalizer among companies and countries. Technological innovation cannot be achieved without considerable energy and investment devoted by corporate management to developing effective linkages among science, engineering and management [5]. Effective management in engineering, computational and economic sciences demands from managers and engineers an integrated point of view to inter-disciplinary studies. They have to acquire the knowledge and skills that will enable them to compete in professional career.

The concept of technology management is rather broad since it covers not only research and development (R&D), but also the management of product, process and information technologies. The management of technology is thus the practice of integrating technology strategy with that of business in the company. This integration requires a deliberate coordination among research, production and service functions and those of marketing, finance and human resources in the firm. There is a possibility to provide an understanding of alternate educational degree programmes as models for developing managerial skills in technologists, e.g. management of technology (MOT) curriculum [6]. The advantage of MOT is evident; nevertheless a shortcoming of such alternate educational degree programme lies in its narrow area of implementation.

Numerous publications deal with the virtual education (VE), distance education (DE) and application of modern information technologies to the education of students and retraining of engineers. European trends in the virtual education delivery of education (VED) are discussed in [7]. The European Union, with its various research and development funding initiatives has been a major driver of educational change over the past 10–15 years. Wide range programmes such as Fourth/Sixth Frameworks, Tempus, Leonardo, Socrates and Adapt have initiated a large number of projects all over Europe. They have exerted a vital influence on virtual teaching and integrated environment for pan-European delivery of courses. This study has concluded that the growth of virtual teaching/learning in Europe can be identified by specific issues: technology infrastructure limitations, financial impact, human resources impact, learner and teacher acceptance, the reaction of conventional institutions and demographic characteristics.

A distance learning environment architecture developed on a multimedia research platform aimed at the design, generation, deployment, management and use of DE is presented in [4]. The competence notion is a central component around which both authors and students interactions gravitate. The authors generate the training material on the basis of competencies to be acquired by a student and the means to get them, i.e. the related activities and contents. A student accesses the pedagogical material by first selecting his/her learning objectives. The training path is built of dynamically created pedagogical activities.

The advantage of the VE, which is a teaching/learning process based on the principles of active pedagogy when student should take the responsibility for a frequent and effective participation with the characteristics of DE, is emphasized in the work [8]. The DE could be arranged during all classes, or most of them and with the possibility of synchronous or asynchronous interaction among students and lecturers. Another suggestion to apply the VE in teaching as a partially virtual course in which a study module is delivered partly in a traditional classroom setting and partly online is presented in [9]. The paper emphasizes that this approach in addition to its successful aspects has obstacles, too. The principal successful aspect—the partially virtual curriculum—has to be an attractive alternative to both traditional classroom-based courses and exclusively asynchronous ones, because the teaching connected with technology has the potential for active learning. Active learning requires active teaching, particularly in the virtual context. The main obstacle is that transferring an existing course to a virtual setting requires a considerable investment of time and effort in address to various technical and pedagogical issues. The strategy formation in the VE is discussed in [10] and there an administrative model of university or college borrowed from business is offered. Its appeal reflects more the contrast of academic and administrative cultures within higher education, rather than the applicability and value of a virtual learning-planning scheme.

For strategy formation to be successful in conti-

nuing education, it must be precisely attuned to the abounding realities, constraints and opportunities. An interesting study combining the traditional and virtual teaching techniques in cross-border higher education between Finland and Russia is presented in [11]. There, a realistic solution is devised for equal collaboration between two different systems combining the directly applicable features of both academic sectors into an innovative educational structure that offers attractive study programmes and provides a wide range of educational services worldwide. It is succeeded in moving from a set of courses, taught in a conventional manner for foreign students in a host country, to the prototype of a semivirtual international course, accepted by participants and recognized by the academic authorities in two countries.

A culture-based model for strategic implementation of the VED [12] is designed to examine the critical success factors for implementing it in Thailand and to identify the ways for facilitating its adoption leading to effective outcomes. The study incorporates an analysis of three specific factors related to Thai culture. This paper reviews the development of a research model, describes the conceptual underpinning of a cultural model and presents the four findings to enhance VED implementation, namely: improving educational technologies, increasing competency and skills of students and instructors, changing their attitude to accept usefulness of the VED and enhancing the members' cooperation and commitments.

