Developing an Interdisciplinary and Multinational Software Engineering Curriculum

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***Abstract* - The European Commission and the US Department of Education have funded ATLANTIS initiative to promote collaboration in the higher education between European and American universities. In this paper, the authors present a brief description of one of the funded projects. The goal of the project is to create a new collaborative multinational model for interdisciplinary education in real-time software engineering. The proposed study will lead to creation of an international curriculum framework focusing on important aspects of this multidisciplinary computer/system/control/software engineering education.**

Index Terms - engineering education, curriculum design, multinational, international education, multidisciplinary

INTRODUCTION

University-industry relationships often act as the inspiration for applied research and curriculum development, raising new questions and challenges. Industrial multidisciplinary engineering projects often require new and diverse staff competencies. Engineering educators face the challenges associated with industrial demands, which are considered as one of the driving forces for faculty to modify educational curricula.

In numerous areas of business and engineering, increasing international co-operation has led to new demands on employees. Universities should prepare its graduates to adapt to increasing globalisation and to be open to the ideas and experiences of the international community in research, design and administration [1].

Only few universities in the US and Europe have systemically adapted their engineering curricula to address the needs of engineering practice in a global environment [2]. Due to specialization, the traditional research is often more depth- than breadth-oriented, the interdisciplinary activities and close collaboration between departments are often hampered by the administrative constraints. The modification of engineering curricula is limited by the interests and competencies of the faculty, the availability of well equipped laboratories and the related costs.

International cooperation is an important element for the university to develop relevant educational and research programs in a cost-effective manner. Several universities are conducting international study abroad programs. However, they do not support new programs, particularly in interdisciplinary, computing-related fields.

The European Community and the US Department of Education have funded an initiative (ATLANTIS) to promote collaboration in the higher education between European and American universities. One of the recently funded projects is described in the paper. The objective of the project is to create a new collaborative multinational model for interdisciplinary education in real-time software engineering.

A two-year policy-oriented project engaging four university partners was proposed. The proposed study will result in creation of an international curriculum framework focusing on important aspects of this multidisciplinary computer/system/control/software engineering education. An interdisciplinary specialization in Real-Time Software-Intensive Control (RTSIC) was not only selected to produce educational artifacts in a domain highly demanded by the industry [3], but intended as an example of methodology for creation of engineering programs with compatible quality assurance and assessment process. The multidisciplinary project poses a challenge for a single institution due to required range of competencies and resources. The project partners provide a good mix of competences in the field of control, hardware, software, and the pedagogical aspects, to achieve the proposed objectives.

The project described in the paper leads to designing a curriculum framework, identification of implementation and assessment mechanisms, collection of data necessary to evaluate the process, and guidelines for expansion of the proposed approach to other engineering programs.

COLLABORATION: MOTIVATIONS, GOALS AND SCOPE

Universities develop international cooperation and create international educational programs for many reasons. Such collaboration ranges from special courses or events offered over a few days (e.g. summer schools) to full curricula that include several courses and may take quite a few semesters to complete.

The ILERT project described in this paper leads to establishing a methodology for a **multinational, engineering program** producing graduates capable of working efficiently in **multidisciplinary teams** engaged in

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international collaboration on industrial projects, requiring conformance to specific standards mandated by regulatory authorities. The ultimate objective is creation of a "model curriculum" accepted by partner institutions, which can be used by other engineering schools in the US and EU.

Preliminary research [4], [5], [6] have shown that, at this time there is no international, interdisciplinary curriculum in information technology that directly focuses on real-time control systems, dependable software development, safety, reliability and the certification issues in highly regulated industries like aerospace, medical, transportation, and nuclear that would reach across the Atlantic.

The proposed two-year project includes two complementary groups of activities. The first one is more general and focuses on methodology and process of creation of a unique area of real-time software-intensive control. This one is of a great interest to industry and combines elements of control, software, and computer engineering programs. The second is a practical case study adapting a selected curriculum unit acceptable for engineering programs in the four participating organizations. The ultimate goal of the project is to establish credible methodology for a complete engineering curricula implementation.

