

# On Transnational Exchanges of Postgraduate Students in Industrial Mathematics

F. SCHURER

*Department of Mathematics, Eindhoven University of Technology, Eindhoven, The Netherlands*

*This paper deals with experiences obtained with the placement of students in foreign industry during the past six years by the University Enterprise Training Partnership (UETP) set up by the European Consortium for Mathematics in Industry (ECMI). These students participate in the common European postgraduate (two-year) programme 'Mathematics for Industry', which is now operational at approximately 10 universities in Europe. Part of the programme (about half a year) has to be spent abroad, preferably in industry. Since 1987 ECMI has been funded by COMETT's strand B, and this has greatly contributed to the execution of these transnational student exchanges. In general, it can be said that the implementation of a strand B-programme is a very time-consuming process, but also quite rewarding. To date we feel it has been a resounding success, and is a vital part of the UETP-ECMI's activities.*

## 1. INTRODUCTION

ECMI, the 'European Consortium for Mathematics in Industry', was established in 1987. The consortium's objectives are threefold: (i) to promote the use of mathematics in industry; (ii) to train highly qualified mathematicians for industry; and (iii) to operate on a European scale. Originally, ECMI was mainly an initiative of a number of mathematics departments of European universities. To achieve its objectives, in particular objective (ii), a common European postgraduate (two-year) programme 'Mathematics for Industry' was designed in which the universities of Eindhoven (Netherlands), Kaiserslautern (Germany), Oxford (UK), Glasgow (UK) and Firenze (Italy) have participated from the start. Gradually, other universities have joined and the postgraduate programme is now operational in Dresden (Germany), Grenoble (France), Linz (Austria), Trondheim (Norway), Göteborg (Sweden), Lyngby (Denmark) and Helsinki (Finland). Hence the objective of operating on a European scale has been realized. Objective (i) has been partly fulfilled as the graduates of the aforementioned educational programme have become engaged in industry as industrial mathematicians. Another aspect, which also furthers objective (i), is a change of attitude towards industry by (some of) the university staff who contribute to this programme. Obviously, it was a happy coincidence that COMETT, the Community Programme for Education and Training in Technology, came into being approximately at the same time as the Consortium was founded. In view of COMETT's objectives, it was quite natural for the Consortium to set up a University Enterprise Training Partnership (UETP), because the Consortium's objectives (i)-(iii) as stated above fit nicely with those of COMETT. [ECMI has been funded by COMETT

since 1987. Grants were received under strand A (COMETT's infrastructure), under strand B (transnational exchanges of students and personnel) and under strand C (joint university-industry projects for continuing training). In this paper we only deal with ECMI's activities under strand B.] Within each country participating in ECMI, a number of industrial enterprises—a total of about 50, sometimes also laboratories, public service organizations, etc.—have joined forces with the local ECMI university centre(s). Taking into account the above description of ECMI's objectives, it clearly follows that our UETP is a sectoral one, and that ECMI's strategy is targeted at developing a network of universities around Europe which contribute to the training of industrial mathematicians; this goal cannot be achieved without a close collaboration with high-tech European industry.

## 2. CHRONOLOGICAL SURVEY OF GRANT IMPLEMENTATION

In view of the objectives stated in section 1, the UETP's participation in COMETT's strand B, the placement of students in industry, is quite natural and completely compatible with ECMI's overall strategy. Indeed, a vital part of our postgraduate programme 'Mathematics for Industry' consists of (approximately) half a year during which the student has to study, or get training, abroad. For some of our students the COMETT placements in industry are used for this purpose and, hence, this B-strand of pool character fits smoothly in with our educational programme. Under COMETT I, a first contract of 13,500 ECU was obtained covering, roughly, the period July 1988–October 1989, and granting ECMI five student placements in industry (of 30 student-months in length). The implementa-

tion of this contract was difficult; out of the five assigned placements we realized only one. The next COMETT contract (8700 ECU, covering three student placements and equalling 18 student-months) was carried out completely, with one additional placement.

