Int. J. Engng Ed. Vol. 10, No. 1, pp. 142–146, 1994
Printed in Great Britain.

0742–0269/91 $3.00+0.00

Engineering Education in India—The Role of Bilateral Co-operation

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International co-operation plays an important role in engineering education. By way of example, the bilateral co-operation between India and Germany in science and technology is reviewed, especially in the fields of engineering science and engineering education. This co-operation involves a number of partner institutions working on the basis of government agreements between the two countries. It includes academic exchange programmes, major technical projects of co-operation, and joint projects in many fields of science and technology. Under the exchange programmes, several thousands of engineers and scientists have spent extended periods of time in the respective partner country. Among the projects of technical co-operation, the joint establishment of IIT Madras is an outstanding example. Over the past two decades, balanced co-operation in joint projects has developed to a level that reflects the advanced state of engineering education and of science and technology in India. Co-operation on the whole can be characterized by continuity, achievements, mutual benefit, and great personal commitment of many scientists. The changing economic policy in India as well as the unification of Germany have broadened the scope of future co-operation with the continued support of both the governments.

INTRODUCTION

MODERN society depends heavily on engineering and thus on engineers and engineering education. This is true not only for industrialized countries but increasingly also for developing countries, even if the focal points of engineering differ. In India, capable engineers are needed in many sectors, like construction, transport, electricity, communication, mining, production of equipment and consumer goods, but also in the food industry and in others.

As a recent review article in this journal [1] and many articles of this issue show, there are a large number of colleges, universities and the Indian Institutes of Technology offering higher technical education in India. In one way or another, all of them have contributed to the high level reached. But co-operation with foreign countries in engineering sciences and engineering education has also assisted in reaching world standards. It was Britain, first of all, which influenced engineering education in India, not the least by introducing the British educational system, which has not been abandoned to this day.

After gaining independence, India began to co-operate also with other Western nations, especially the Federal Republic of Germany, which, after World War II, gradually resumed its role as one of the leading nations in engineering science and engineering education.

This article will review the co-operation between India and Germany as an example of the role of bilateral co-operation.

INDO-GERMAN BILATERAL CO-OPERATION IN SCIENCE AND TECHNOLOGY

Co-operation in engineering science and engineering education is part of a broader co-operation in science and technology initiated in the 1950s by the governments of India and the Federal Republic of Germany. It took a number of years for personal contacts between scientists, links between universities and research institutes, and between the administrations to develop and appropriate arrangements for the organization of co-operation to be established. Today, co-operation is very intense and lively, with several hundred scientists and engineers going to the respective partner country every year.

The exchange programme and the joint projects in engineering and the natural sciences are executed under the umbrella of various government agreements, by the German Academic Exchange Service (DAAD), the Alexander von Humboldt Foundation (AvH), the Deutsche Forschungsgemeinschaft (DFG), and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), and by the International Offices of the national research centres, KFA, Jülich; DLR, Cologne; and GSF, Munich, on the German side and the University Grants Commission (UGC), the Department of Education (DOEd), the Council of Scientific and Industrial Research (CSIR), the Indian Space Research Organisation (ISRO), and the Department of Science and Technology (DST), the Indian National Science Academy (INSA), the

Department of Atomic Energy (DAE), and the Indian Council of Medical Research (ICMR) on the Indian side.

The following 'special arrangements' exist:

DAAD — UGC		
DAAD — CSIR		for exchange of scientists
AvH — UGC		
DFG INSA		
KFA — DAE		for joint projects in science
KFA — CSIR		and technology, sponsored,
KFA — DOEd		on the German side, by the
DLR — CSIR		Federal Ministry for
DLR — ISRO		Research and Technology
GSF ICMR		(BMFT)
GSF — CSIR		

and there are also special project arrangements between the Government of India and the German Federal Government for technical co-operation projects sponsored on the German side by the German Federal Ministry for Economic Co-operation (BMZ).

There exist two more co-operative programmes under BMZ sponsorship which have a bearing on engineering education, executed by the German Foundation for International Development (DSE) and the Carl Duisberg Society (CDG), respectively.

The DSE is chiefly concerned with the advanced training of Indian experts and managerial personnel, mostly in connection with rural development, food security and industrial education.

