

# An International Network for Collaboration in Engineering and Science Education

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**Abstract** – A consortium of US and European universities has been established with the help of two projects funded jointly by the US Fund for the Improvement of Post-Secondary Education (FIPSE) and the European Commission (EC-US projects). The academic focus of the projects was in computer science and engineering with an emphasis on computer modeling and simulation. The main aim of the first project was to establish student mobility between the US and Europe. The second project focused on the development of course materials that would enhance international experience particularly by providing international team projects based on simulated systems accessible on the Internet. These projects are to be integrated into a complete e-learning environment. The EC-US projects also featured faculty exchange and the development of shared course materials and projects. A demonstration on-line simulation project, based on a multi-modal transportation system has been successfully completed. To ensure a lasting collaboration beyond the funding period, several of the universities involved plan to establish a permanent consortium with the ultimate goal of establishing joint degrees.

*Index Terms* – International joint degrees, computer science and engineering, web-based learning, modeling and simulation.

## BACKGROUND TO THE CONSORTIUM

Informal personal contact for the purposes of collaborating on research and the development of educational materials is a familiar feature of the academic world. Sometimes these informal contacts develop into something that is more ambitious and more permanent. In the hope that the story of one such effort may inspire or, at least, assist the development of other consortia, this report presents the experiences of and lessons learned by one budding consortium. This has been the case with a group of US and European universities operating with the provisional title *International Consortium for Research and Education in Modeling and Simulation*. The story of how this consortium developed starts in the 1990's with contacts between faculty

members in the US and Germany with common interests in the field of computer modeling and simulation (M&S). M&S is a relatively new academic discipline, indeed it is not yet universally recognized as a discipline in its own right, and there are few departments so-named in today's universities. Typically M&S is addressed in those departments which represent the most mature applications of M&S: computer science, engineering, business, natural sciences. There is, however, a relatively small but dedicated community of academics and others who see a need for establishing M&S as a discipline in its own right on the basis that there is an accepted M&S "Body of Knowledge" that identifies theory, methodology, techniques and applications. Whether or not this is a valid argument is not relevant to this paper. What is important is that it set the scene for an international collaboration, and that the lessons learned in establishing this collaboration may be useful in other disciplines.

The key event in the US was an invitation from a former colleague at California State University, Chico, who had moved to the University of North Dakota, to participate in a project involving six universities, two each in the US, Canada, and Mexico, as part of the tri-national Program for North American Mobility in Higher Education established between the US Department of Education through its Fund for the Improvement of Post-Secondary Education (FIPSE), the Mexican Ministry of Education and the Canadian Human Resources Department. Chico joined with North Dakota, and the Canadian and Mexican partners to establish a student mobility program in engineering. The success of this program, which has produced continuing collaboration, including student exchanges, between three of the original six partners (CSU, Chico; University of Manitoba; and the Autonomous University of Zacatecas) prompted further efforts to establish new projects. Building on existing links between CSU, Chico the University of Hamburg, which also had previous experience of these international projects, a consortium was established and a proposal made to the EC-US program funded by the European Commission in Europe and FIPSE in the US. The US-Europe: Mobility in Computer Science and Engineering (USE-ME) project received funding for a three-year student mobility project [1]. The consortial partners were CSU, Chico (US lead), University of

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Nebraska-Lincoln (UNL) and Old Dominion University in the US and the University of Hamburg (European lead), the University of Glasgow, and the Technical University of Vienna in Europe. When funding for this project ended, a two-year project (later extended to three), the US-Europe e-Learning Network (USE-eNET) was initiated and funded. A major aim of USE-eNET was to develop web-based design projects using system simulations in which students could act as members of international teams. Partners in this project were: on the US side, two former USE-ME partners, CSU, Chico (US lead) and UNL along with a new US partner, the University of Alabama at Huntsville (UAH); and in Europe, again two former USE-ME partners, the Universities of Hamburg (Europe lead) and Glasgow, with two new partners, the Budapest University of Technology and Economics and the University of Aarhus. The funding for this project ends in 2007, but a permanent consortium, the *International Consortium for Research and Education in Modeling and Simulation* is planned which will continue to pursue and expand the aims of USE-ME and USE-eNET.

