POST-GRADUATE ENGINEERING EDUCATION IN A GLOBALISED ENVIRONMENT - THE EINDHOVEN & SINGAPORE JOINT DEGREES

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Abstract— *As countries with small populations, Singapore and the Netherlands by necessity have adopted an international and global outlook, relying heavily on trade, manufacturing and communications services for their livelihood. Since business processes are in most cases part of an international chain of collaboration, both countries have identified the need to raise engineers that are able to operate on a global scale. The National University of Singapore and the Technische Universiteit Eindhoven initiated a collaboration in 1991 which today has resulted in broadband interactions involving joint programmes in research and education leading to joint degrees and joint Professorial appointments. This partnership also brings in industry from both countries who participate in the research projects. It now extends to include the establishment of a research institute working in industrial design jointly set up by the two universities. The factors which led to the success of this collaboration will be discussed.*

Index Terms ¾ Engineering education, design, globalisation, Netherlands, Singapore.

INTRODUCTION

The benefits and drawbacks of globalisation as a concept is much debated in international forums today. However, for many smaller nations, globalisation (or in its older expression 'internationalisation') is a reality which has existed for a good many years. It brings many opportunities and provides a very effective avenue for development and properity. For many of these countries have a small domestic population does not provide a sufficient critical mass for its own industries and services. By choice as well as necessity, they adopt an international outlook, looking to the international marketplace as the arena in which to make a livelihood through trade, manufacturing and communications services. Such an international orientation of the country's economy requires its workforce to share a similar outlook, and this in turn must be reflected in its education system. The schools and universities must play its part in the formation of an international mindset, producing professionals who are able and willing to work on a global scale.

Singapore and the Netherlands face many similar challenges. Both countries have small populations. Their economies rely substantially on high value-added manufacturing, trade and communications services. Schiphol and Changi Airports, Rotterdam and the Port of Singapore are major air and shipping hubs for their respective regions. In manufacturing, electronics and petrochemicals are important contributors to both economies. Both countries are changing from a production environment to a design and development environment. In both countries, business processes are, in most cases, at the front end of an international chain of collaboration. Research and development groups, designers, product engineers, and manufacturing engineering managers are often now part of multi-disciplined and multi-cultural teams spanning many time zones.

Two universities from these countries, the National University of Singapore (NUS) and the Technische Universiteit Eindhoven (TU/e), have built a collaboration in engineering education which encompasses research and education, industry and academia. Its activities now include student exchange, joint degrees at the Master's and PhD levels, joint academic appontments and a jointly established research institute.

This paper will describe the range of activities with a historical perspective and a discussion on the factors which enabled its success.

COLLABORATIVE ACTIVITIES

The contacts between NUS and TU/e began in 1991 in a seminar at NUS given by one of the authors (ACB). These contacts continued largely at a personal level, sustained initially by a common research interest in robust design and reliability of electronic and mechanical systems, plus a healthy dose of industrial inputs. As these contacts grew, a number of activities were initiated. In chronological sequence, they were:

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Student Exchange Programme

Student exchanges began in 1994. At this time, NUS began to encourage student exchanges with the purpose of providing some of its undergraduates with an overseas experience as well as to increase the international presence in its Singapore campus. TU/e also had similar objectives. However, language was at this time a hurdle which needed to be surmounted, as TU/e's undergraduate programmes were taught in Dutch, while NUS uses English for its curriculum. The solution which was adopted was for TU/e students to spend a year in Singapore working on their Master's project while NUS students had a six months industrial attachment in Eindhoven. On both sides of the exchange, the projects were given a strong industrial flavour and involved students from the Electrical, Mechanical and Chemical Engineering programmes.

Collaborative Student Project Teams

Student exchanges, while intensive in its international experience for the student, was not able to cater for large numbers of students. Realising that most students would work in their professional career as part of international teams without direct personal contact, other systems were explored. In order to bring the opportunity of international team work to a large number of students, a NUS-TU/e student team project was initiated. The team comprised, typically TU/e students in Mechanical Engineering working with NUS students in Electrical Engineering at the 3rd year level. The project would be mechatronic in nature. The TU/e student would carry out the mechanical design and construction while NUS students would be responsible for the electrical design and construction. The students would communicate regularly through video conferencing or net meeting. Through this means, all design co-ordination was carried out. Towards the end of the project, the teams would send what they had constructed to their counterparts for integration, thus ensuring that both groups of student had a completed unit of the system.

This approach enabled students to gain experience of a multi-cultural and multi-disciplinary team working in two different time zones. The cost was less than that for student exchange and more students could access to an international experience through this means. However, effort and commitment was required on the part of the academic supervisors especially in co-ordination and close supervision.

Joint Supervision of Graduate Theses

A natural step in the collaboration which arose out of common research interests was in joint supervision of Master's and PhD theses. This arrangement grew from an initial informal arrangement to a formal recognition of supervision arrangements in both universities.

Theses External Examiners

A logical progression in the collaboration was the inclusion of academic staff members of one university as external examiners in the theses of Master's and Doctoral students in the other university. There are some differences in the examination processes between the two universities, most of which arise from different historical traditions. Through this exchange of examiners, understanding of the other university's processes increased greatly. It became clear that the differences lay in the ceremonial and procedural elements, and that there was a shared commitment to the same set of high academic standards. This was an important step which paved the way for other collaborative activities.

Joint PhD Degree Programme

In 2000, discussions for a joint PhD degree were initiated. What was envisaged was one degree awarded jointly by the two universities. The degree scroll would contain the names and seals of TU/e and NUS. Such an undertaking clearly needed the approval of the highest leadership levels of both universities. It is interesting that up to this point, most of the collaborative arrangements needed only the commitment of the individual professors and sometimes the approval at the department or faculty level. A joint degree would be quite different.