COMETT I came to an end in 1990. Its successor, the COMETT II programme, differed in some aspects from COMETT I—e.g. European Free Trade Association countries were entitled to participate. ECMI was fortunate to be able to continue its strand B activities (although still small in scale) under the new programme. Data concerning subsequent contracts are as follows: 1990/92: 27,840 ECU and 11 placements equalling 60 student-months; 1991/93: 40,320 ECU and 16 placements equalling 80 student-months; 1992/94: 45,990 ECU and 18 placements equalling 88 student-months and, finally, 1993/95: 70,260 ECU and 30 placements equalling 148 student-months. In comparison with COMETT I, our UETP thus saw a significant expansion in the area of transnational exchanges of students taking up placements in industry. Placements included in the first two COMETT II contracts were carried out in full. Contracts covering the period 1 July 1992–31 July 1994 and 1 July 1993–31 July 1995 were also implemented. Leaving these two contracts aside, we have brought together the accumulated placements in industry as of 31 July 1993 in Table 1.

### 3. VARIOUS THEMES CONCERNING THE PLACEMENT OF ENGINEERING STUDENTS

In what follows we describe a number of topics which we have come across when placing students in industry. Each subsection is concluded with a brief statement of what can be learnt from our experience.

#### 3.1 *Management aspects*

Each programme starts with the design of an application for which a number of planning steps have to be taken. Initial filtering and preselection of proposals is to a great extent determined by ECMI's common European postgraduate programme 'Mathematics for Industry' (cf. section 1); students enrolled in this programme who have successfully completed their first year qualify for a placement in industry. This training period (lasting 4–6 months) is a compulsory part of their education. Each local university programme co-ordinator (a group of which forms ECMI's so-called Educational Committee) knows approximately how many of her/his students are eligible during the COMETT period under consideration, and a meeting of the Educational Committee decides how many students will be included in the application and which flow schemes are most appropriate. At this stage of the planning, the receiving enterprises are not yet taken into account; initially, i.e. at the start of our UETP, we have assured ourselves of a sufficient number of industrial enterprises (cf. sec-

Table 1. Sending (vertical) and receiving (horizontal) countries regarding student placements

	NL	UK	D	I	DK	F	E	A	SF	N	Σ
NL	X	1	1	1	1		1	1	2	1	9
UK	5	X	1								6
D			X					1	1		2
I	1		1	X							2
DK			1		X						1
F						X		1			1
E							X				-
A	2		3					X	X	X	5
SF	3		3					X	X	X	6
N								X	X	X	-
Σ	11	1	10	1	1	-	1	3	3	1	32

NL, Netherlands; UK, United Kingdom; D, Germany; I, Italy; DK, Denmark; F, France; E, Spain; A, Austria; SF, Sweden/Finland; N, Norway.

tion 1) qualified to take in our students. Assuming a contract is obtained, the Educational Committee takes care of its implementation. Observing the guidelines as set forth in the COMETT contract, an adjusted scheme of placements is usually drawn up in such a way that, preferably, each of the universities involved gets its fair share; reciprocity with respect to receiving countries is also taken into account. The submission of an interim report to the COMETT Technical Assistance Office marks another important step in the finalization of the implementation of the programme; minor changes affecting earlier decisions of the Educational Committee may still be carried out, e.g. because a specific student is, most likely, not available during the contract period or because difficulties have arisen with allocating an appropriate enterprise within our UETP network. The level of funding awarded to each student is again a decision for the Educational Committee. Observing the ceilings included in the contract for the various types of cost, each student placement is awarded a specific sum for travel, for subsistence and for language preparation. With respect to travel, the distance between the two countries involved is taken into account. Similar measures are taken for the costs of subsistence—these are definitely higher in Finland, for example, than in the Netherlands. A uniform sum is generally assigned to each placement for language preparation; the same holds for institutional costs. It follows that in principle the Educational Committee takes all decisions with respect to this theme; the project manager takes care that they are carried out and, moreover, sees to it that the COMETT contract rules are observed.

