
A learning network for the semiconductor industry

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Abstract Demand for skilled staff is one of the factors limiting growth in both the design and the manufacture of integrated circuits and other semiconductor devices. This paper describes how the semiconductor industry in the UK has been collaborating with further education colleges, universities, regional development agencies, and educational and funding bodies to build a Learning Network capable of developing the required skills. Issues that still need to be addressed, from an industrial perspective, are discussed together with some potential solutions.

Keywords collaboration; continuing development; further education; Learning Network; postgraduate

Economic growth is driven by the utilisation of ideas and technology. As explained below, much of the infrastructure behind this growth is built upon electronics in general, and on its semiconductor content in particular. In common with the rest of high technology, the global semiconductor industry faces a shortage of skilled individuals. There is a world-wide shortage and the location of product development and manufacturing facilities is strongly driven by the availability of a skilled workforce. Investment is starting to follow the availability of skills.

The semiconductor industry in the UK produces approximately £8 bn of integrated circuits (ICs) and optoelectronic devices per year. It employs over 10 000 people directly and about half that number again within its supply base. In addition, about 30 000 engineers are employed developing integrated circuits and associated software.

The industry is growing rapidly and considers the development of skilled staff to be a strategic issue. It established the National Microelectronics Institute (NMI) to co-ordinate the formulation and implementation of an agreed education and training strategy. Central to this strategy has been the development of a Learning Network, which consists of:

- a collaborative network, involving industry, further education (FE) colleges, universities, accrediting and awarding bodies (such as SQA, Edexcel and EMTA),¹⁻³ the institutions, LECs/TECs, and the educational funding bodies, together with regional development agencies and government departments;
- industry support being focused on a limited number of recognised specialist institutions;
- a set of recognised courses and qualifications for developing the skills required by the industry;
- the development of a strategic vision to guide the participants in the network and which can be communicated to potential students, parents, employees, employers, funding bodies and government.

The network is presently delivering over 200 trained technician qualifications per year and will be producing the equivalent of over 20 full-time MScs per year when the Masters-level programmes are fully operational.

The growth of high technology

The growth in the use of electronics in everyone's daily life continues to explode. The number of mobile phone users is expected to reach over 1 billion by 2003 compared to 300 million in 1998. The majority of car engine control and braking systems are already controlled by electronics. The Internet is becoming a commonplace. And digital electronics are expanding into existing applications, such as television. This has led to electronics becoming the fastest growing industry in the world, and it depends on a supply of semiconductor integrated circuits (ICs). Semiconductor sales have grown at an average rate of 17% per year for 30 years; sometimes growing more than 40% a year but sometimes falling by 10% in sales value (although unit output has always risen) (Fig. 1).

It is the high rate of growth that makes it difficult for the semiconductor industry to match capacity with demand. It takes close to three years to build a new manufacturing plant and bring it to full capacity. By the time a shortage has arisen, it is too late to invest. And at times of excess capacity it is not economic, as we shall see, to run at less than full capacity, so that prices fall rapidly to boost demand. In 1995, a shortage of manufacturing capacity and ever-rising demand for memory and microprocessors had pushed prices higher. In that year about \$45 bn of the memory that goes into computers (DRAM)

