

Developing a Western-Style Information Systems Engineering Curriculum and Infrastructure*

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A previous paper (Neal and Kratchanov, [1]) described the background to the TEMPUS project 'Establishing a Model Faculty of Advanced Information Technologies'. This has created a Western-style undergraduate degree course at two Bulgarian Universities. This paper describes the results of the project three years into delivery of the curriculum. The new curriculum is described as well as the infrastructure to support it. The work has been carried out as part of a three-year TEMPUS programme, JEP 2614, which has included many mobilities and exchanges between Bulgarian and Western European academic staff and students. New structures have been set up at the two Bulgarian universities to administer the courses and an International Board of Study has been instituted to ensure that the standards are seen to be compatible with similar degrees in the West. The Departments have been equipped to Western standards. The new curriculum has been established and the course recognised by the Bulgarian Ministry of Education, Science and Technology.

INTRODUCTION

THE PROJECT, which started in September 1991, has initiated the creation of an educational infrastructure across two Bulgarian provincial universities that acts as a focus for the development and delivery of a number of undergraduate degree programmes in Information Systems Engineering. This division is considered to be a model of a complete pattern of Western-type education, both as regards organisational structure and teaching methodologies. A report on the background and early stages of the project is to be found in Neal and Kratchanov [1].

The project comprised partner universities and companies from Bulgaria, UK, Germany, France, Belgium, and Ireland. The type of academic partners involved varied from typical universities to higher education institutes such as INSA (France) and Fachhochschule (Germany). In addition, students and staff from Bulgaria were able to benefit from extensive work experience with Siemens-Nixdorf in Munich, Germany and Hitachi in Dublin, Ireland.

This paper addresses the successes arising from

completion of the TEMPUS project and the results of implementation of the curriculum in its first three years. The new curriculum as planned is described as well as necessary modifications together with the infrastructure needed to support the delivery of the curriculum. Innovative networked computing facilities have been introduced to the universities and access to these facilities have been made to other colleagues within the institutions. The paper aims to share the experiences gained in contributing to the higher education reform in an Eastern European country, and in particular in overcoming some of the many difficulties such undertakings inevitably face.

BACKGROUND

Changing needs

As described in the previous paper, the main thrust of the new courses was to produce graduates who would be able to support the commercial infrastructure steadily being built up following the changes. The economic need now is for a new type of information system engineer: knowledgeable and skilful in the modern systematic procedures for analysis, specification, design, testing and

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maintenance of complex information and control systems.

The two Bulgarian universities

The two Bulgarian universities involved are the oldest (Rousse) and the newest (Plovdiv) technological universities outside of the capital, Sofia. Each has a heavy engineering bias with computing expertise in narrowly defined areas. Degree programmes in Computer Engineering but not in Computer Science or Information Systems have been in place for a number of years.

The staff available are on average comparatively young. In many cases their lack of experience is complemented by their ambition, modern outlook and enthusiasm. The two regional Universities have proved more open for change than some parts of the country's centralised and dominant institutions. It must be stressed that the project has to be implemented under conditions of a severely restricted budget, hence they had to be very careful about undertaking any steps (bearing financial consequences) of their own connected directly or indirectly with the project.

National and institutional policies in higher education

In reforming the higher education sphere there is a consensus that Bulgarian university education should become more closely aligned with European and world standards. However, the transition process is a slow and difficult one, with a number of factors impeding it.

The final state at which the reform is aimed is as yet unclear—even the basic milestones are not fixed yet. One of the first new laws adopted by the Parliament, as early as in January 1990, only two months after the beginning of the changes in the country, gave the universities a really high and unprecedented level of autonomy. However, this law for Academic Autonomy of Universities, which was intended to be of temporary nature only, led also to certain contradictions and ambiguities in the higher education legislation. At that time, the responsible Ministry and Parliament failed to continue the legislative process and to produce an interrelated and balanced formal basis for the reform in higher education.

For a number of years now it has been widely believed that the two-degree 'Anglo-Saxon' system (Bachelor/Master) will be advantageous but, during the formation of the courses, only the old single degree formally existed. (In engineering education this is the Diploma award of 'engineer' which is typically awarded after completing a course of five-years duration). Some universities have introduced Bachelor and Master courses though their legal status was unclear. To overcome this particular difficulty the new courses were planned to produce graduates comparable with a United Kingdom first degree after a four-year period of study, but leaving the possibility to add a fifth year if necessary. However, in December

1995, a new Law of Higher Education was passed, introducing Bachelor and Master degrees, allowing for the original plans to come to fruition.