#### **USE-ME: EXPERIENCES AND LESSONS LEARNED**

The USE-ME project was first and foremost intended to encourage student mobility. The primary goal was to send students from each of the US campuses to one of the European campuses for a semester of study and vice versa. The student population that was intended to supply candidates was upper division and graduate students in computer science and engineering. A particular emphasis was in modeling and simulation, but it didn't take very long for the partners to realize that if they were too narrow in their focus there would be no chance of reaching their targets for the numbers of participating students. Eligible students who were accepted into the program received a stipend of \$3000 from the US side and a similar amount from the European side. Only students who were US citizens or legal resident aliens (so-called green card holders) were eligible for FIPSE-funded stipends, but this did not rule out participation by international students and one Chico international student spent a semester in Germany as part of the program. Study was intended to be full-time for one semester. Fees were paid to the home university and tuition at the host institution was to be waived on a reciprocal basis. The program of study was required to include courses that would be accepted for credit by the home university. It could also include courses that enhanced the student's appreciation of the culture of the host country including language courses where relevant.

The main problem encountered in trying to meet the project goals was the unexpectedly high resistance of both US and European students to study abroad. This was particularly true of graduate students who were reluctant to give up important research or teaching assistantships in order to participate. Other factors were unwillingness to interrupt personal relationships, apartment rentals, and a fear that a semester abroad might delay graduation. On the other hand, those students who did participate were universally positive about the experience. This applied even to those who ran into problems during their study abroad semester.

Not surprisingly, students from the US tended to favor Glasgow, the English-speaking option rather than Hamburg or Vienna. All of the students who chose a German-speaking campus went to Hamburg. There are several possible reasons for this. First, relations between the US universities and Hamburg were much closer, with faculty exchanges occurring in both directions, which provided the opportunity for meetings between US students and Hamburg faculty. The availability of some courses taught in English was also a key factor and some of these courses were taught by visiting professors from the US partner campuses. Visits by German students to the US were helped by simultaneous visits by German faculty. In addition to encouraging German students to participate, the contacts made between US students and their European counterparts and instructors did a great deal to increase their interest and confidence in the program.

Once students expressed a desire to participate in the program and selected a preferred host university, it was necessary to overcome a number of obstacles. One problem in trying to coordinate studies in Europe and the US is the lack of uniformity in both the program structure (e.g. number of years, level of qualification achieved) and differences in the timing of quarters, semesters or terms. This situation is improving as European universities transition to a 3+2 year (Bachelors + Masters) structure and as some institutions also switch to semester-based rather than academic-year-based courses. Even so, great care was required in selecting courses of an appropriate level or content and special arrangements were often necessary to accommodate calendar differences. In one case a student from Chico studied in Glasgow during the Fall semester. Fortunately Glasgow was in the process of changing from the traditional system in which a single course spanned an entire academic year to a semester-based schedule. The student wanted courses both from engineering and from computer science, which involved two different departments that were at different stages in their adoption of the new system. The engineering courses did not present a problem. They were confined to the fall semester with tests at the end of the semester. One course in computer science, however, was a year-long course split into two modules, one in the fall and one in the spring. The good news was that the content required by the student was covered in the fall, the bad news was that both modules were tested by a single final examination at the end of the spring semester. The solution was to allow the student to attend only in the fall and to be given grades by the host campus for completed assignments, but for the final exam to be prepared and graded by Chico faculty on the student's return to the US.

An important factor in ensuring the success of the program and individual student placements is the availability of dedicated faculty in the discipline at both the home and host campuses, and they must be backed up by supportive staff at the international programs office of both campuses. There are numerous administrative details that must be taken care of including visas, fee waivers, course registration, providing accommodation, and health insurance. These are not all subjects that faculty deal with on a regular basis. Experienced counselors with knowledge of international student exchanges are essential to the process.

The experience gained from the USE-ME project led to the conclusion that, at least for this student constituency, different modalities would be necessary to provide a significant number of students with some intercultural experience as part of their studies. The key component in our view was to provide means for students to work together in international teams, even if it could only be done remotely.

This conclusion led to a second US-EC proposal for a project that does not incorporate student mobility (known to the funding agencies as a complementary activity). The proposal was funded and the US-Europe: e-Learning Network (USE-eNET) was launched [2] [3].

### THE USE-eNET PROJECT

An understanding of the ideas that prompted the USE-eNET project requires an understanding of the status of the burgeoning academic discipline of Modeling and Simulation (M&S).