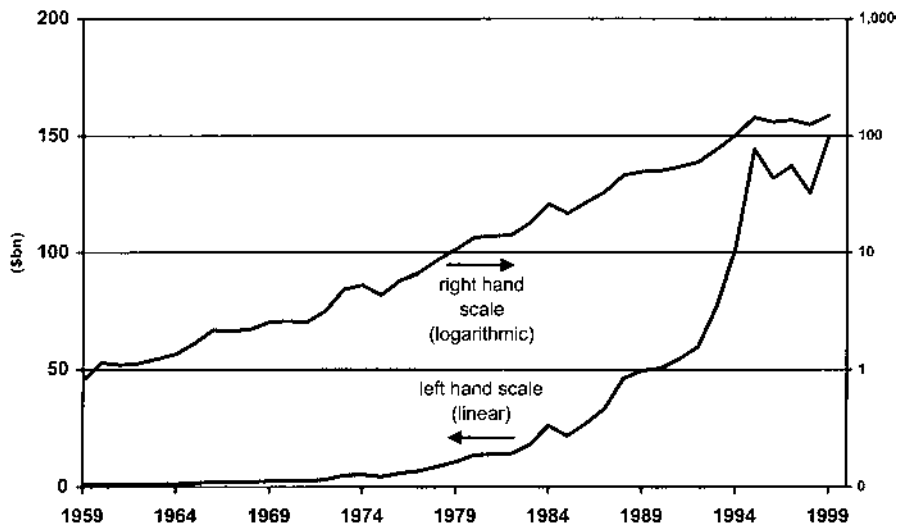


Fig. 1 World semiconductor sales.

was sold. Total semiconductor sales exceeded \$150 bn. Margins were high and the industry was highly profitable. So profitable that many corporations, investors and governments around the world saw it as an industry that they had to be a part of.

Plans were put in place to build new manufacturing facilities and most of these came to fruition in 1997. Some were heavily subsidised by governments for 'strategic' reasons. Others were funded by companies that were able to borrow excessively by European standards. One of the reasons that the NMI was established was to support the demand for manufacturing staff from three new, state-of-the-art manufacturing facilities in the UK, in Dunfermline, Newcastle and Newport. So much capacity was added, world-wide, that it exceeded demand and prices started to fall. Excess capacity drives down prices because a large percentage of the cost of manufacture lies in the capital cost of building and equipping a plant. A large facility costs over \$1 billion to equip today. At times of excess capacity it is better to run a factory at full capacity and ship product at a loss as this still covers the ongoing operating costs; the parts still make a marginal profit.

By 1997, the value of the DRAM memory sold had fallen to only \$14 bn — memory plants (and others) were forced to run at a loss. This fall in the value of the memory sold occurred even though the number of memory devices shipped continued to increase dramatically and the amount of memory on each device increased. During a normal slowdown in the semiconductor market, IC manufacturers would simply wait for the demand to rise to match the available capacity. But in 1998 the recession in the Asian economies made the situation even worse. Growth in the dollar-value of ICs shipped fell further, although it was still rising in unit terms. Around the world, manufacturers were unable to continue to sustain their losses. They put the construction of new plants on hold, closed existing capacity and put factories up for sale. Major closures were announced in the USA and Japan.

In the UK, the Korean manufacturers Hyundai and LG Semiconductor put their major new plants in Dunfermline and Newport, Wales, on hold. Siemens and Fujitsu announced the closure of their plants in the North East of England. Seagate closed its facility in Livingston. However, although many people were made redundant most found jobs in the remaining semiconductor fabrication plants or in related industries. Indeed, the period demonstrated that staff in the industry have technical skills that are in great demand in the rest of the economy. Yet everyone in the industry knew that rising demand would exceed capacity before long. NMI forecast that the turning point, when demand would exceed capacity, would occur in 1999, and indeed that did occur towards the end of the year. With a shortage of capacity lead times are lengthening and semiconductor prices are firming rapidly.

Plants in the UK are running at capacity. Many are expanding and taking on more staff. Filtronic have purchased the mothballed Fujitsu facilities near Durham, and are ramping up to produce GaAs circuits for mobile phones.

Atmel and Motorola have taken over the new, but empty, plants built by Siemens in Newcastle and Hyundai in Dunfermline, respectively.

Only by understanding the business cycle of the semiconductor industry (and other high technology industries) can the academic community develop the confidence to educate and train the skilled staff that will be required in future.

Implications for education and training

In the previous section we saw how the semiconductor industry is growing rapidly, with periods of hectic growth interspersed with periods of consolidation. This market dynamic is shared by many other high technology industries, and successful economies have to learn to cope with it. It gives a particular problem to educators. How can they plan to provide qualified individuals when industry itself has difficulty forecasting the capacity it will require? We need to find a way for the education and training system to cope with the rapid fluctuations in demand for staff from individual industry sectors. We must avoid taking the easy option of not encouraging students to follow engineering and science options. These are the very skills that are enabling economic growth.