Other problems and challenges

One other national factor which is of major importance for the implementation of our project is the status of the newly introduced fee-paying student education, as an alternative to the free (i.e. fees financed by the state) education. A serious drawback of the fee-paid courses is that, in contrast to the state-supported ones, the male students have to complete their compulsory military service before they go to university. Combined with the necessity to pay substantial fees, this results in a general decrease in the quality of the student intake. The Ministry refused initially to approve any state funds for new courses arising from TEMPUS projects. So, at both Bulgarian universities, the courses started, from the academic 1993/94 year, as fee-paid ones. This problem has now been overcome in Rousse with the new intake into the second year of the course.

The project started in September 1991—the first year in which Bulgaria was eligible for funding within TEMPUS. TEMPUS itself was the first international large-scale programme involving Bulgarian academia. This meant that the project co-ordinators have had to spend considerable energy setting up the new procedures and overcoming the considerable difficulties associated with an innovative project of this nature.

Amongst problems at institutional level that had to be overcome was the subsidiary nature of TU-Plovdiv to its parent, the Technical University of Sofia. Proposals for the new curriculum were blocked by this latter Institute for no apparent good reason. The new courses at Plovdiv were only able to be mounted by obtaining approval through the main, independent, 'Paisiy Hilendarski' University in Plovdiv. Fortunately there was excellent, positive support at Rousse, where the university is independent.

Another major factor at local level was the psychological impact of change that the implementation of the project exposed. The moment of inertia of the existing structures and academic staff is considerable. On several occasions we had to face active distrust and fear of new ideas and any changes, suspicion and fright of competition or any change of the status quo, envy, parochialism, or simply apathy. But, at the same time, the great enthusiasm shown by so many colleagues at both Bulgarian universities, from the partner institutions, and elsewhere, has contributed towards the project's success.

BASIS OF THE CHOSEN SYSTEMS AND COURSE

A lot of attention, especially during the first year of the project, has been paid to studying the

organisation of teaching in the EC partner universities, USA and elsewhere.

Our exploration showed that there were great (even principal) differences from country to country, smaller though substantial ones between higher education institutions within a country. For example, the first two years are effectively common for all engineering students in France, almost the same for all students of electrical engineering courses in Germany (and Bulgaria), but quite specialised in the UK. The degree of liberty a particular student has in choosing his or her own curriculum also varies substantially, which is strongly connected with the level of inter-subject dependencies.

It was decided to take the British model as a basis for designing our new programme of study. We would like to just mention some of the cardinal differences between the UK and the existing Bulgarian systems for higher education. The way of delivering the material is much more pragmatic and inductive (rather than deductive) in the UK. The forms of teaching are much more diverse and flexible. The staff pay a lot of attention to individual work with every student. There is greater emphasis on private, self-organised and self-paced work. The preparation for assessment, associated with quality issues, is wider than in Bulgaria. The laboratory exercises (workshops) are very often integrated into a separate module, including material from different subjects. A unique system of external examiners is functioning to maintain academic standards and engineering courses are periodically reviewed and accredited by recognised professional organisations. The allocation of duties and authority within the faculties and the departments is also different.

For the new curriculum it was necessary to draw up new academic rules (the normal existing internal university regulations were not adequate for the new programme of study). The timetable of studies adopted was also new to the Universities with each year consisting of two terms of contact classes, a short period for exams, followed by a term of project work or practical placement. The curriculum and syllabuses produced for all the subjects incorporated a much greater flexibility in forms of teaching and assessment than previously known in Bulgaria. Based on regulations and arrangements at the partner British universities, especially Brunel University and Imperial College, the new arrangements are essentially new. They are an adaptation and a combination of the existing ones but targeted at the conditions in Bulgaria.

TEACHING CONSIDERATIONS

In common with the trend in Computing Education both in the United Kingdom and elsewhere, the approach taken has been to view the construction of computer systems as very much an engineering activity. A good engineer draws from

his scientific knowledge to construct artefacts by evaluating their fitness for a purpose. The objects that an information system engineer creates (software packages or integrated hardware/software systems) are of a very high complexity and reflect comprehensive human concepts. This is then precisely an area where the use of an engineer's systematic approach to the management and assessment of solutions is of vital importance.

The present expertise of the Bulgarian staff overlaps with that required for the new schemes of study. However, it is within restricted fields of computing and has a bias towards applications of certain areas of traditional engineering (especially computer and control engineering).

The country has had no business community with the competitive markets upon which a large part of the commercial information technology of Western computing degree courses is focused. Also larger companies and specialist computing firms use project teams to construct the software for large systems using the concepts and disciplines of 'information systems engineering'. This is seen as the application of engineering principles and methods to the construction and use of software needed for information systems. At the start of the project this area was new to existing Bulgarian academic staff. During the project staff were able to retrain so that they are now in a position to educate the next generation of information technologies that will be needed to lubricate the structure necessary for Western-style commerce. In the three-year period of the project over 150 exchanges, visits and mobilities took place to enable staff to update their knowledge and to retrain in new areas. Also a small number of students have had the opportunity to study in the West and also to work for periods in Western computing firms.