M&S is the process of developing a mathematical model of a system under study, converting the mathematical model into a computer program, and executing the program with selected parameters so as to determine how the real system would behave with the corresponding parameters. M&S is widely used in engineering design, diagnostics, in testing hardware and software (interfaced to the simulation), and in training of humans for a variety of complex tasks from plant operation to combat. It is also used to test scientific theories, to predict the outcome of natural phenomena, to design manufacturing plants, health-care delivery systems, business processes and many others. It has been described as one of the key enabling technologies of the 21<sup>st</sup> Century. In 2006 several members of the US House of Representatives established the Congressional Caucus on Modeling and Simulation. M&S is not, however, recognized as a distinct discipline by most universities. M&S techniques are instead dealt with within the individual disciplines that use them. This is an effective approach for producing professional engineers, scientists, business managers etc. with an understanding of the use of simulation within their discipline. It does not produce graduates with a broad understanding of the full range of M&S methodology, techniques and applications, and particularly of the pitfalls that can result from the inappropriate use of M&S tools and techniques.

The current route to becoming an M&S professional, if indeed it is accepted that such a specialty exists, is through the path outlined above followed by extensive interdisciplinary experience of a wide range of M&S applications. In many university departments there is an individual professor who has developed an interest in M&S beyond the scope of the departmental discipline, studying M&S for its own sake, a member of a professional organization centered on M&S, and establishing a claim to be recognized as a simulation professional.

These individuals and the M&S organizations to which they belong (The Society for Modeling and Simulation International or SCS, for example) form the core of the initiative to develop M&S degree programs. Some campuses

feature M&S degree programs. Old Dominion University, for example, one of the USE-ME partners offers MS and PhD programs in Modeling and Simulation. Arizona State University is developing an undergraduate program in M&S. One feature of these programs, however, is that despite the increased breadth of content that is not confined to a particular disciplinary area, they still reflect the particular interests and expertise of the host academic unit. Old Dominion, for example, emphasizes the use of M&S for training, and the program at Arizona State is focused mainly on Industrial Engineering and plans to seek accreditation by ABET (Accreditation Board for Engineering and Technology).

In an attempt to provide a more broadly based M&S program, CSU, Chico offers a program in Simulation Sciences as part of its MS degree in Interdisciplinary Studies (MSIS). The requirement for an MSIS program is that it should include in its core courses from more than one disciplinary area. The Simulation Sciences option requires a nine-unit core of courses on various aspects of simulation methodology, courses taken from at least one selected application area, and a project or thesis on a simulation topic. The flexibility afforded by these requirements allows students from a wide variety of disciplines to extend their knowledge of simulation and its applications. The Chico program has graduated students with undergraduate degrees in computer science, electrical, mechanical, chemical, and marine engineering, biology, mathematics, and physics among others. Even so, the range of M&S topics is limited by the expertise found on the campus, with the exception of occasional special courses given by visiting faculty.

The vision of the partners in the USE-ME and USE-eNET projects has been to establish a virtual campus in which the collective expertise of several universities can be concentrated into a single comprehensive degree program in M&S. Given an international participation, a program of this kind would combine intercultural benefits with the interdisciplinary nature of the program. The efforts and activities of the USE-ME and USE-eNET projects were seen as preparatory to the development of such a program jointly by several international collaborating universities. This is still the ultimate goal of the participating universities.

USE-eNET, therefore, sought to investigate the effectiveness of different approaches both to providing students with intercultural experience and to developing resources that would help in the establishment of a virtual campus.

The USE-eNET proposal suggested the following activities as ways of moving in this direction:

- Jointly developed on-line courses
- International summer schools
- Student visits for a full semester or short visits
- Faculty exchange
- Simulation-based on-line international team projects
- A consortium web-site

Within the relatively short project time-line (2 years with a possible extension to 3) a decision was made at the first partner meeting to concentrate on the development of course materials and the on-line projects.

The partners agreed that in order to gain the full benefit from the on-line projects it would be necessary that they were capable of being integrated within a web-based course delivery system such as Web-CT so that they could be seamlessly included as part of an on-line course. In this way, students from different universities could register for a joint on-line course and, as part of the coursework, could participate in the project as a member of a distributed international team.

Selection of the web-based learning system presented some problems. There are several commercial e-learning systems available and in use at campuses throughout the world. All of them have the potential to support the simulation-based learning features planned by USE-eNET. It is, however, necessary that all participating campuses should use the same system. Given the costs associated with establishing many of these systems, the consortium sought a lower-cost option. This consideration led to the choice of Dokeos. Dokeos offers software translated into 31 languages, and used in more than 1.000 organisations worldwide to manage learning and collaboration activities. The crucial factor is that it is free to academic institutions. In addition the Danish partner, the University of Aarhus, has wide experience and expertise in using Dokeos.