Experience shows us that, for a sectoral UETP, a body similar to our Educational Committee, with a composition similar to ours as described above, is a key instrument for a successful implementation of transnational student exchange programmes. Furthermore, the existence of our common European educational programme 'Mathematics for Industry' has turned out to be an ideal framework in which to establish placements in industry. Full academic recognition of the training of students is thus ensured. Contacts of local programme coordinators with their national industry are such that a good matching of these student secondments can be achieved.

### 3.2 *Agreements between partners*

Written agreements between the various members of the Educational Committee (who represent the universities involved) about the exchange of students are included in the minutes and other notes of the Committee. Given the nationality of the students, the choice of who will be sent is the prerogative of each member of the Educational Committee; in some cases a COMETT grant offer to the student is confirmed in writing. Determining appropriate enterprises within the ECMI network is a complicated process in which actors representing the sending university, the university in the guest country,

and the receiving enterprise are involved. Implicitly, the student is also an actor here, and is represented by the local programme coordinator of his/her university. In this part of the implementation, the role of the project manager is rather marginal; he/she is informed and watches over the procedure. Much attention is given to the content of each actual placement (the training received by the student); the main actors are here, again, the two local programme coordinators of both universities involved, a representative of the receiving enterprise (an authority in the technical field in which the student will receive training) and, less prominently, the student. In each case, proper agreements are made up, but they need not be of a formal written character. It also happens that, in the case of a contract between student and enterprise, the project manager and the local programme coordinator are not acquainted with specific details of its contents because some companies consider it confidential. Sometimes, there are just oral arrangements, which have the advantage of flexibility. However, good monitoring by the receiving enterprise is then a 'must'. It may be difficult to prescribe in detail advanced training needs (we are dealing with postgraduate students!) during the whole length of the period of the placement; if necessary, they should be adjusted.

We have found out that, with respect to (written) agreements, we can do with a rather low degree of formalization. Because of our common educational programme (cf. sections 1 and 3.1), local programme co-ordinators are well acquainted with the training needs of students. Thus, concerning the content of placements we mostly work with flexible agreements between partners, based upon, preferably, a clearly defined 'project' to be written down in close collaboration with the host industry. Occasionally, confidential contracts between student and enterprise are established, e.g. when some sort of classified research is involved.

### 3.3 *Assignment and payment of grants to students*

The allocation of the grants is governed by the rules as set forth in the contract. Assuming a (possibly adjusted) scheme of flows has been accepted by the Educational Committee (with this scheme subsequently being included in the interim report and having the status that it can probably be implemented), the project manager draws up a proposal how the total COMETT grant will be divided up between the placements as earlier agreed upon by the Educational Committee. In subsection 3.1 we have described the rules according to which the COMETT grant is assigned to the various placements. Subsequently, the project manager transfers the associated amounts to the accounts of the local university programme co-ordinators who, in turn, directly credit their students going abroad. Ideally, the grant is paid to the students as a lump sum before they depart for their placement with foreign industry. If it so happens that the implementation of the placements accomplished deviates substan-

tially from the planning scheme upon which the various assignments were based, a correction in financial assignments is carried out afterwards.

The COMETT contract prescribes ceilings for the various expenditures involved (travel, subsistence, language preparation, institutional costs). Experience teaches us that this financial framework allows the project manager to subdivide the grant in such a way that all partners feel reasonably happy. Uniform contributions are assigned to language preparation and institutional costs. International transfer of money sometimes takes too much time. Occasionally we have come across the situation that universities receiving money from the co-ordinating institute (Eindhoven University of Technology), have difficulty tracing back the purpose for which these EC funds are meant. Apparently, in the process of transfer between banks, specifications are lost or the financial administrations of these universities are not adequately equipped for these transfers. As a result, students may not receive their grants in time.