One obvious approach is to develop generic abilities that are applicable across a range of industries or industry sectors. At the most generic level it is widely recognised that modern societies must continue to develop literacy, numeracy, information technology and interpersonal abilities to be able to exploit advances in technology. At the next level, we require graduates with skills in fields such as electronics, computer science, chemical engineering and mathematics. We require technicians with skills in the installation and maintenance of complex capital equipment. These skills include programmable control, pneumatics, robotics, vacuum, RF equipment, and process control, for example. Both the graduate-level and technician-level skills are applicable across a wide range of industries. They are vital to support a modern society.

This observation should allow those broad areas of knowledge and skills that are likely to be in short supply to be identified and for the education and training system to be well resourced in these fields. On receiving their qualification, individuals will naturally flow to where growth is occurring at any point in time. However, supplementary education and training courses are required to provide the specific skills required by given industry segments. This is illustrated in Fig. 2.

Industry as a whole can work with the education and training system to develop individuals with appropriate sets of broadly based generic skills. Additional courses can be developed to provide more specific skills for given industry sectors and to facilitate retraining between sectors as shown by the arrows in Fig. 2. This provides a number of benefits:

- it is flexible for young people, who can initially target a range of industry sectors without making a final choice and take sector-specific modules later in their education;

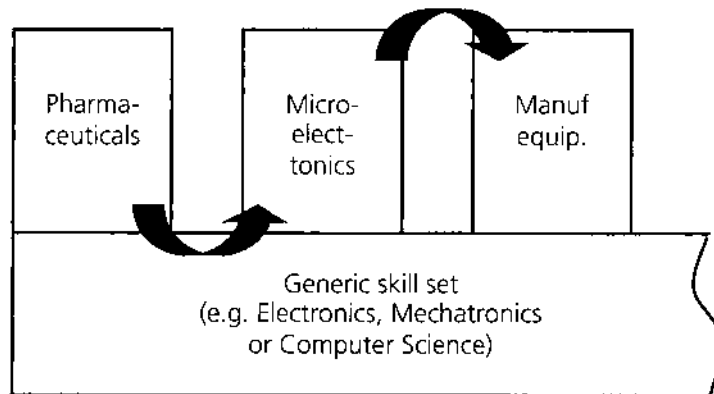


Fig. 2 *Generic and specialist skills.*

- it makes engineering more attractive to young people — they see that common modules give them access to a wide range of job opportunities;
- it insulates individuals from given sectors' 'ups and downs' as they can easily retrain for jobs in other sectors;
- it allows rapid retraining between industrial sectors, thereby allowing industry to grow without having to train staff from scratch.

This is exactly the approach that the semiconductor industry has adopted by adding specialist semiconductor modules to the HNC/HND mechatronics core, as described below.

Skills lead investment

The trend is for high-wage economies to move towards higher skilled and higher value activities. This is especially true for product design and development. In the case of manufacturing it implies a continued trend to industries with high capital investment where salary costs are a small proportion of overall costs. The equipment employed requires a focus on high-skilled technician support as well as graduate engineering skills.

We have seen earlier how ideas are driving the rapid growth in the electronics industry, and how this in turn is supporting the changes in business models we are seeing in the rest of the community. But the growth in business occurs wherever the skills are available to support the activity. We are operating in a global economy and able people attract investment. Indeed, investors look elsewhere when skills are not available. In short, skills must lead investment.

At present large grants towards training are available for inward investors who locate new facilities in the UK. These grants are given for the correct purpose, but the expenditure is too late: it only commences once the investor starts to recruit. Funding must be applied in advance to develop the required generic skills pool. The bodies responsible for encouraging inward investment into the UK must become more involved in the planning and funding of the overall future needs of industry. Steps are being taken in this direction with a

number of the Regional Development Agencies (RDAs) in the UK funding training courses for technicians, with industry providing work experience.

The role of 'needs analysis'

The UK education and training system is complex. How can industry decide on a selection of qualifications to use from within it? The following approach is based upon work, funded by SE Wales TEC, to develop personal development plans (PDPs). The development of a PDP is a two-stage process:

Carry out a 'needs analysis' This identifies the competencies required to perform a specific job or set of related jobs. A competence may be a skill or some required knowledge. The set of competencies is independent of any given country's education and training system.