Dokeos allows instructors to create content, structure activities along a sequenced path, interact with students and follow their progress. The Dokeos development community includes more than 80 developers spread in a dozen of organisations, mainly in Europe and the United States.

Another issue that had to be addressed at the start of the project was the selection of initial topics to use as demonstration topics. The predominant interests of the partner representatives lay in electrical, computer and control engineering, but the partners were anxious to use the project to demonstrate the scope of M&S and the USE-eNET initiative. As a result it was decided to select two topics for the development of course materials. The first, discrete-event simulation, is a methodology that is applied across a broad spectrum of simulation applications from engineering to social systems. The second, medical applications, reflected expertise from two of the partners and represented a rapidly developing use of M&S in an exciting relatively new area.

The choice of topics for the on-line projects was keyed to these decisions. To obtain maximum leverage a project based on a transportation simulation project at UAH was selected as an example of discrete-event simulation. It was also decided to use a medical application for the second project. A key feature of these projects was that they would eventually be embedded in coursework for a course delivered by Dokeos. As an example the transportation project is described in the next section.

### THE TRANSPORTATION PROJECT

The transportation project is based on the Alabama freight transportation model, which has been developed to meet USE-eNET criteria [4][5]. The original model has been simplified to make it more suitable as a student project and a version has been developed that can be accessed remotely

over the Internet. Using this facility, students at Hamburg are studying the model and adapting it to serve as a model of Hamburg harbour. It is not yet available as part of a Dokeos course.

The Alabama freight transportation model

- incorporates the major highway network of the entire state of Alabama and links multiple Metropolitan Planning Organizations
- addresses alternatives for freight transport on waterways and rail and accesses impact on highway congestion
- incorporates statistical information, such as travel times, average vehicle speeds, number of vehicles, tonnage of freight moved, fuel usage, congestion levels
- represent a discrete-event model of freight traffic on roadways, navigable waterways, railways, and intermodal centers in Alabama
- is based on ProModel software interfaced with Excel spreadsheets
- provides an animated graphical display showing the movement of vehicles, trains and vessels with color-coded representation of congested areas
- provides Excel spreadsheets containing the statistical information referred to above.

The simulation provides opportunities for a variety of student team projects including the testing of different options for improving traffic flow such as new highway lanes, transferring freight from one mode to another, e.g. road to rail or waterway, building new highway or canal links etc.

For computer science majors the task may be to improve the features of the simulation itself or to change it as exemplified by the Hamburg effort to adapt it to a simulation of Hamburg harbor traffic.

### DEVELOPING A SUSTAINING CONSORTIUM

One of the key issues for a consortium that has been established with funding that is provided for a specific purpose over a short period is sustainability. In most cases, as with USE-ME and USE-eNET, there are long-term goals that require a sustained partnership. The USE-eNET partners are now in the process of establishing a basis for continued cooperation with an agenda that will lead to these goals. A new Memorandum of Agreement (MOA) is in preparation that sets out the goals, the planned activities and the responsibilities of individual institutions. A draft version of the MOA can be found in the Appendix. This will be based on the MOAs that were established for the two earlier funded projects (FIPSE and the EC require funded consortia to sign an MOA guaranteeing that the partners will support the goals of the project). There are, however, major obstacles to the establishment of a joint degree, or even to gaining approval for joint courses. Administrative procedures required for course and program approval even on a single campus can pose problems for the developer and they differ

considerably between institutions making joint approval even more problematic.

It is clear that the ambitious goals of the consortium can only be achieved, if at all, through an incremental, step-by-step approach. The first requirement is to establish a relationship of trust and cooperation between the cooperating individuals and institutions. This has been achieved in large part through the opportunity afforded by the funded USE-ME and USE-eNET projects. It is significant that the initial membership of the new consortium consists mainly of those partners who have participated in both the earlier projects. They are the University of Hamburg; the University of Glasgow; CSU, Chico; and UNL. UAH, which has taken the leading role in the transportation project, is also involved. The minimum membership for a successful consortium is seen as at least two institutions on each side of the Atlantic. A draft of the proposed MOA appears in the Appendix.

Reaching the point at which several universities have signed on to an agreement in the above form involves a lot of discussion and effort. Some institutions have a fairly informal process for approving this type of agreement. Others require an extensive process involving formal approval by university-wide bodies. For this reason it has been agreed that the agreement becomes effective once at least one US and one European partner approves it. This avoids delays while the more deliberative processes are completed. The official creation of the consortium, whether it is with two or more members, does not, however, guarantee success in achieving the goals set out in the agreement. This must be done one step at a time. USE-eNET has established some of the basic requirements for progress to be made. In addition to continuing the activities established by USE-ME and USE-eNET, the next step, once the consortium is in existence is for the partner institutions to identify a set of courses that they plan to consolidate as common courses which can be delivered on-line to students on two or more campuses. As the program develops the hope is that the lengthy process of establishing a basis for a common degree program will gather momentum.