The development of study courses on the Website becomes of great importance in the VE environment. A number of works related to this topic are published. The smart-learning adaptive tele-learning system on the Website is presented in [13], where the learner is able to attend courses according to his/her own rhythm and accesses only the elements of the course that relates to his/her interest. This development is based on the intelligent hypertexts XML, which allow the use of widely available tools. A portal of teaching construction contracts [2] presents a Web-based learning package for post-graduate management courses.

The three key elements of the on-line course framework are active participation, support and course content. The Web provides the learning platform. Active participation is achieved by e-mail and on-line discussion forum. Multidisciplinary nature and diversity of non-traditional manufacturing education have been successfully solved by the developed Web-based curriculum with interactive features in [14]. In this study apart from text, images and sound, the interactive methods have been applied.

A new course of an integrated approach in design, manufacturing and production in the engineering curriculum is presented in [15]. The primary objective of this course is to provide an integrative, hands-on experience in all of the elements of the product realization process and an additional objective is to develop students' competence in the job skills, including teamwork, project management, independent learning and effective communication. The advantage of this course is that the theoretical part (lectures and practice work) is provided together with practical realization of developed products and processes in university laboratories. In the frame of this course mechanical and electronic engineering are integrated. Together, these laboratories offer a broad range of manufacturing capability, which renders the students significant flexibility in product design.

On the basis of the review of published literature, a number of observations have been made. In engineering education the developments related to the virtual education environment in teaching/learning of inter-disciplinary study courses are inconsiderable. The overall conclusion of surveys is that virtual education is really essential for students and employees. On the other hand, systematic investigations and new developments of virtual education methods in engineering context are to be continued.

IIDSP PORTAL DESCRIPTION

Taking into account the importance of technology management in the existing traditional academic degree programmes, in such as the Master of Business Administration (MBA), the Master of Engineering Management (MEM) and the Master of Industrial Engineering and Management (IEM), this paper takes as its requisite to provide an IIDSP on the Website, which can economize study time and resources. Using the DE environment and modern information technologies as HTML, Java/Tapestry and Web server Apache Tomcat the economy of study time and resources are achieved. The IIDSP is oriented to self-training students taking traditional academic Master programmes MEM, IEM and MBA in universities and engineers in companies. It can also facilitate the work of lecturers and instructors in universities and consultation firms.

The main objective of the portal is to develop an integrated knowledge-based inter-disciplinary study programme and teaching materials which can offer a new approach for both students in universities and engineers in companies to acquire the knowledge that is at the boundary of neighbor domains: engineering, computational sciences, economics and management. The students and company employees need the newest information, the data and methods of interaction in neighbor fields of their activities. On the other hand, students and employees frequently work in teams where better communication is possible when each member of a team knows and understands the main principles of an activity in the above-mentioned neighbor disciplines. It means that on the boundary of some different technical, eco-

nomic and management areas of an activity both sides have to search better communication and understanding of each other. Long experience of work with students in universities and engineers in companies has shown the urgency of this problem; therefore it has been kept on the equal partnership in the labor world and educational institutions.

The presented Internet-based IIDSP [16] of an integrated knowledge-based inter-disciplinary study programme in English and Lithuanian languages consists of several intelligent knowledge-based study modules and each of them is located on the individual site. It is a product of international collaboration, because the study courses are jointly generated by six partners of the European Union: Germany, Sweden, Finland, Estonia, Poland and Lithuania. The promoter and developer of the portal is Kaunas University of Technology, Lithuania [17]. The portal structure has in vertical columns the links for home, news, study modules, partner contribution, software, useful links, forum, registration and rules of use. Its horizontal row has guidemarks of portal objective, partners list, results, summary, users and contacts. The outcomes of the portal will help intensify the existing educational study programmes and improve the acquisition of skills and competences of students and practicing engineers in each partner country. The portal contains the modern multimedia technologies, techniques and innovations with Web-based training applications for visualization of teaching materials, practice and lab works.

The overall portal structure is presented in Fig. 1 and its view of MS Window study modules is shown in Fig. 2.The portal is devoted to collaboration in the domains of mechanical engineering, computational sciences, marketing and management where six partners from various countries are involved.