Document the education and training provision that will be used to develop the knowledge and skills required This constitutes a mapping of competencies onto the learning outcomes of courses available in a given country.

The resulting PDP is a structured 'syllabus' that indicates clearly to individuals what they need to learn and why each learning outcome of their courses is relevant. It also demonstrates to industrial management that the outcomes of the learning process will add value to their company. This approach formalises the implicit process that the semiconductor industry has been following for a number of years. Because the approach identifies development needs independently of any educational system, we have found it helpful in comparing the vocational education and training available in the UK with that available in Germany and the USA. In the UK, it is particularly helpful when considering qualifications available for operators and technicians, as described in the section below on 'education and training for operators and technicians'.

A UK semiconductor Learning Network

This section describes some of the core components of the Learning Network in the UK. Courses are available, or under development, to support three groups of employees (and potential employees):

- operators and technicians in semiconductor manufacturing;
- engineers in semiconductor manufacturing;
- engineers in semiconductor design.

The courses available in each of these areas are described in the following sections, along some background on the collaborative activity leading to the courses.

Education and training for operators and technicians

Vocational education and vocational training in the UK are nominally (and somewhat artificially) split into two separate and disconnected systems.

Vocational education is provided through National Certificates (NCs), Higher National Certificates (HNCs) and Higher National Diplomas (HNDs) normally through courses at FE colleges. In the following, these are referred to collectively as 'College Qualifications'.

College Qualifications include knowledge-based subjects such as maths, physics and chemistry and practical application of knowledge to, for example, pneumatics, hydraulics and robotics. They are awarded by Edexcel and SQA.

Vocational training is controlled by the (National/Scottish) Vocational Qualifications, referred to collectively as 'Vocational Qualifications' (VQs) in this document. These provide a mechanism for employers to give training at the place of work and assess that employees have achieved specified learning outcomes. Employers' assessors are registered by recognised awarding bodies, such as the City and Guilds of London Institute and EMTA Awards Ltd. The awarding bodies act within a framework and assessment regime developed by the National Training Organisation (NTO) for the industry (we work with EMTA — the Engineering and Marine Training Authority). They are awarded by EMTA and SQA.

College Qualifications and Vocational Qualifications are independent. They can however be linked and the semiconductor industry continues to work to ensure that they are complementary. In addition, certain government-funded schemes, including the Modern Apprenticeship scheme described below, require trainees to take a defined combination of College and Vocational Qualifications.

College Qualifications

Although there are some differences between College Qualifications in England and Wales, and in Scotland, it has proved possible to develop (via SQA and Edexcel) a series of courses that are effective for the industry throughout the UK.

The major difference between the two systems is the amount of work required to obtain a 'credit' and, therefore, the number of credits required to obtain a qualification. The requirements for HNCs and HNDs are summarised in Table 1.

As described earlier, many industries require the same generic skills for their technicians. These are frequently referred to collectively as mechatronics, and include the electronics, mechanical and programming skills required to install, operate and maintain complex, high value capital equipment.

TABLE 1 *Qualification requirements for HNCs and HNDs*

	England and Wales	Scotland
HNC	10 credits 6 core + 4 optional	12 credits 7 core + 5 optional
HND	16 credits 6 core + 10 optional	30 credits 11 core + 19 optional

Following an informal needs analysis, a joint college/industrial working group identified which existing mechatronics modules would satisfy the generic skills requirements. A number of specific specialist modules were then developed and added to the list of optional modules for HNC and HND qualifications, first in Scotland and later in England and Wales. This created the HNC/NND in Mechatronics with Semiconductor options in Scotland and HNC/HND in Plant & Process Engineering in England and Wales, as outlined in Table 2. Core modules are listed in normal font and typical optional modules are listed in *italic*. Other college qualifications available are:

NC	Scotland:	Engineering with Science
NC	England and Wales:	Semiconductor Process Technology
HNC/HND	Scotland:	Semiconductor Process Engineering

Paper-based distance learning material for all of the optional semiconductor modules has been developed (managed by COLU with advice from several semiconductor engineers). Semiconductor manufacturers have joint ownership of this distance learning material and are able to use it on site and with their local college.

