

Introducing IT-based environmental simulation courses at Slovak technical universities

JAN HENSEN¹, JOZEF HRASKA², SHAUNA MALLORY-HILL³, ROMAN RABENSEIFER²

¹ University of Strathclyde
75 Montrose St.
Glasgow G1 1XJ Scotland
jan@esru.strath.ac.uk

² Slovak Technical University
Radlinskeho 11, 813 68 Bratislava
Slovak Republic
hraska@ultra.svf.stuba.sk

³ Eindhoven University of Technology
Den Dolech 2, 5600 MB Eindhoven
The Netherlands
shill@fago.bwk.tue.nl

Abstract

Since the 1995/96 academic year, four Slovak universities (Slovak Technical University Bratislava, Technical University Kosice, Slovak Agricultural University Nitra and Technical University Zvolen) in co-operation with two EU universities (University of Strathclyde Glasgow and Eindhoven University of Technology) have prepared IT-based environmental simulation courses in the framework of the TEMPUS Structural Joint European Project S_JEP 09909-95. This project aims to develop and introduce building performance simulation courses that are integrated and highly interdisciplinary in their content, involving architecture, building engineering, environmental engineering and mechanical engineering. To achieve this aim, course materials are made available through the World Wide Web. In addition, the project required the establishment of IT laboratories, development of new courses, staff retraining, and collaboration with local industrial partners.

This paper presents current results of TEMPUS project which is funded through European Training Foundation in Torino.

BACKGROUND

Energy consumption in buildings typically accounts for over 40 - 50 % of the total energy consumption of Central European countries. Provision of the energy services for the indoor environment produces a large amount of outdoor environment pollutants. The energy intensity (consumption in relation to the GDP) in Slovakia is higher than in the OECD countries. In the past, energy prices for consumers in Slovakia were very low and did not reflect the real value of energy. It is expected that energy prices in Slovakia will increase to world market levels in the next years.

Recent years in Slovakia are characterised by a restructuring process towards a market economy. This strong process involves a number of economic, political, social and technical developments. The rational use of energy is already being encouraged by the introduction of new laws and more stringent standards [1, 2]. Slovakia is also currently undergoing a period of transformation within its higher education system according the 1996 Higher Education Act.

The problems mentioned above and the need for an integrated approach to buildings as a complete "system" (comprising building structure, environmental control systems, and occupants) were the main reasons for the Tempus proposal in the year 1995. Tempus is a programme of the European Union (EU) which aims to promote social and economic changes through the reform of higher education in Central and Eastern Europe, the New Independent States and Mongolia.

Tempus achieves results through supporting international co-operation between higher education institutions in the EU with partner countries.

The main objectives of Tempus No. 09909-95 are to: (1) equip Slovak students in building and mechanical engineering with powerful engineering skills before they enter the competitive market and, (2) prepare continuing education courses for industry. The Tempus grant covered creation of the necessary infrastructure (60 % of the grant was for hardware), updating and training of Slovakian staff members (20 % of the grant), and generation and implementation of courseware for new and restructured degree courses (20 % of the grant). This paper focuses on courseware component of the project.

INTRODUCTION

Computer modelling and simulation have become powerful methods for assisting architects and engineers in increasing of quality of the built environment. Integrated simulation allows engineers and architects to evaluate a number of energy saving measures that cannot be judged adequately by simple techniques. Despite the rapid improvement of information technology in the Slovak Republic, computer modelling and simulation techniques are very seldom used in engineering.

In an effort to promote energy efficiency of architecture, several environmental simulation courses are being introduced into the curricula at Slovak universities. Four Slovak educational institutions, in collaboration with EU partners, developed three separate courses in support of reaching the same goal - energy efficiency of building construction and operation. These courses are based on modern information technology and are available on Internet.

This paper describes the results of the ongoing three-year Tempus - Phare project (1995 - 1998). It focuses on the environmental simulation courses recently introduced at the Slovak universities as part of this project and describes the experiences and lessons learned.

ABOUT THE COURSEWARE: GENERAL ISSUES

The Tempus project partners want to introduce energy and environmental systems modelling courses at Slovak universities that are compatible and equivalent with EU partner universities. Realising that only 5 % of course content is specific to individual countries (e.g. relates to national codes, local materials, construction techniques, and/or climatic data) it is possible to create mutually-accessible (on-line), compact, and modular courseware in a common language (English).

The general content and structure of the courseware are based on the concept that "learning" is more important than "teaching". Teaching methods need to focus on the outcomes for learners - what can they do as a result of what they have learnt. Therefore the learning environment needs to provide:

- active problem-solving methods (the student is at the centre as the main problem solver, with a well-balanced ratio between the student's own learning activities and the information provided by the teacher; students formulate the problems themselves)
- clearly stated learning objectives
- a modularization of the curricula
- open-ended learning material.