Each partner as an informative agent represents his/her own development that is integrated via the Internet Web and forms the whole common educational system. Within an individual site, the site controller manages his/her own activities and communicates with other sites via the portal through the network interfaces. It is a multi-user method that combines the techniques of HTML, Java/ Tapestry Application Framework and Web server Apache Tomcat. The content of study modules on the developed portal is as follows:

- The study module, Computer-Integrated Manufacturing (CIM), is offered to graduate students in English and Lithuanian languages. This study module integrates various elements and data in marketing, business, engineering, manufacturing, operation and delivery. Some additional products of the CIM study course such as its functional module, business modules in Small and Medium Enterprise (SME) and large organization and peculiarities of production system in CIM environment are made. The CIM study course consists of a theoretical part (11 chapters), six laboratory works and five class works. 3D Computer-Aided Design (CAD) Unigraphic, Solid Edge, Master CAM, engineering modelling software Workflow Modeler as well as KTU developed Computer-aided Process Planning (CAPP) software for laboratory and class works are used. The basic consideration is given to development of interfaces among different manufacturing areas and teaching materials for laboratory and classes, to CIM functional model in particular. This study module has six ECTS credits.
- The study module Virtual Prototyping (VP) is developed for graduate students in English, Estonian and Lithuanian languages. The VP study module has a theoretical part where basic principles of virtual and reverse engineering available in the market 3D CAD systems are presented. It also contains class works where the alternatives of new products and components are developed and estimated by 3D CAD systems seeking the best variant. Modern multimedia tools (3D graphics, pictures, animations, virtual reality, etc.) have been used to build the teaching materials of VP study module on the Website. This study module has three ECTS credits.
- The study module Design for X (DFX) is devel-

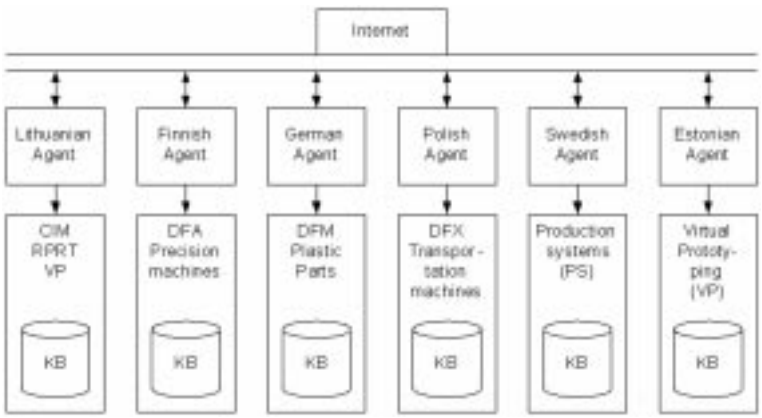

Fig. 1.