TABLE 2 *Example college qualifications available in the UK*

	Scotland (SQA)	England and Wales (Edexcel)
HNC 1 year full time	Mechatronics with Semiconductor Options	Plant & Process Engineering
2 years part time	Typical core:	Core:
HND 2 years full time	Mechatronic systems	Business management techniques
4 years part time	Microelectronics	Analytical methods for engineers
	Applied engineering computing	Engineering science
	Interactive communication skills	Engineering design
	Engineering project: Mechatronics	Project
	The organisational environment	Plant & process principles
	Typical options:	Typical options:
	<i>Introduction to semiconductor devices and fabrication processes</i>	<i>Safety and cleanroom protocol</i>
	<i>Semiconductor industry process equipment principles</i>	<i>Vacuum systems</i>
	<i>Power sources for s/c fabrication</i>	<i>Silicon and s/c device properties</i>
	<i>Radio frequency for s/c fabrication</i>	<i>Pneumatics and hydraulics</i>
	<i>Introduction to vacuum technology</i>	<i>Semiconductor fabrication processes</i>
	<i>Vacuum system operation and maintenance</i>	<i>Statistical process control</i>
	<i>Safety and cleanroom practice</i>	<i>Energy management</i>
		<i>Health and safety and risk assessment</i>
		<i>Programmable logic controllers</i>
		<i>Control systems and automation</i>

Vocational Qualifications

Vocational Qualifications recognise a person's ability to do their job. They are awarded following assessment of evidence that work-based activities carried out by the individuals concerned meet 'National Occupational Standards'. The qualifications are identical across the UK but are awarded as National Vocational Qualifications (NVQs) in England and Wales and as Scottish Vocational Qualifications (SVQs) in Scotland.

VQs are available across five different levels, which reflect differing levels of work role. The first three levels are:

- Level 1 foundation and basic work activities;
- Level 2 a broad range of skills and responsibilities;
- Level 3 complex skills and/or supervisory skills.

Unlike college-based qualifications VQs set no formal timetables for accomplishment and do not use examinations as a basis for success.

The Vocational Qualifications used for operators and technicians within the semiconductor sector are mainly awarded by EMTA. The following VQs are available in the UK:

- Foundation award for Modern Apprenticeship at level 2;
- Performing Manufacturing Operations level 2 — for Operators;
- Engineering Maintenance level 2 — three variants for Facilities Technicians, Equipment Technicians, and Test and Assembly Technicians;
- Engineering Maintenance level 3 — three variants for Facilities Technicians, Equipment Technicians, and Test and Assembly Technicians;
- Technical Services level 3 — two variants for Process Technicians and Calibration Technicians.

The qualification comprises a number of units of competence, which describe an area of work. Each unit is broken down into elements of competence, which describe a function.

The most frequently used VQ, Engineering Maintenance level 3, for example, consists of the mandatory and typical optional units shown in Table 3.

Modern Apprenticeship training

Semiconductor companies in the UK have the option of employing young people through a Modern Apprenticeship scheme. If the candidate completes the Apprenticeship before the age of 25 the company can receive part funding from their local Training Enterprise Council. The schemes can vary depending on the needs of the employer. Typically this scheme will last for either three or four years. The four-year scheme involves the Apprentice being off-site at an engineering school for the first year, learning craft skills as described in the units listed below.

Additionally, in England and Wales the trainee must develop 'key' skills (covering communication, information technology, application of number, improving own performance and working with others) that have been defined by EMTA. In Scotland, similar 'core' skills are added to the Modern Apprenticeship training.