### CONCLUSIONS

Great benefits can accrue from formal international collaborations between institutions. In addition to the obvious advantages of providing students with intercultural experiences as well as different perspectives on the norms of professional practice in different countries, they can provide a greater breadth of expertise in the relevant discipline than can be provided by most individual universities. This is particularly true in disciplines such as Modeling and Simulation which shares its body of knowledge with many other disciplines and which covers a very wide range of fields of application. Combining the resources of several institutions to provide a truly broadly based educational and cultural experience to students in the field is well worth the effort involved in establishing joint programs across international boundaries. Formal agreement of the purpose and goals of the collaboration is an important first step in the process.

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### APPENDIX: M&S INTERNATIONAL CONSORTIUM

A draft MOA has been drafted and is presented below. The list of participating institutions is omitted since it has not been finalized at the time of writing. It is to be expected that amendments will be required before it is approved by the partner institutions. The contents of the draft represent the thinking of the lead faculty involved in the USE-ME and USE-eNET consortia and in that respect stand only as a collective summary of the ideas of those individuals. The draft does not, as yet, reflect formal positions that might be taken by individual institutions.

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#### Memorandum of Agreement (Draft)

<List of partner institutions>

The Universities named above have a mutual commitment to furthering academic exchange and cooperation in teaching and research in the field of Modelling and Simulation and hereby agree to promote, facilitate and implement cooperation under the following headings:

#### ARTICLE 1: PURPOSE

This Agreement establishes an International Consortium for Research and Education in Modeling and Simulation involving all of the Universities as equal founding partners.

#### ARTICLE 2: AREAS OF COOPERATION

The partners agree the following goals for the Consortium;

- (a) exchange of scientific, academic, and technical information and appropriate academic materials and other information of mutual interest;
- (b) academic exchanges, including mutual visits of faculty members to pursue research, to lecture and allow new courses to be developed, and student exchanges on a reciprocal basis in which students take courses for credit at the partner Universities;
- (c) recognition of selected courses at the partner Universities with appropriate arrangement for credit transfer and cross-listing in course catalogues;
- (d) develop e-learning courses in the area of Modelling and Simulation to be made available to students of all the Universities;
- (e) exchange and cooperation and joint research and development of areas of mutual interest;
- (f) organisation and participation of joint academic and scientific activities such as summer schools offering credit-bearing courses (usually with multiple partners), seminars and conferences.

#### ARTICLE 3: ARRANGEMENTS AND FUNDING

The partners acknowledge that in the absence of any specific agreement to the contrary, each partner institution within the proposed Consortium will be responsible for all its own costs.

The Universities acknowledge that in the absence of any specific agreement to the contrary, expenses of salary, travel, living and allied costs for academic staff visiting partner institutions will be determined at the discretion, and be the sole responsibility of the visitor's home university.

Financial arrangements for exchange students will be determined on an individual basis in accordance with the normal practice for exchange students within each institution.

Appropriate arrangements will be put in place by the partner institutions regarding fee payment and registration for e-learning courses.

#### ARTICLE 4: MANAGEMENT COMMITTEE

Each partner can appoint one representative to a Management Committee for the Consortium. Representatives may appoint an alternate to represent them at meetings of the Management Committee, when necessary. There should also be a named contact person for each partner within the relevant International Office (or equivalent) of the university. The Management Committee will set its own agenda and will carry out most of its work using electronic communication. Representatives should normally meet on an annual basis to review progress in the implementation of the agreed arrangements, as well as discuss matters relating to the MoA.

#### ARTICLE 5: AMENDMENTS

This MoA may be amended by the mutual consent of the Universities. Such amendments can include addition of new members. The process for approval of new members is to be established by the Management Committee.

#### ARTICLE 6: TERMS OF AGREEMENT

This Consortium shall exist from the date of execution this MoA by any two of the Universities, at which point the signatory institutions shall have the status of partners of the Consortium and the remaining universities shall have the status of associate members. The Consortium shall remain in force for an initial period of five years, at which point it can be continued by consent of all partners. A university wishing to withdraw must give at least six months notice in writing to the Management Committee. In such cases partners will honor arrangements for existing students undertaking courses within that university.

(Signatures)

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