The process for a joint degree between two well-established universities with very different traditions and histories would normally have expected to take many rounds of protracted negotiations, even in this age of globalised education. But the process was successfully concluded in a one or two months. This was largely due to the experience of working together in the other collaborative activities. This generated the confidence among the professors that academic standards would upheld, and that there was commitment and goodwill on both sides. Further, the professors were convinced that a joint degree would be in the interest of both universities, their professors and students. They were then able to convey this confidence to the leaders in both universities.

In this arrangement for the joint PhD degree, students will have to satisfy the admission requirements for both the host university and the partner university. For graduation with a joint PhD, the candidate will have to satisfy the PhD requirements of both universities, going through both PhD examination processes, where possible in parallel; where necessary sequential. In addition, the student is expected to spend a minimum of two semesters away from his hosting university (i.e. in the partner university). In this way, nothing is lost in the rigour of the quality assurance procedures in either university. The first two students of this joint PhD degree programme are expected to graduate in December 2002, one each in Electrical Engineering and Industrial Engineering.

Design Technology Institute

The increasing intensity of research collaboration and staff and student exchanges, especially in the area of robust design, reliability of electronic products drew considerable interest from industry in Singapore and the Netherlands, and from govenrment organisations charged with economic development and manpower development. It was recognised that this collaboration was of value to industry and that it should strengthened. The theme for the collaboration was brought into sharper focus and the area of design technology was adopted. With strong support from industry, the respective Ministries of Education and the Singapore Economic Development Board, a Design Technology Institute was set up by the two universities.

Through global market competition, product development cycles have become shorter and will continue to shrink. Manufacturers are forced to produce goods within increasingly shorter time constraints.

The classical product development process has a functional structure in which different individual functions in a product are very likely to operate independently under well-defined procedures and guidelines. Product integration is usually done in the late phases of the development process.

This classical structural process is found in various fields of engineering such as electrical, mechanical and software development as well as in design and manufacturing. Most engineers today continue to be trained in these independent fields according to the classical structural process.

Research in many leading companies has shown that if product integration takes place in the late phases of product development, the resulting product is far from optimal and usually requires late & inefficient iterations before reaching the market. For this reason, a different concept in product development, known as the Iterative Engineering approach is used. In this approach, most development activities/iterations are structured to take place early in the product development cycle and where possible concurrently.

However, iterative engineering puts considerable demands on organisational structures - particularly with regards to communication and labour processes in the organisation. People from various disciplines are called upon to solve problems during the product development process, which require cross-disciplinary expertise long before the final stages of product development.

Implementing iterative engineering principles in an industrial context often gives less than satisfactory results in practice. Some of these practical problems are:

a. Inadequate training and expertise in the concurrent development process

b. Difficulty in synergizing cross-disciplinary labour functions

c. Difficulty in managing or controlling technical processes in the strongly iterative development processes

In order to provide industries, operating in highly competitive environments, with viable solutions both in concept and expertise, the National University of Singapore and the Technische Universiteit Eindhoven (TU/e) together set up a Design Technology Institute (DTI). This Institute will train engineers who are able to translate technical concepts into real products efficiently in line with time driven, competitive markets, or in other words, to marry form and function across several domains early in the design process. DTI will engage in cross-disciplinary research and education in the several key areas of engineering and technology management. For relevancy to the needs of the industry, there will be an industrial component integrated in both areas of research and education.

Currently DTI run three education programmes, each with a Master of Technological Design (MTD) conferred jointly by the National University of Singapore and Technische Universiteit Eindhoven. These degrees are in the areas of Embedded Systems, Rapid Product Development and Mechatronics respectively. The first two programmes have started while the third will commence July 2002.

Joint Academic Appointments

The level of research and education exchanges made the discussion of joint academic appointments a natural development. In this arrangement which is currently in process, it is envisaged that a small number of professors who are involved in the collaboration will hold dual appointments in both universities, and be involved in the teaching and research at both sites.

FACTORS FOR SUCCESS

The collaboration between NUS and TU/e has progressed smoothly over a ten year period. Among the possible reasons for its success are the following:

a. It was a collaboration that grew organically out of existing collaborations between professors in the department level. In this sense, it was a bottom-up collaboration, rather than a top-down relationship.

b. There were very compatible convictions regarding academic values and standards, which was tested over a long period of time through collaborations of growing complexity.

c. The collaboration involved education, research and industry. The focus of the collaboration found resonance with industry in the two countries, hence the benefits to all parties were tangible and not merely theoretical.

d. The leadership of both universities had a very strong, long term commitment to going global. This commitment was demonstrated by the ability to make decisions quickly

even when the decisons involved investment of significant university resources.
e. There was strong support from the public sector, especially the Ministries of Education and the ecocomic development agencies. This support was crucial in the setting up of the Design Technology Institute.

CONCLUSION

This paper describes the collaboration in engineering education between the National University of Singapore and the Technische Universiteit Eindhoven which has led to four joint degrees which are:
a. Master of Technological Design (MTD) in Embedded Systems,
b. Master of Technological Design (MTD) in Rapid Product Development,
c. Master of Technological Design (MTD) in Mechatronics,
d. Doctor of Philosophy

It was noted that this collaboration was one which grew organically from informal collaborations between individual professors in the two universities into a jointly established research institute, joint academic appointments and joint degrees. The partnership brings in industry from both countries and encompasses research, education and industry research projects.