TABLE 3 *N/SVQ in Engineering Maintenance — level 3*

Maintain the conditions of engineering assets under complex conditions
Return engineering products/assets to service by component removal and replacement
Reinstate the work area after engineering activities
Contribute to the effectiveness of work activities
Diagnose faults in engineering products/assets
Typical optional units — a minimum of five units must be chosen:
<i>Install engineering products/assets under complex conditions</i>
<i>Configure engineering products/assets</i>
<i>Conduct specified testing of engineering product/assets under complex conditions</i>
<i>Operate computer-controlled engineering processes</i>
<i>Prepare resources for routine engineering activity</i>
<i>Monitor and assess the performance and conditions of engineering assets</i>
<i>Check engineering product/asset compliance with specifications</i>
<i>Contribute to improving the organisations working practices and procedures</i>
<i>Co-ordinate activities with others</i>
<i>Contribute to minimising risks to life, property and the environment</i>

Industry support for FE college partners

In recent years, the industry has looked to develop the capability of FE colleges to support the semiconductor manufacturing. Support has been focused on a limited number of colleges which are expected to be specialists in the support of high technology manufacturing. Each manufacturing site has nominated an FE college that it works with. These are shown in Table 4. Each company assists its local college directly.

The industry supports the colleges through four programmes:

TABLE 4 *Supported FE colleges*

Semiconductor Manufacturer	Partner College
NEC Semiconductors	West Lothian College
Motorola	West Lothian College, Lauder College
National Semiconductor	James Watt College
Seagate	West Lothian College
Fujitsu	Darlington College
Siemens	North Tyneside College
Philips Semiconductors	Stockport College
Newport Wafer Fab	Gwent Tertiary College
Mitel Semiconductors	Gwent Tertiary College, Plymouth College

College workshops These are three day events run by industry specialists to provide in-depth training to College Lecturers. They include visits to manufacturing sites and equipment vendor training facilities.

Lecturer development plans An industrial working group has produced a lecturer development plan. This plan outlines the training needed for any lecturer supporting the semiconductor industry. It takes into account training provided by industry and details the training required to support specific modules from educational courses. College Principals were consulted about the introduction of the development plan. It requires a significant amount of time on the part of the individual lecturer but this can be spread over a number of years.

Regional college consortia Three regional college consortia have been formed in the North East of England, Scotland and Wales by the respective Development Agencies. The consortia are collaborating to develop distance-learning material using a common framework. This avoids duplication of effort and makes the best use of regional funds.

Donation of equipment

Postgraduate courses in semiconductor manufacturing

Over the last two years the industry has worked with ten UK universities to develop a series of postgraduate courses on silicon manufacturing at Masters level, with the support of funding from the Engineering and Physical Sciences Research Council under the IGDS Masters-level training programme.⁴ The universities were selected based on their specialist expertise in silicon processing and technology. Industrial experts have been actively involved in the development of the modules to ensure that the technical content of the course is fully up to date and relevant to industry's needs.

Silicon manufacturing demands knowledge of materials, device physics, process chemistry, batch manufacturing, statistics, quality management and other disciplines. There is general agreement that this breadth of knowledge cannot be achieved through undergraduate courses. The industry prefers to attract employees with undergraduate training in a wide range of relevant disciplines. The modules are therefore designed for graduate engineers employed in the silicon manufacturing sector. They provide specialist training for staff wishing to extend their technical knowledge and provide a 'fast track' for the development of future senior engineers and engineering managers.

The technical content of each module has been developed in close collaboration with industrial advisors. When appropriate industrial experts act as lecturers. The programme presently offers a choice of 16 modules, as listed in Table 5.

The first module was delivered at the University of Edinburgh in March 2000 and the second at UMIST in June 2000. In future, modules on magnetism,

TABLE 5 *Initial modules and specialist universities*

Device and Process Integration for Silicon ICs	University of Edinburgh
Measurement Techniques and Failure Analysis	UMIST
Power Devices and Processes	University of Swansea
Statistics for Semiconductor Manufacturing	Heriot-Watt University
Layer Deposition and Diffusion	University of Southampton
Interconnect and Metallisation	University of Newcastle
Optimisation of Processes	University of Edinburgh
Production Management	Heriot-Watt University
Device and Circuit Design for VLSI	University of Cardiff
Ion Implantation	University of Surrey
Lithography	University of Edinburgh
Etching: Physics and Chemistry	University of Glasgow
Test, Assembly and Packaging	University of Cardiff
Oxidation and Isolation Technology	University of Liverpool
TCAD and Compact Modelling	University of Newcastle
Device Operation and Process Architectures	University of Glasgow