THE NEW CURRICULUM IN INFORMATION TECHNOLOGY

The Curriculum developed for the new course is shown in Table 1. The nearest analogue is the integrated engineering study scheme in computing introduced recently at Imperial College, with also strong influence from Brunel's syllabuses for individual modules. A detailed comparison between the Imperial College curriculum and well known standard curricula and recommendations of ACM/IEEE and IEE/BCS has been done in Finkelstein *et al.* [5]. Comparisons were made between the core computing material in our curriculum with the above, and those of Brunel University, Imperial College and also Carnegie-Mellon University in the USA.

One structural aspect felt important was the use of a three-term pattern, with the teaching in the first two terms and extended project work in the third. This was to recognise the worth of industrial and commercial work placement of students, an

Table 1. Information Technology Curriculum at University of Rousse and Technical University of Plovdiv, Bulgaria

Y1	PC101 Computers and Applications	PC601 English		CS301 Discrete Mathematics
	CS102 Programming 1	CS201 Computer Systems 1	PC602 Professional Communications	W1 Integrated Workshop 1
	Project 1			
Y2	CS103 Programming 2	CS202 Computer Systems 2	CS302 Continuous Mathematics	W2 Integrated Workshop 2
	CS104 Information Systems 1	CS203 Computer Systems 3	CS303 Statistics	W3 Integrated Workshop 3
	Project 2			
Y3	CS105 Software Engineering 1	Information Systems 2 IS107	CC206 System Engineering IS108	CC204 Hardware W4 Integrated Workshop 4
	Software Engineering 2 IS106	CC205 Computer Measurement and Control	OH Humanities Optional O1 Optional 1	W5 Integrated Workshop 5
	Practical Placement			
Y4	CS401 Marketing and Law	Artificial Intelligence 1 IS109	CC501 Computer Integrated Manufacturing	O2 Optional 2 W6 Integrated Workshop 6
	Management IS402	O5 Optional 5	O4 Optional 4	O3 Optional 3 W7 Integrated Workshop 7
	Final Year Project			

important part of the courses at Brunel University. In Bulgaria there is little scope as yet for such industrial-based work. The intention, however, is to base the student project work in real-life contexts, producing systems for direct use by Bulgarian enterprises.

In designing the curriculum we have also taken into consideration the following three points. British universities normally have a few similar courses centred around theoretical computer science, applications (in management, business, economy, psychology, etc.), artificial intelligence, etc., or joint courses (e.g., with mathematics or electrical engineering). There are usually also separate programmes in computer engineering or electrical engineering with specialisms in computing. This does not seem to be feasible for our case because of the much more limited needs for specialist graduates in Bulgaria, the constrained

staff resources, and the much smaller number of students. The second factor to be taken into account was the existing good background among the staff in computer, electrical and system engineering. For these reasons we adopted a unique curriculum with two streams: Information Systems and Computer-based Control Systems respectively. Finally, what is being designed is a Bachelor, not a Master course.

The intention was that the course will be taught primarily in English, with textbooks and reference books in English only. For those students whose command of English is not enough, a preparatory year is envisaged (not shown in the table). The question of the medium of study (English/Bulgarian) is still under discussion.

In preparing the syllabuses and the teaching materials the experience of all the university partners has been used. However, always the final

result is something new, designed especially for the particular degree course. It was felt entirely inappropriate in this area to transplant an existing Western course curriculum directly into Bulgaria.

THE INFRASTRUCTURE

The need for networked systems

A modern computing department makes use of several levels of information technology. The practical exercises and workshop activity within an undergraduate degree course require student access to a range of computing equipment from standalone PC's through networked workstations to wide area networks for information retrieval. The TEMPUS project has enabled a large number of Bulgarian staff to spend time at Western universities to up-date their knowledge in this area and also to develop their research expertise. The project has been able to provide small research laboratories at each location as it is important that staff teaching particularly the latter parts of the courses do so from a firm research base. Also an administration infrastructure is needed for student records, procedures and regulations, module outlines and study guides and, increasingly, for teaching purposes such as automated assessment and the provision of teaching material via multi-media technology.

During the first year of the project Bulgarian hardware specialists increased their knowledge by studying the present-day facilities used in computing departments in Western countries particularly in the United Kingdom and Germany. The second year saw the specification of the new systems required to equip the laboratories and workshops of the new faculty. The core of these systems have now been installed at both Bulgarian universities. In addition international links were created with partner universities, providing direct access to much Western information.

Solutions

At the start of the project the universities were equipped with 286 processor technology, VAX 11/750 minicomputers with ASCII terminals and graphics stations. There were no networking facilities in the local laboratories or in the rest of the universities. Nationally, the level of equipment in other Bulgarian universities was very similar. There were no links between universities and also no international links.