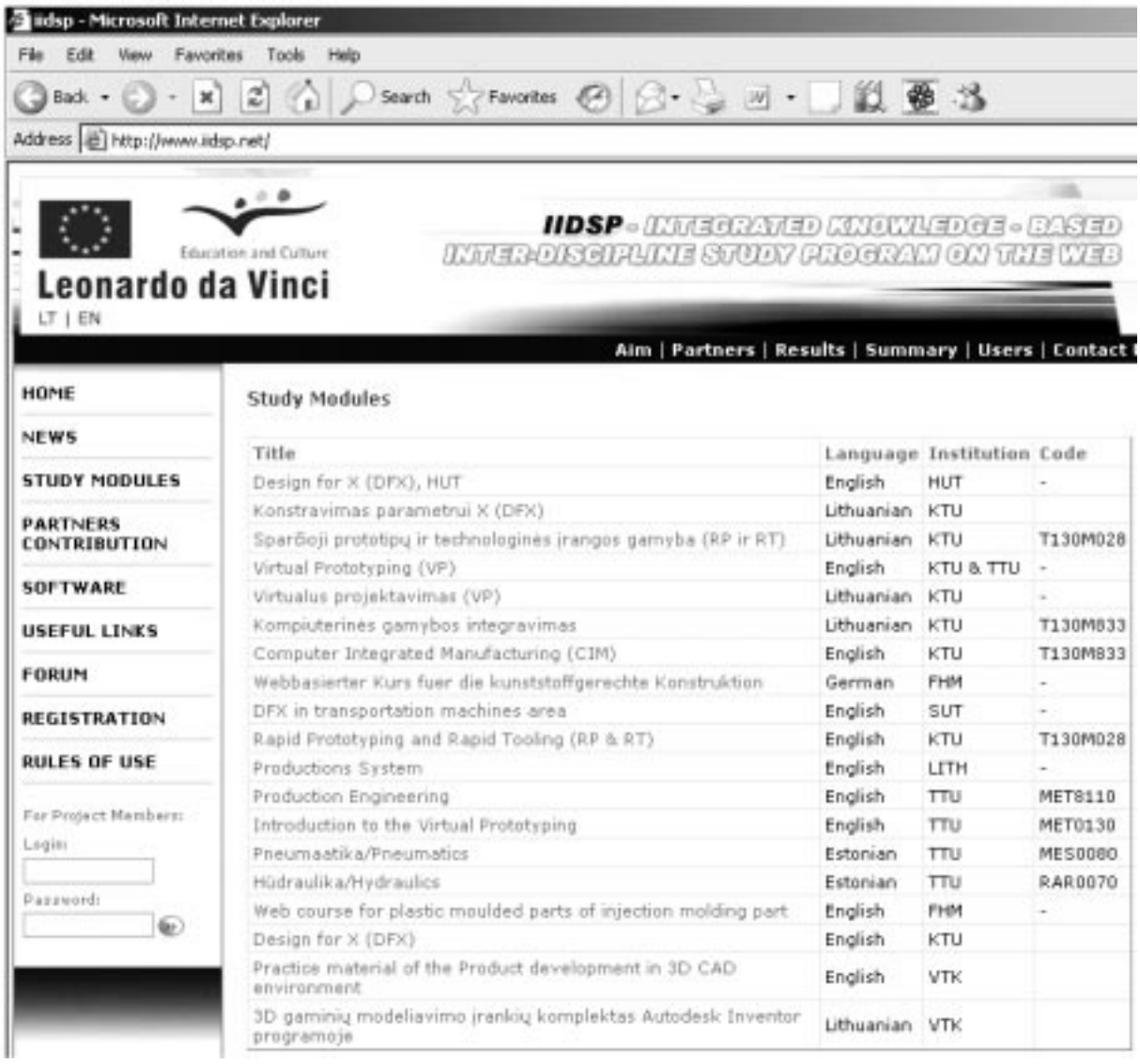

Fig. 2.

oped for graduate students in English, Lithuanian, German, Finnish and Polish languages. Performance X in an acronym DFX bears the meaning of various parameters, namely: design for manufacturability (DFM), design for assembling (DFA), design for quality (DFQ), design for cost (DFC), design for process capability (DFPC), etc. This study course is based on the concurrent engineering approach and consists of a theoretical part, laboratory and class works and case studies. The theoretical part of the DFX study module describes the essence of this method, performance X peculiarities in various technical areas, concurrent engineering advantages in manufacturing and engineering as well as the possible areas of implementation. Laboratory and class works are devoted to achieve the profound knowledge in product and process design, modelling part geometrical form, material to be chosen, variety and number of design features and appropriate processes, machine tools, operations and manufacturing cost. The vital experience of lecturers and research fellows from different European universities grounded on the knowledge-based (KB) systems for developing this study module has been used. Typical study cases for development precision and transportation machines and design of plastic and sheet metal parts are presented in this study module. The DFX study module has six ECTS credits.

- The study module Rapid Prototyping and Rapid Tooling (RPRT) is prepared in English and Lithuanian languages for graduate students and for retraining engineers. Its theoretical part describes five main RP principles with their advantages and disadvantages, peculiarities of an implementation, possible materials for prototypes and practical examples. The developed study module is supplied with an additional material of case studies and short video cases for visualization of the mentioned proto-

typing procedures in virtual environment using multimedia technique. This study module has three ECTS credits.

- The study module Production Systems (PS) in the English language is offered to graduate students. It provides a structured survey of the most important aspects of a modern manufacturing system and develops a systems model for an important type of a manufacturing organization. The PS study course consists of a theoretical part (six chapters) and class works (four topics). This course is created for the route taken by a product as it goes through the whole system, from customer inquiry to final delivery. The class works involve 16 hours and are based on the IDEF system (integrated computer-aided manufacturing). This technique can completely specify the functional relationships of any manufacturing environment. The PS study module has six ECTS credits.