#### 3.4 *Establishment of workplans and monitoring of students*

The procedure we have followed is roughly as follows. Within every participating university the students eligible for a placement are selected and interviewed. On the basis of their mathematical specialization, their knowledge of (or their affinity with) a discipline of application and taking into account their wishes to go to a specific country, the representative of the sending university addresses his/her colleague in the university in the desired guest country with a request to arrange a suitable project. Assuming this is successfully accomplished, a student's curriculum is presented to the enterprise; sometimes an interview (by telephone or through a visit) is arranged and further details (project description, rules concerning confidentiality, contract between the enterprise and the student, supervision, etc.) are discussed. When a project cannot be defined successfully at the first attempt, another country and/or another student are 'substituted' and the procedure is repeated. We place a high value on matching; of course, the enterprise involved cannot decide the contents of the project alone and the ECMI representative in the guest country plays a major role in the whole process. Placements are only acceptable when educational circumstances are rated as good. To this end, the project itself must have its merits (not just work, but some interesting (sub)problem meeting the training needs of the student), there must be adequate supervision on the spot (in practice, supplied by the company) and academic supervision must be available as well (in most cases supplied by the university partner in the guest country, occasionally by the sending university). In some cases, short weekly reports are faxed to the academic supervisor which allows almost continuous monitoring. After completing their secondments in industry, students are requested to write a one-page report about

their training period. These reports almost invariably show that these kind of placements are rated very positively; besides increasing the student's technical knowledge, they also add to his/her foreign language skills (and, to quote from a leaflet promoting language courses: 'the illiterate person in Europe today is he or she who can speak and write one language only').

At the end of subsection 3.2, some remarks have been given concerning (part of) this subject. The workplan has to fit in the student's curriculum of the aforementioned postgraduate programme 'Mathematics for Industry'. As such, the workplan of training needs is pretty well described. Experience shows that monitoring by company employees can be carried out quite well; however, the global goals of training must be specified well in advance and, before the project starts, the supervisor in the company should be known and be briefed about what he/she is expected to do regarding monitoring. Furthermore, we consider reports by students about their training period an indispensable part of their stay abroad.

#### 3.5 *Co-funding*

The placements of postgraduate students within our UETP are frequently co-funded by the receiving enterprise. This is done by one or several of the following means:

- a traineeship-payment for the extra costs of housing, local transport, etc.;
- the offer of free housing in a guest house or apartment from the company;
- free lunch or dinner in the company restaurant, or meals at a reduced price;
- free insurance (e.g. health, third party, accident);
- attendance at workshops, conferences etc., or visits to other plants of the host company.

Certain national or regional institutions operating in the public sector follow the same policy. Not all do; this also depends on their financial situation. In some cases the extent of the co-funding furnished by the enterprises is not known exactly, for reasons of confidentiality. However, in view of the data available to us over the past six years, we conclude that, on average, each postgraduate student was, in addition to his/her COMETT grant, paid approximately 400 ECU per month (either in kind or cash).

Companies within the UETP-ECMI network are, in general, quite willing to lend additional support to COMETT students. No doubt, part of the explanation for this is that we are dealing with postgraduate students of a high level in an attractive branch of industrial science. These mature students often really contribute to the company's core activities.

#### 3.6 *Survey of problems encountered in completing placement programmes*

In order to understand the context in which ECMI operates, one should bear in mind that

mathematics is a very broad discipline with many independent specializations, and that the use of mathematics in enterprises nowadays has to do with a wide variety of applications. Consequently, a student and a project fit together only if the student happens to have adequate prior knowledge of mathematics and enough knowledge of (or affinity with) the industrial branch of the enterprise in question. We list just a few examples of these branches to illustrate what is meant:

- systems and control in relation to a chemical plant;
- inventory control for a wood-processing company;
- numerical mathematics and the behaviour of oil reservoirs in certain geological structures;
- computer-aided geometric design for car industry.