In this way, the environment shifts the focus from teaching to learning.

The courseware currently consists of three courses: **Introduction**, **Practice** and **Theory** - see Figure 1. These courses are the same for all partner universities.

The course materials are in hypertext (HTML, Hypertext Markup Language) and are available on the WWW: <http://www.strath.ac.uk/Departments/ESRU/courseware/Class-mod+sim>

To speed up access time, a copy of the courseware was also installed on local servers in Slovakia.

The courses' contents reflect the current state of energy modelling and simulation. Features such as: "Frequently Asked Questions", built-in exercises, assignments, many links to other related WWW sites, and reference materials are used to aid study. Such a learning environment can be used in a variety of ways: for self-directed learning, as on-line course material, as supporting lecture material, or as reference material in project work.

The classes "Introduction" and "Theory" are general in nature and do not involve the direct use of any simulation tools. The "**Introduction**" course gives students an overview of the main tasks connected with simulation studies - model creation, performing simulation and analysing results. This course is characterised by the use of many different case studies to illustrate the great potential of energy and environment simulation techniques. The "Introduction" course is intended to motivate students and give them initial answers to questions such as:

- What are the potential benefits from architectural building features such as: sunspaces, solar walls, shape and orientation, etc., on energy performance?
- What will be the effect of a making a design change such as: increasing wall insulation, altering the window shape and size, changing type of glazing, introducing sun control devices, re-zoning the building, re-configuring the plant or changing the heating/cooling control regime, and/or using lighting control strategies?
- What is thermal and visual comfort and how does it vary throughout a building?

The case studies cover several types of buildings in different countries. As a result, this class can be interesting for students of architecture, building or mechanical engineering located in different countries.

The information in module "**Theory**" aims to give students an understanding of the theoretical and operational principles of energy and environmental simulation. The topics are developed from the basic principles, and assumes that students have a limited knowledge of computers and application software. This course currently consists of 17 sub-modules. All sub-modules have the same structure - a list of key concepts, an outline of the lecture structure, a summary, course material for studying by the student, and in some cases, links to further study material on the WWW. Each module ends with an assignment that aims to link the theory to practice.

The course "**Practice**" is based on a series of hands-on exercises and assignments. One of many exercises is in Figure 2. Students send the results of assignments to the teacher by e-mail.