On the long run, these objectives are consistent with the following complementary goals:

- Obtain international perspectives on the extent to which local curricula work is consistent with evolving professional needs.
- Expose the engineering students to the opportunities of international collaboration and thus stimulate them to consider the area of real-time safety-critical control systems as their chosen career.
- Encourage the exchange of staff and students among partner institutions.
- Offer multidisciplinary and multicultural experiences to students who would not otherwise have such opportunities.
- Provide a forum for the faculty teaching in this domain to exchange ideas on the issues of curricula building, laboratory experiments, and assessment activities.
- Produce new concepts and ideas for developing short studies, courses, or curricula in partner institutions.
- Create a base for Internet-based educational experience for students in different countries exposing them to tools, methods, and techniques used in creation of highly dependable safety critical systems for regulated industry.
- Stimulate faculty of the European partners where the language of instruction is not English to develop and introduce English versions of lectures and teaching materials.

COMPETENCIES OF PARTNERS

The proposed project is multidisciplinary in nature and requires competencies that may be challenging for one single institution. Opportunely, the project partners provide good mix of competence in advanced information technologies [7], [8], [9]: not only control, hardware, and software, but also the pedagogical aspects, thus assuring a full coverage of the expertise necessary to achieve the proposed objectives (see Figure 1).

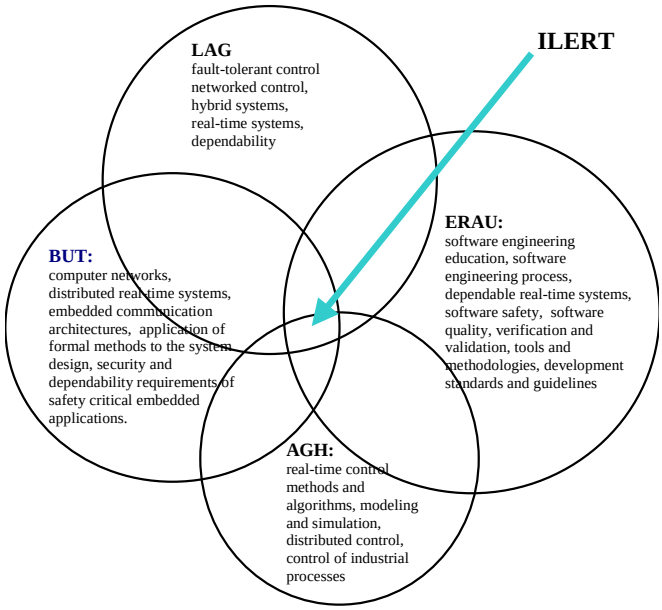

FIGURE 1: EXPERTISE AREAS OF THE ILERT PROJECT PARTNERS: ERAU- EMBRY RIDDLE AERONAUTICAL UNIVERSITY, AGH - AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY , BUT - UNIVERSITY OF TECHNOLOGY BRNO, LAG - LABORATOIRE D'AUTOMATIQUE DE GRENOBLE

The proposal uses the expertise and educational experiences of the four partners to address and enhance learning of RSIC in an integrated way. However, the objective of this activity is not only to serve narrow population of the safety-critical real-time control system developers, but also to disseminate results and provide guidelines to a broader audience of engineering education faculty. The project plans to capture the process and methodology of creation such multidisciplinary and geographically diverse activity for potential re-use by others and thus increase the benefits gained from the project participants' experiences. The partners include one American and three European universities located in three EU countries, where English is not the language of instruction. These partners not only have the necessary human and material educational/research potential but, through their extensive industry and international outreach, they also recognize the needs of the current and prospective labour market for real-time control education, both in Europe and in US. There is a commonality of goals of the partners, but significant differences in organization, funding, and procedures.

PHASES OF THE PROJECT

Development and implementation of international curricula can be divided into several phases. In this case four phases were defined: the Preparatory, Research, Pilot Implementation, Long Term Application and Evaluation (Fig.2).

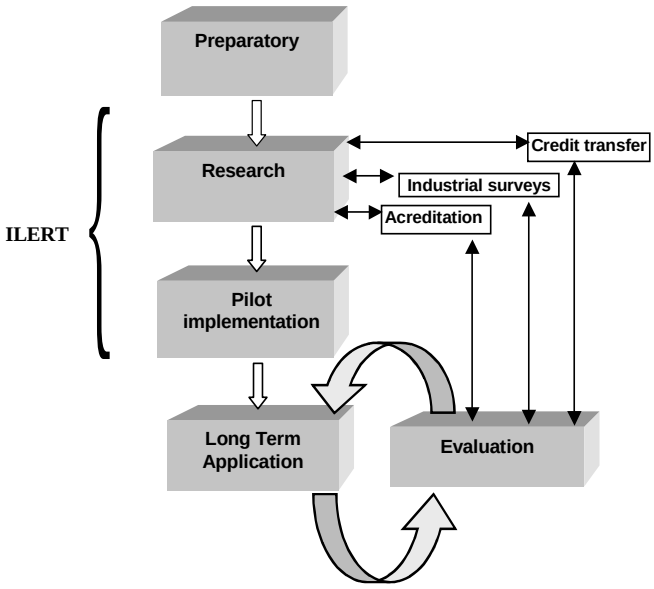

FIG.2 DEVELOPMENT AND IMPLEMENTATION OF INTERNATIONAL CURRICULA

PREPARATORY PHASE

The preparatory phase started with opening a dialogue at faculty management level about why international relationships are advantageous for the faculty. The following items identify the activities:

- Inventory of international informal personal contacts already existing in institutions.
- Brainstorming on the type of activities to be engaged and with whom and defining goals and priorities (the most obvious curriculum-related cooperation are international exchanges of the faculty expertise).
- Exploration of potential for financial support (including industry funding, international cooperation programs, international projects, international and national systems of grants).

This phase was concluded by writing a successful proposal of educational research project.

RESEARCH PHASE

The research phase started with **analysis of industry requirements** on graduates in the RSIC domain. Next steps are the following:

- **Defining learning objectives** and outcomes, identifying the curriculum framework, exploring the partners' programs commonalities, laboratory infrastructure, identification of the curriculum content, and analysis of the educational process assessment. One needs to note, that the existence of common characteristics does not mean that there is automatic commonality among the ways in which individual institutions pursue common educational objectives. Universities often find their own ways to let shared content shape the development of procedure and method.
- **Curriculum development includes** two complementary groups of activities. The first one, more general, focus on methodology and process of creation of a unique and demanded by the industry curriculum framework in the area of real-time software-intensive control, which combines elements of control, software, and computer engineering programs. The second is a practical case study adapting a selected RSIC curriculum unit acceptable for engineering programs in four organizations based on the commonalities in the partner curricula. The curricula are reviewed as a way of prioritizing and integrating the various elements in order to fulfill the specific program requirements of interdisciplinary specialization in Real-Time Software-Intensive Control. A proper sequence of courses is proposed.
- **Credit transfer and accreditation issues.** The development of new curriculum framework in information technologies may in turn require new approaches to validating and accrediting learning programs. Existing and emerging structures for accreditation, quality control and credit transfer (such as the European Credit Transfer and Accumulation Scheme) are analyzed and coordinated. The proposed curriculum units are developed according to ABET standards (and the applicable standards of Ministry of Higher Education in the European countries) focusing on the objectives and outcomes of the educational activity.
- **Students' mobility plan.** Based on the developed curricula a schedule of students' mobility between partners' institutions is proposed, opening possibility of collaborating and enrolling in the same course offered concurrently in four partner sites.

PILOT IMPLEMENTATION PHASE

Possible agreements between institutions or "memoranda of understanding" in delivery and mutual recognition of RSIC courses need to be prepared at the beginning of this phase. During the pilot implementation phase the experimental courses are created, instructional material is developed and experimental concurrent delivery with limited student engagement is conducted on a special topic basis, compiling a number of studies on transatlantic exchange. The participating students will be supervised by a co-ordinators from partners' institutions.

Final Report including **guideline for extension of the approach to other engineering programs** will be prepared. The recommendations for selection between single or dual degree programs will be given in the report. Important part of this phase includes analysis of the sources and mechanisms of **financial support** for future transatlantic educational collaboration.

LONG TERM APPLICATION PHASE

The long term application and evaluation phase will develop internal and external procedures for long term application of the project results:

- **Internal selection procedures** for students who want to be engaged in exchange studies abroad. In collaboration with partner institutions abroad, a standard application procedure and standard learning agreements will be developed.

- **Agreement on the recognition issues** will be proposed to use credit transfer points.

CONCLUSIONS

The project is intended to strengthen EU/US co-operation and the international links in engineering education. An interdisciplinary specialization in RSIC was selected to produce not only a number of educational artefacts in a domain highly demanded by the industry, but also (what is more important) a process and a methodology for creation of engineering programs with compatible quality assurance and assessment process. The graduates of such a program will be better prepared to work on projects requiring interdisciplinary and multicultural viewpoints. This enhances mobility of the future workforce and facilitates their advancement and career changes.

This project is only a beginning. It provides analyses that contain understanding of curricular expectations, evaluation mechanisms, and definitions of quality and assessment. The collected observation and data will provide the base and guidelines for future implementation of complete coordinated multinational engineering programs. These programs become starting points for the transatlantic efforts between individual schools.

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