There are a huge number of such combinations that make sense, and our UETP only has a limited number of students eligible for placement. In order to obtain a good match, we therefore have to start from the known prior knowledge, skills and wishes of our students, and subsequently have to determine suitable projects. During the last several years our UETP has been working hard in order to commit enough enterprises in different fields, with the effect that, presently, all reasonable combinations can be implemented. This explains the need for a long list of industrial partners, as well as the fact that, occasionally, placements have to be realized with new partners not yet formally included in our list of ECMI-related enterprises. In our view, only a sectoral UETP potentially has the capabilities to arrange such a broad spectrum of placements, and to deal with the intrinsically difficult situation we have just sketched.

A problem of quite a different nature is the economic recession in Europe during the past few years, which has hampered transnational exchanges of students in industry. In the UK, for example, R&D activities have slowed down considerably, thereby also affecting the emphasis on industrial mathematics and the opportunities for associated training. Most small and medium-sized enterprises and many British companies involved with defence are not prepared to take in foreign (non-UK) students. The so-called 'peace dividend' has had its effect on placement opportunities in general, as much R&D work in the UK is defence driven. Placements originally planned to happen in the UK have been realized elsewhere, in particular in German industry, where it is still easy to find placements for foreign students—although, apparently, the reunification of Germany has had, at

least in the short term, a negative effect on the flourishing of the country's economy. Likewise, due to the continuing recession in the Finnish economy, it is not at all easy to persuade companies to take in foreign students. The economic recession also hurts the employment of (foreign) students in Austrian industry. In comparison with a few years ago, the European economy as a whole has declined and the signs of recovery are still weak; at present, they seem the most promising in the UK.

Another problem concerns the ceiling for the institutional costs, as imposed by the COMETT rules for using the grant. Experience shows that the initial arrangements, needed for a good project abroad already use up more hours of senior staff time than apparently correspond to this part of the COMETT grant. In practice the universities within the system thus pay for the majority of the extra time needed to implement placements over national borders.

We finally add that a sudden change in the private situation of students may also affect the implementation of placements. Recall that, in our situation, we are dealing with grown-ups aged 23–26 years, an age critical for developing social relations. To show what we mean, we give just one example. One of our male students fell in love with a female student (both enrolled in ECMI's postgraduate programme) of another nationality. We tried, and succeeded, to find him a placement in her home country. Family circumstances (death of relatives, sudden illness, etc.) may also seriously jeopardize well-prepared placements. Occasions similar to those sketched here put extra pressure on the organization and implementation, taking into account that rules as prescribed by the COMETT contract ought to be observed.

Problems will, most likely, always be encountered in the implementation of transnational exchange programmes placing students in foreign industry. Some of these problems may be of a structural nature; for instance, who knows whether the economy in Europe will substantially improve in comparison with, say, the past three years? Success of implementation of programmes is, in our opinion, to a great extent determined by realistic planning ahead (in ECMI's case, how many qualified students do we have available during the (overlapping) contract periods), and by dedicated, flexible, management operating within an adequate and well-defined structure.

*Acknowledgement*—The author is indebted to Professor P. L. Cijssouw, chairman of the Educational Committee, for critically reading the manuscript and for a number of valuable remarks.

**F. Schurer** was born in 1938 and studied engineering mathematics at the Delft University of Technology in the Netherlands. From 1962–1964 he was a junior staff member at that university. In 1965 he obtained, at Delft, a Ph.D.; his dissertation dealt with a subject in approximation theory. In 1964 he joined the mathematics staff of the newly established Twente University of Technology. During the academic year 1967/68 he was awarded a NATO

Science Fellowship by the Netherlands Organization for the Advancement of Pure Research (ZWO); this year was spent at the University of Texas in Austin and, during the summer, at the University of Washington in Seattle. Since 1968 he has been associated with the Eindhoven University of Technology and, from 1980 onwards, has been a professor in mathematics there. His research interests are in approximation theory, mainly in so-called spline approximation. Eindhoven University of Technology acts as co-ordinating institute for a number of EC programmes (ERASMUS and COMETT), within the framework of ECMI, the 'European Consortium for Mathematics in Industry'. Since 1989 the author has been the project manager of ECMI's educational and training activities funded by ERASMUS as well as by COMETT.