The CDG, an organization funded by the Federal Government, the federal states and German industry, is involved in industrial training. It is named after a famous German industrialist, who was a pioneer in the field of vocational training, and organizes advanced training programmes in various fields, both in Gemany and abroad.

Since the early 1950s, several thousand Indian scientists and engineers have come to Germany for extended periods of time within the framework of these arrangements and project agreements for specialized education and training, postgraduate work and co-operation with German partners in special fields of research. A similar number of German scientists have gone to India—mostly for shorter periods of time—for special studies, as visiting professors, to assist in setting up new laboratories and other technological facilities, and to work on joint projects.

India has become one of the main partner countries of Germany in science and technology apart from the industrialized nations. This co-operation has developed, grown and borne fruit because of the continued support by both governments and the absence of impacts caused by political change. It is characterized by continuity, calculability, mutual benefit, and personal involvement. Two High Level Meetings on Science and Technology held in 1992 and 1994 in Bonn and New Delhi respectively as well as meetings of the newly established Consultative Group on Indo-German Relations, confirmed the long-term perspective and the high value of this bilateral co-operation. Prospects for the future are bright, as the unification of Germany offers additional opportunities in the new German federal states, and changing economic policies in India will provide for closer economic ties and will stimulate co-operation also between industrial R&D groups.

THE EXCHANGE PROGRAMMES

Exchanges of scientists under the agreement with the DAAD and the AvH are arranged for individuals, while co-operation under the arrangements with the BMZ, the KFA, the DLR and the GSF covers joint projects including, of course, the exchange of staff between the project partners. In many cases, an exchange of scientists forms the basis for subsequent project co-operation.

Within the DAAD–UGC and DAAD–CSIR arrangements, a total of about 2500 Indian scientists have come to Germany so far, over half of them for extended periods of time (1–2 years) [2]. The DAAD today provides the following:

- up to 32 annual scholarships for young Indian scientists working at universities or research institutes on leave of absence from their home institutions. Some of these scholarships are extended to two years. These scholarships are granted to acquaint young scientists with new research methods and techniques which will be of use to them after their return to India. Of the 32 scholarships, some 15 are in the fields of engineering and engineering education.
- Ten annual scholarships for young German scientists or graduates going to India for special studies, mainly Indian studies and the humanities, but more and more also in natural science and engineering.
- Funds to allow German professors and lecturers to be delegated to universities and/or research institutes in India, both for short (1–3 months) or long periods (1–5 years).

The DAAD also supports 'interdepartmental links' between Indian and German universities. This programme, which is sponsored jointly by the DAAD and the UGC, allows for successive exchanges of scientists co-operating in a specific area within a well-defined programme of work and research over an extended period of time. In addition, the DAAD invites a limited number of Indian scientists for periods of up to three months for specialized studies in Germany. In this case, however, international travel costs have to be paid by the Indian side.

Since 1960, the DAAD has had an office in New Delhi which also assists the AvH Foundation in organizing its exchange programme [3].

The exchange programme of the AvH Foundation is similar in scope. Since 1954, some 960 Indian scientists have come to Germany as AvH scholars for long-term stays [4]. These scientists now work at more than 200 Indian universities, colleges, research institutes and industrial companies. A substantial proportion of AvH fellows from India are in the fields of natural sciences and engineering. Out of the 960 scholars, nearly 900 are scientists, 160 of these are engineers, i.e. mechanical, civil, electrical and electronics, or metallurgical engineers. Their host organizations in Germany normally have been universities or technical universities, but also industries, national research centres and institutes of the Max Planck Society. This exchange programme has helped establish many valuable contacts, leading to an intensive and fruitful transfer of know-how, influencing the state of engineering science and engineering education in India in a positive way.

TECHNICAL CO-OPERATION PROJECTS

Engineering education in India has benefited a great deal from the large technical co-operation projects sponsored by the German Federal Ministry for Economic Cooperation (BMZ). Their purpose has been to set up a modern infrastructure for research and technical education in India. The outstanding example of this kind of bilateral co-operation is the joint establishment of the IIT Madras, but other projects, like the research vessel, *Sagar Kanya*, the Institute of Remote Sensing of the Anna University in Madras, and the Welding Technology Laboratory of Roorkee University, should also be mentioned.