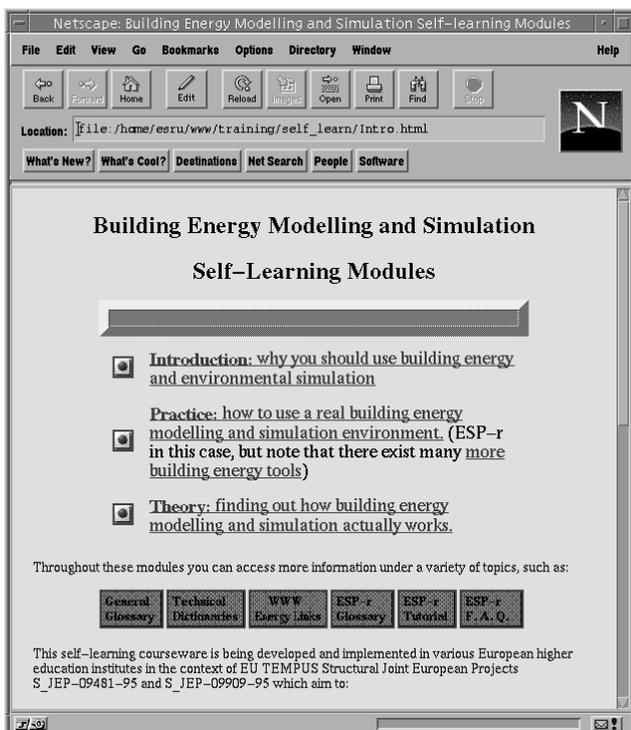


Figure 1. The three main blocks of courseware as appear on WWW page

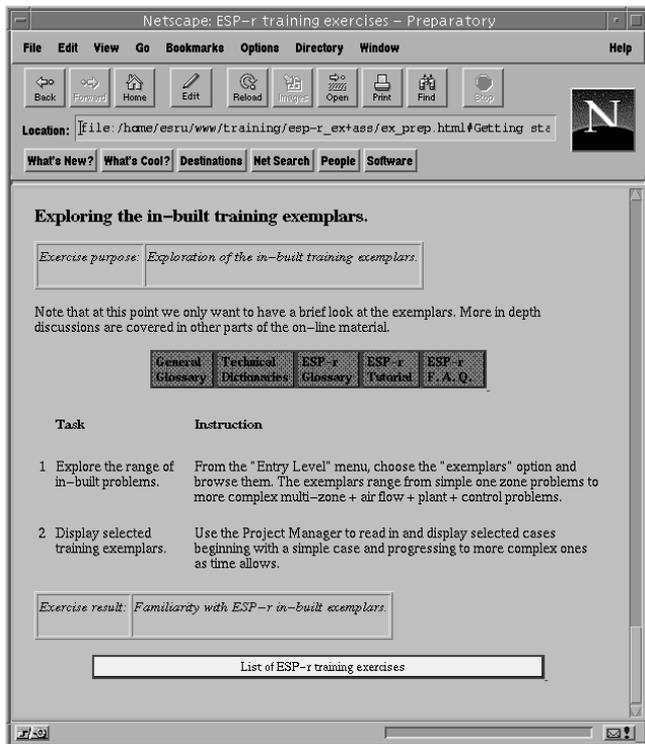


Figure 2. Typical example of training exercise in class "Practice"

Practical learning of computer modelling and simulation cannot be separated from the use of real simulation tools. There are different methods of building energy analysis that vary in complexity. Generally, as a method becomes more complex it becomes more accurate. However, improved accuracy usually comes with increased effort and time in order to learn to work with a more complex tool.

The ESP-r system for building and plant energy simulation [3] was chosen as the main tool for the introduction of energy simulation courses at the four Slovak universities involved in Tempus. ESP-r is a transient energy simulation system developed at the University of Strathclyde in Glasgow (UK). It runs on the UNIX platform. For research and educational purposes the University of Strathclyde is normally able to provide a free system licence for ESP-r.

ESP-r allows users to build, relatively quickly, models of complex physical systems. It is useful for education for various reasons:

- It has an on-line tutorial and built-in examples that are very useful for beginners.
- It can operate within a *Project Management* environment that allows easy importing/exporting of information between a number of related programs.
- It has many options for graphical display of building descriptions and calculation results.
- It has flexible databases and libraries.
- It is capable of modelling the energy and fluid flows within combined building and plant systems with and without advanced technological features.
- It has been tested by several organisations and found to agree well with known analytical solutions and monitored data sets.

The exercises in the "Practical" course are designed to guide students from beginner level to expert level in ESP-r.

THE ROLE OF SLOVAK UNIVERSITIES IN TEMPUS PROJECT

The principle aim of Tempus project 09909-95 is to develop and implement new interdisciplinary energy/environmental simulation courses and courseware at four Slovakian and, to a lesser extent, two Western European universities.

The Slovak Technical University (STU) in Bratislava is contractor and co-ordinator of Tempus project. Slovakian universities have common and individual tasks within this project framework.

Common tasks are characterised as follows:

- establishment of teaching/computer IT laboratories
- retraining and updating of staff
- providing platform to continuing education for the building industry
- inter-university collaboration, particularly in preparation of "national" course materials.

Inter-university collaboration is particularly evident in the development of case-study material for the courses. For example, in Slovakia many of residential dwellings are made of prefabricated concrete blocks or panels. About 233,000 buildings in the Slovak Republic have been constructed based on this principle. Many of these buildings now need major renovations due to poor construction quality and high energy losses. The potential energy savings through increased thermal insulation, better glazing, reduction of thermal bridges and improvements to the heating systems are huge. STU and Technical University Kosice co-ordinated their efforts to create a case-study of this building type.

At STU a computer model of an apartment building with the panel system T06B was prepared. The model takes thermal bridges into consideration during reconstruction of the outer envelope. The first page of case study, which is incorporated into the "Introduction" course, includes 1D and 3D calculations of the influence of thermal bridging upon the overall heat loss of a panel building (see Figure 3).

A second issue concerning Slovakian panel apartment buildings is that most have a flat roof. The construction of attics on such buildings may solve several problems such as: (1) shortage of flats (provide additional space), (2) repair defective flat roofs with poor thermal insulation, and (3) improve the appearance of the building. Therefore a case study of energy aspects of new attics on panel buildings was prepared at Technical University (TU) in Kosice. Also within the framework of the Tempus project TU Kosice continues to create a common database of typical Slovakian materials and building constructions. Slovak Agricultural University (SAU) in Nitra prepared case study material of modelling and energy simulation of agricultural buildings.