After consultation with the Western partners to the project and building on their experiences, it was decided to create a heterogeneous network interconnecting UNIX servers and several PC's and terminals. These facilities were required to support the following activities:

- local laboratories, including student laboratories and research centre;
- university-wide facilities, including links to other departments and the library;

- national and international links, including connections to other Bulgarian universities and to the Internet via BULPAC.

Ensuring quality—the International Board of Studies

One aim of the project is to produce graduates whose qualification is recognised as of comparable standard to graduates in computing in the rest of Europe. The mechanism chosen to achieve this has been to set up an International Board of Studies for the degree programmes. This Board will set standards and be responsible for changes to the curriculum. Each Bulgarian university will implement this curriculum according to its own procedures but must work within the criteria set up by the Board. Membership of the Board includes computing professors from Western Europe who will act in a manner similar to 'external examiners' in the United Kingdom. One such examiner has already monitored the first-year results at both institutions. Also staff in the Bulgarian departments are being encouraged to take up the quality procedures, for example reviewing examination papers and moderating marks, now in place at most UK universities.

CONCLUSIONS AND ACHIEVEMENTS

The new course successfully started at both Plovdiv and Rousse in October 1993, with a first year intake of over 20 students at each university. At the end of the year conclusions were drawn from the first examination results and from detailed students' questionnaires.

As a general observation, the year proved the feasibility of the approach taken. The students' interest in attending classes, learning and private work with the definitely attractive computer facilities provided was unusually strong. In contrast to many other fee-paying courses the students' progress was good. The examination results produced a good distribution. Some students, already enrolled into other traditional courses, have expressed interest in transferring. Both the academic staff and the students successfully adapted to the novel teaching environment and style though there is a lot of scope for further improvement.

The students who joined the new degree course in 1993, are completing their third year of study in 1996. It is becoming very clear that their specialised knowledge and skills will surpass by far those of the students reading the traditional courses (mainly because of the very early start of the teaching of specialised topics that form the basis of computer science). Generally speaking, the level of these students at their third year is approximately equal to that of the traditional students by the time of their graduation (year five).

In their project work, the students of Information Technology have found a variety of 'real-life' problems to tackle, usually on their own initiative and with the lecturers' support. They have started 'real' work on the development of the departmental information infrastructure (information systems covering the teaching documentation, students' status, etc., the preparation and maintenance of the university web pages). A number of students in years two and three took part-time jobs, mainly as system administrators with firms pioneering in the introduction of advanced information technology.

The intake at both universities has stabilised at about 25 students a year. With its very active policy, the Rousse University has achieved a very important step forward—it has been assigned by the Ministry of Education, Science and Technology to teach 25 students financed by the state.

When the departmental LANs were firstly designed and installed, they were among the first and the most advanced at Bulgarian academia. Very few people at the universities (if any) knew about the possibilities that such networks provide, especially their connection with the Internet and the world's information resources. Now many teachers, students, and external users, on their own experience, discovered these incredibly rich facilities. At Plovdiv, for example, users of the LAN are 173 students (the total number of IT students being only 56), 50 staff (the staff of the Computer Systems Department being only about 20), and 57 external clients. The development of university-wide LANs (the kernel of which are the ones developed within the project) is under consideration. A full Internet connection has been installed at Rousse and is under development at Plovdiv, with the financial support of the Open Society Fund, the Ministry, and the so-called Co-ordination Centre for the Usage of Computer Technology in Sofia.

A very interesting and beneficial co-operation has been established between the departments responsible for the degree courses in IT and in European Studies at Rousse. As a result of this the preparation has begun of Master courses at the borderlines of IT, Public Relations, and Media Production (in collaboration also with local TV, radio, and newspaper). An application has been submitted requesting TEMPUS support for this new and innovative undertaking.

It is the enthusiasm, real interest and progress of the first students following the courses both at Plovdiv and Rousse that has brought satisfaction. Also during these three years of the implementation of the project we have clearly observed the evolution in the academic community's attitude to the project, even amongst those with the most negative stance at the beginning. Several are now involved with new TEMPUS projects, building on the experiences gained. Challenges for the future include the evolution of the new course within the evolving academic structures at each Bulgarian university. Also there could be major problems associated with the maintenance and long-term replacement of the equipment now that external funding for the project has ceased. Similar problems will arise with seeking to keep up-to-date with software, literature and journals.

To conclude, the project has achieved its limited aims. However, as the above analysis shows, there is still a great need for further support beyond the expertise already gained if the present work is to be successfully built upon. The overall aim is to produce computing professionals capable of serving Bulgarian industry and commerce so that it can compete in a wider European market. To achieve this there needs to be improved support and direction given at a national level as well as further support from the European community in the development of the knowledge and skills needed in this area.

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