Each partner can use its own development and can work with the developments of the other ones over the portal. To accomplish this combination the programming software of HTML and Java are used, which provide all necessary interfaces to the partners and users. It allows a partner to insert the desired information into a series of text boxes. Each user has a specific username and a password in which, when permission is given a space is allocated on the server to the user, so that all the interactions occur within that space. This method prevents the conflict among the existing users, namely:

- students of mechanical engineering, computational science and management specialties in universities and colleges;
- lecturers in universities and colleges and consultants in industry;
- engineers and managers in retraining courses or long life learning tasks.

The IIDSP concentrates the preparation of study modules on the boundary among mechanical engineering, manufacturing and computational sciences, management and economics. The interfacing procedures in the above-mentioned areas for new product and process development are emphasized. The developers of new products and processes are located in different countries and companies, therefore inter-disciplines study modules are reasonably urgent in the modern manufacturing environment. Considerable attention has been bestowed to the interfacing tools among various study modules, such as software and hardware, functional models, KB and expert systems (ES) in laboratory and class works. The available standard software—CAD has been also successfully applied in combination with original CAPP and Enterprise Resources Planning (ERP) developments [18] for self-training and teaching of students and engineers.

The structure of each study course on the IIDSP is presented in Fig. 3. Each study course developed in accordance with the DE requirements using WebCT [19] and CDK [20] tools (Fig. 4) is of a unified structure. The picture of a study module titular window in the CDK environment is shown in Fig. 5. The basic characteristics of a unified study module structure are expressed as follows:

- Study module material is portioned into lectures and presented concrete and consecutive; it is illustrated by appropriate examples.
- The point of learning is said at the beginning of each lecture with the following questions: What is this lecture about? What will you learn? What kind of skills will you acquire?
- The answer variants to students' self-control tests are given at the end of each lecture; they comprise either three or more questions, or a practical exercise.
- The list of prime and additional literature for each lecture is given.
- Glossary of all material is formed.
- All material for the study course is prepared by the MS Word text editor.

The IIDSP is implemented in the Master study programmes MEM and IEM of Kaunas University of Technology (KTU) and Siauliai University (SU); it is also used in the curriculum of Vilnius Technical College. The benefit of IIDSP implementation in the education process of two Lithuanian universities KTU and SU has been considered for both lecturers and students. The comparison of lecturers weekly/monthly work-schedule plans applying the IIDSP in the period of 2004 spring—2006 spring to those without the mentioned technique applied in the period of 2002 spring—2004 spring has shown an evident tendency of a decrease in lecturers daily preparation time to 20–40% due to the IIDSP. In fact, basic job and investments for portal development have been done prior its implementation.

The student questionnaire for estimating the benefit of using the portal has been also prepared. Unfortunately, only 32% responses have been

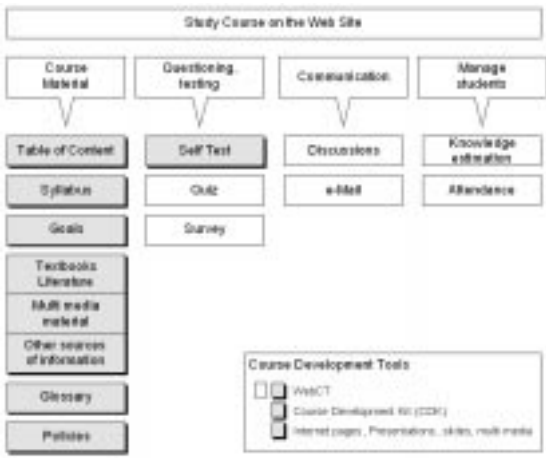

Fig. 3

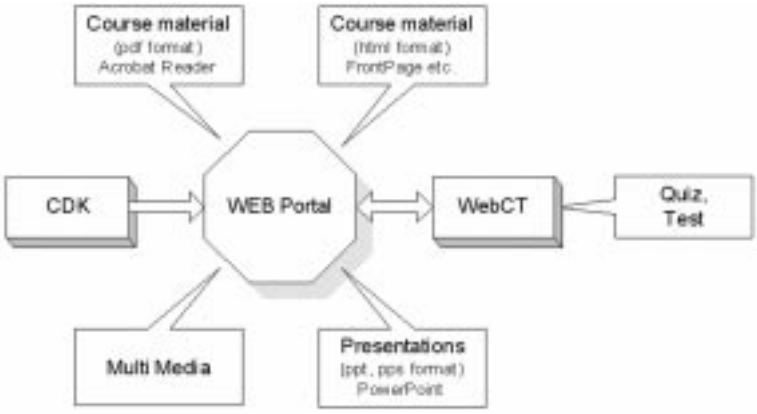

Fig. 4.