The IIT Madras was the largest project anywhere in the world under the FRG technical co-operation progamme. It represented a joint effort by many German institutions and by the Government of India [5]. In his opening address at the Indo-German Seminar on International Co-operation in Higher Technical Education organized by the AvH, the DAAD, the DFG, the GTZ and the IIT Madras on the occasion of the institute's Silver Jubilee in Madras in January 1984 [6], the then chairman, board of governors, IIT Madras, Sri A. Sivasailam, called it 'one of the success stories of international cooperation in technical education'. He recapitulated the stages of the programme until 1983 as follows:

There have been five successive Indo-German agreements on IIT Madras, spanning the twenty-five year period from 1958–1983. In the first two agreements, which ended in 1971, emphasis was laid on provision of equipment to the various laboratories and central workshops, and training of young Indian faculty in German universities. Many German faculty and technical staff were seconded for long periods to IIT Madras to help in the establishment of laboratories and student training programmes. At the end of the two agreements, the IIT had established strong undergraduate and postgraduate programmes, and commenced on building a research base. The establishment of computing facilities with the installation of an IBM 370/155 system in the third agreement helped accelerate the research and development programmes. In the IV and V agreements, 36 Joint Research Projects were funded. Each research project was undertaken jointly by a faculty member in IIT and a faculty member in a German university. The Industrial Consultancy Centre was set up to foster contacts with industry. Special laboratories, like the Television and High Polymer laboratories were equipped. Support has been assured for the further development of the Ocean Engineering Centre.

Mr Sivasailam also pointed out that the permanent nature of the co-operation was the key to its success. Mr R. Jerosch, who had been the GTZ representative at IIT Madras from 1971 to 1976, added in his speech at the concluding session of that seminar that the majority of the German experts working at IIT Madras had concentrated on lecturing and setting up modern laboratories and workshops, but had not participated actively in discussions on syllabus, curricula, examination procedures, and the direction the IIT should follow in future. He felt that thus a chance has been missed, because a deeper discussion on the method and content of engineering education, about teaching how to learn, how to do research and how to obtain knowledge on one's own, might have stimulated fresh thinking and increased the impact of Indo-German co-operation on 'scientific cultures'. The parallel programme provided for the training of technicians in Germany to develop technical skills of an international standard, and the setting up of the Industrial Consultancy Centre (ICC), was praised by several speakers, both from Germany and from India. The ICC helped to bring about a close interaction of the faculty of IIT Madras with industry [7]. According to H. Wagner of the FH Karlsruhe, who was adviser to the ICC, the exposure to live technological problems is beneficial not only to the staff members but also to the students whom they teach and, in a larger measure, to the development and growth of industry. The ICC at IIT Madras was the first of its kind in a higher technological institution in India, and served as a forerunner for several similar units established subsequently at other institutions. It has now enlarged the scope of its activities under the name of the Centre for Industrial Consultancy and Sponsored Research.

In summary, one can say that the joint efforts of India and the FRG in the IIT Madras project were successful in building an exemplary place for the education of engineers, who can not only reproduce the state of the art, but can find better solutions to old problems and find solutions for new problems. It was not possible—and perhaps not intended—to modify the educational structures by implanting ideas of the German system.

Since 1984, project co-operation between IIT Madras and German universities and research institutes has continued under the sponsorship of the BMZ. It is now supplemented by bilateral projects under the special arrangement between the KFA and the DOEd while, of course, staff members from IIT Madras continue to be included in the exchange programmes of the DAAD and the AvH.

JOINT PROJECTS IN SCIENCE AND TECHNOLOGY

Let me now turn to the role in engineering education played by the joint projects in science and technology, sponsored on the German side by the Federal Ministry for Research and Technology. These projects are based on government agreements of 1971 and 1974, respectively, and started only in the 1970s under special arrangements with the KFA, the DLR, and the GSF [8, 9]. In order to facilitate bilateral co-operation of the Indian Institutes of Technology, universities, colleges and the Indian Institute of Science with partners in Germany, a special arrangement was concluded between the Department of Education in New Delhi and KFA Jülich in 1986. This special arrangement provides the opportunity to include the topic of educational science and methodology into the scope of bilateral co-operation in science and technology.