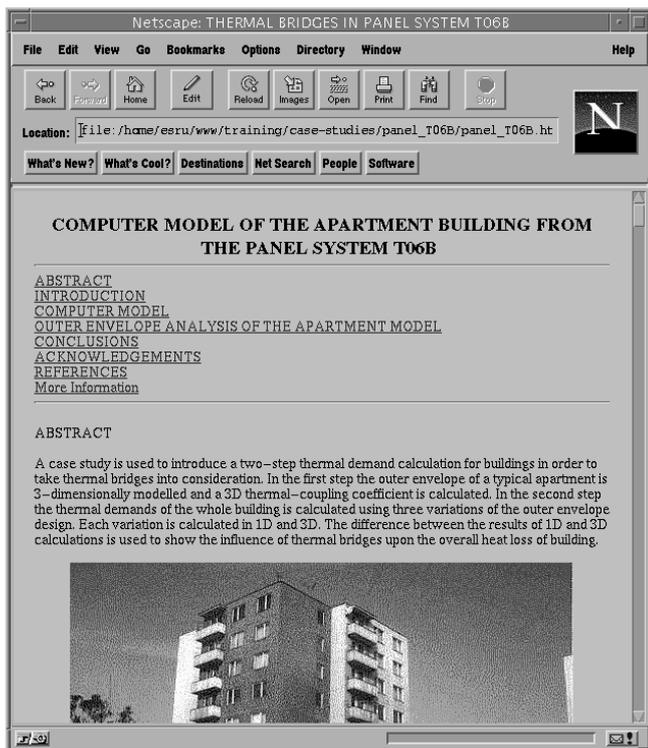


Figure 3. The case study of thermal bridges of apartment panel building

Other common tasks involve the development of educational aids. In Zvolen, the Technical University prepared a draft version of an on-line technical Slovak – English dictionary. This technical dictionary contains terms commonly used in modelling and simulation of energy in buildings cross-referenced in both languages. Zvolen also co-ordinates the other Slovakian universities in the creation of a general on-line glossary of terms. This provides an explanation of terms related to modelling and simulation for environmental engineering.

Individual tasks reflect the particular interests of each university and, of course, relate to the preparation and final implementation of the new courses and courseware into their existing curricula.

At STU Bratislava two existing final year courses on “Energy Efficient Buildings” and on “Special Building Construction” have been upgraded by incorporating parts of the new courseware. Both courses have a duration of one semester (13 weeks) and are carried out in final year of studies. During the first and second years of the Tempus project the courseware was initially tested with small groups of post-graduate and final year MSc degree students. Now, the courseware is finally being fully incorporated into the regular curriculum. The final year students of Building Engineering of the winter semester 1997/1998 will be the first to complete the new course on Energy/Environmental Simulation of Buildings.

The STU course includes a series of lectures and tutorials that are supported by the Tempus on-line course materials. The tutorial material of “Energy/Environmental Simulation of Buildings” consists of four main parts:

Part 1: Basics of working with a UNIX computer (operating system, Internet, WWW, e-mail, HTML documents, etc.)

Part 2: Theory of modelling and simulation of environmental and energy systems of buildings (with selected topics on heat and mass transfer, lighting, theory of similarity)

Part 3: Basics of ESP-r (problem definition – databases, geometry, constructions, operations, inter-zone connections; simulation – climate data and its analysis, control capabilities; results analysis)

Part 4: Modelling and simulation of actual simple buildings in climatic conditions of Slovakia, and report creation.

The content of lectures and tutorials on Energy/Environmental simulation at other Slovakian universities involved in the Tempus project are similar to that of STU Bratislava. For example, the curriculum of the class “Computer Modelling and Simulation” at TU Zvolen has the same features as at STU Bratislava, but is oriented to wooden buildings.

IT-based environmental simulation courses are now advancing the study of engineering problems at Slovakian technical universities. These courses enable a more effective understanding of the physical processes and systems, especially in the field of the building design.

The Tempus project is not finished yet, and many aspects need to be improved and explored further. Only after more experience we will be able to compare this type of hypertext courseware to more traditional teaching methods. This comparison is somewhat problematic in Slovakia where many students have problems with the English language.

Another challenge is finding appropriate ways to introduce computer modelling and energy simulation to the building industry. The Department of Architecture and Building Science at STU Bratislava has prepared distance learning courses on “Energy Efficiency” and “Ecological Buildings” for the building industry in which computer modelling and simulation of building energy processes and systems are involved. We believe that the open learning material developed in framework of the Tempus project will also be very useful in the distance education of professional designers and consulting engineers.

CONCLUDING REMARKS

This paper has described the rationale of the syllabuses of new subjects on energy modelling and simulation at four Slovakian universities. The context and content of these courses are briefly explained.

From our initial experiences some general conclusions can be drawn:

- The students show a keen interest in computer modelling and simulation, but the current level of English language skills of students at Slovakian technical universities are low. This limits the extent to which “international” courseware can be put into general pedagogic practice at this time.
- The young teachers involved in the Tempus project obtained experience in teamwork and networking in an international context. This is seen as useful for both

- accessing educational resources and for future research work.
- ESP-r system for building and plant energy simulation is useful for educational purposes.
 - The new courses represent a significant step towards the next system of education at Slovakian universities; incorporating complex computational techniques and on-line teaching approaches.
 - Slovakian participants in the Tempus project have gained the necessary hardware and software for education, have updated and trained staff, introduced new classes and have become capable of providing continuing education.

ACKNOWLEDGEMENTS

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