Fig. 5.

received and the majority of respondents have pointed out the advantages in self-training quality, learning flexibility and economy of their time preparing reports, exams and class tasks. The discussions with some students on the study module available on IIDSP have also confirmed the economy of their learning time approx to 30–50%.

The portal is also successfully used in the European Socrates/Erasmus programme by students—guests arriving for one semester study from other universities to the KTU, in particular. The implementation of the results of this research in the knowledge-sharing hybrid manufacturing systems and re-training courses is presented in the earlier publication [21], while another publication is devoted to the virtual education development in the transportation disciplines [22].

CONCLUDING REMARKS

The need of special materials has been furnished by creating the Web-based supporting materials and study modules for complementary and additional education in the inter-discipline fields. The development has confirmed the urgency of the interfacing among mechanical engineering, manufacturing and computational sciences, management and economics. The IIDSP devised for graduate students and practicing engineers is to be accessible to everybody. Technical universities and colleges can enrich and enlarge their educational offer in gaining a proper knowledge of broad-minded human endeavour.

The method described in this paper accomplishes the objectives of this research. Nevertheless, it has its advantages and disadvantages. The advantages are: the presented development increases the potentials for students to acquire better skills in the inter-disciplinary field, teamwork, communication and decision making during their engineering education. Students can better imagine and understand the whole business process in company and, in particular in finding successful products for market and processes for minimal manufacturing cost and product delivery time to customer. The main drawback of the described portal is its orientation on mechanical products only, while it has also a few constraints on new product and process concept development.

The brief conclusions are as follows:

- The developed IIDSP economizes lecturers' preparation times for lectures and classes up to 20–40% and students' learning times up to 30–50%, because they can do their individual work and tasks being away from auditorium.
- The portal can successfully intensify European students' mobilities applying the EC Socrates/Erasmus and other exchange programs for students and lecturers.
- The implementation of this development in industry for knowledge sharing in hybrid manufacturing systems and employees re-training courses can upgrade the long life learning European program.

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Algirdas Bargelis is a professor in Mechanical Engineering in the Department of Manufacturing Technologies at Kaunas University of Technology (KTU). His research and teaching interests include computer-integrated manufacturing, intelligent manufacturing systems, concurrent engineering and development of knowledge-based systems in manufacturing. He was a coordinator of EC Tempus JEP Project No. AC_13183–98 Education of Integrated Design and Manufacturing (1998–2001) and was a contractor of EC Leonardo da Vinci pilot project Integrated Knowledge-based Inter-discipline Study Program on the Website (2002–2004). He is a coordinator of the academic programme the Master of Industrial Engineering and Management (IEM) in KTU. Professor Bargelis received a Diploma Engineer in Mechanical Engineering from Kaunas Polytechnic Institute in 1964 and Ph.D and Ph.D habil degrees in 1974 and 1997, respectively, in Mechanical Engineering, from Kaunas University of Technology.

Rasa Mankute is an associate professor in the Department of Manufacturing Technologies at Kaunas University of Technology. Her research and teaching interests include manufacturing strategy, computer-aided process planning and enterprise resources planning. Dr. Mankute received a Diploma Engineer in Computational Sciences from Kaunas Polytechnic Institute in 1986 and Ph.D. degree in 2000 in Mechanical Engineering, from Kaunas University of Technology.

Dalia Cikotiene is a lecturer in the Department of Mechanical Engineering at Siauliai University. Her research and teaching interests include customer–manufacturer relationships, design for costs, computer-aided process planning and ergonomic. She received a Diploma Engineer in Mechanical Engineering from Kaunas University of Technology in 1994 and M.Sc. degree in Mechanical Engineering from Siauliai University in 2001.