Joint projects under these special arrangements are smaller in scope than those sponsored by the BMZ, and depart from the balanced interests of the partners involved. They therefore foresee an equal sharing of effort and expenditure. There is no cash flow between the partners. The costs for personnel exchange are shared, the delegating partner covering the travel expenses and granting leave of absence, and the receiving partner acting as the local host. The areas of research are defined jointly. They shift with time, reflecting current research priorities in the two countries. Natural and engineering sciences are focal areas in this co-operation. Since 1972, a total of 2500 scientists have been exchanged within joint projects. They have spent some 400 man-years in the respective partner countries. Nearly 1000 joint publications and a number of books on technical and scientific topics have resulted from these projects. Some 60 Indo-German workshops, seminars and symposia have been held. Out of the 130 ongoing projects, 45 are in the engineering sciences, but still very few cover topics of engineering education; one such example is a joint project on computer-aided instruction for continuing education. It is being carried out by IIT Madras and the Hamburg Educational Partnership. However the other projects also contribute to the advancement of engineering and lead to valuable contacts, give young engineers the opportunity to learn more about research and education techniques in the partner country, and, in some cases, to use part of the project work for their doctoral theses.

Important areas of co-operation in engineering sciences include materials research, energy technologies, geology, marine technologies, microelectronics, aeronautical science and space research. Partners are the laboratories of the CSIR, the DAE and the ISRO, as well as IITs, the IISc in Bangalore, universities and colleges, on the Indian side; and national laboratories, universities, institutes of the Max Planck Society, and industry on the German side. Priority is given to projects of applied research that hold out prospects for commercial exploitation of the results.

In many cases, the various types of co-operation listed above overlap. For example, let me mention the bilateral co-operation in the area of energy engineering between IIT Delhi and various universities—Fachhochschule Aachen, universities of Kassel, Munich, Siegen—and the KFA Jülich in Germany. This co-operation has been going on for 10 years. Besides research projects on passive space conditioning, solar drying, plastic solar collectors, solar cooking, meteorological stations, stochastic simulation of solar radiation, various textbooks and reference books have been written [10], and an exchange of students has taken place: students from the FH Aachen completed their graduate theses on photovoltaic modules and systems and on solar cooking in Delhi, while two students from the Munich Technical University worked there on a biogas engine and solar drying. In a programme financed by the DAAD, Professor N. K. Bansal of IIT Delhi, Centre for Energy Studies, taught at FH Aachen as a visiting professor. This example shows that joint projects often do relate to questions of engineering education, and that the flow of know-how is not unilateral.

CONCLUDING REMARKS

As engineering is universal, bilateral co-operation in engineering and engineering education will be of great benefit. Co-operation between a highly industrialized country and a developing country, of course, is bound to include problems, which must not be overlooked. These problems result, among others, from the following:

- different traditions influencing value systems and behavioural patterns;
- different economic and social structures determining the requirements to be met by engineers, their working habits, professional expectations and chances;
- different educational systems.

The experience of almost 40 years of Indo-German co-operation in engineering shows that it is possible to overcome these problems and to bridge the gap, if the right approach is taken. The success depends to a large extent on individuals, their personal commitment, and their capability to adjust to, and accept, the differences in thinking and in conditions of living and working. Co-operation must be developed from the bottom, by establishing good personal relations, understanding and confidence, as prerequisites of a frank discussion of the goals, problems and ways of solving them jointly. The exchange programmes have established a good basis, in this sense, on which it was possible to build project co-operation. Several thousands of engineers and scientists have had the chance to spend extended periods of time in the respective partner country, some more than once, and thereby have become familiar with the host country and with their counterparts.

I know from experience how important exposure to foreign surroundings is for a young scientist. The year I was able to spend overseas after receiving my doctorate added very much to my technical education, and became decisive in my professional life. It also broadened my mind and made me better understand foreign cultures, but also that of my native country. It shaped my later attitude towards colleagues from abroad and made me open to contacts and co-operation.

I hope that most of the Indian engineers and scientists who were able to spend extended periods of time in Germany share this positive experience. If this is the case, all of the bilateral programmes between India and Germany mentioned have a positive and favourable bearing on engineering education in India, even if their main goal is and was not 'education'.

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