III/V manufacturing and optoelectronics may be added. Each module involves the equivalent of 2 weeks' distance learning (over a period of two to three months) plus an intensive one-week residential course held at the specialist partner university. It is open to delegates from anywhere in Europe. The programme is very flexible. Students can enrol at any one of the ten participating universities. Delegates can choose to take a single module. Subsequently they can take additional modules to gain an academic qualification: 4 modules to obtain a Certificate, 8 modules for a Diploma, or 8 modules and an in-company project to obtain an MSc. They can defer registration for a qualification until after they have taken one or more modules. An MSc delegate would be absent from their place of work for no more than 12 weeks during a typical three-year period of study. The large number of university partners created a number of logistical and organisational problems, which have been resolved in imaginative, novel ways.

Ownership The programme is jointly owned by the partner universities.

Quality assurance The partners have established a single validation panel to ensure that the highest academic standards are maintained across all partners. It avoids each university having to validate all other university's courses before awarding a degree. This is a unique concept in the UK and has proven to be highly successful.

Registration and awards Delegates register with one of the partner universities and the academic awarded is in the name of that university. They may transfer their registration between universities.

Common procedures UK universities are autonomous institutions, each with its own statutes, regulations and procedures. The consortium has endorsed a Memorandum of Agreement documenting common procedures for the smooth running of the programme. In a few situations, such as appeals and discipline, the individual partner's regulations take precedence.

Meeting industry needs A Board of Management controls the programme. The board has industrial and academic members and the industrial members have the casting vote via the Chairman.

We anticipate that at least 80 person modules will be delivered each year. This is the equivalent of 10 MScs per year, or 30 MSc students enrolled at any one time.

Postgraduate courses in IC design and embedded software

The UK is playing a leading role in the design of many electronics systems, including digital video (set top boxes, graphics and games), cellular communications (both voice and data), wireless communications, avionics systems, automotive systems and financial systems. IC design in these fields is rapidly expanding, with over half of the IC design groups in Europe located in the UK. They include some of the most successful in the world, including ARM, STMicroelectronics, Mitel, Motorola, Sony, Xilinx, Atmel, Analog Devices, Philips and hundreds of others. New design investments are announced continually. To help support this growth, NMI has led a submission to the Engineering and Physical Sciences Research Council (EPSRC) to establish a Masters-level training programme for IC design and systems integration. The programme builds on the wide range of courses available to support systems, IC and embedded software development, including those offered by:

- The Institute for Systems Level Integration (ISLI), consisting of the Universities of Edinburgh, Glasgow, Heriot-Watt and Strathclyde: the ISLI offers a range of courses aimed at system design, and partitioning into silicon hardware and embedded software;
- The Radio Frequency Engineering Education Initiative (RFEEI), consisting of the Universities of Bristol, Bradford, Surrey, Portsmouth and York: this initiative offers courses in support of RF systems design;
- The Advanced Microelectronics for Industrialists IGDS offered by Bolton Institute and UNN: this is unique in offering an MSc in microelectronics design supported totally by computer-based distance learning;
- A number of other universities including Cambridge, Essex, Imperial College, Manchester, Newcastle, Sheffield, Southampton, and Queens University Belfast: the bid reserves funding for some of these universities to contribute modules in their field of expertise as requested by industry.

The initiative offers students a catalogue of the high-quality modules selected to meet the demands of industry. They are available on the same basis as for the manufacturing modules. Many engineers will take one or more stand-alone modules. However, others may wish to achieve the eight modules plus a project required for the award of an MSc. The modules will be upgraded to support distance learning wherever appropriate. Residential periods will be used to address those sections of modules where distance learning is not the best approach. Involvement of industry from the outset will ensure that there is a demand for each module to be provided. Modules will be linked to either industrial best practice in design and product introduction or to leading research activity on electronic systems.

Modules will be offered from October 2001, with the initiative providing an extendable framework to which additional modules can be added as technology advances or industry needs change.

Summary

The availability of skilled staff for the semiconductor industry is a major factor limiting its continued growth worldwide. To help meet its needs, the industry in the UK has established an effective Learning Network involving the industry, colleges, universities, accrediting and awarding bodies (such as SQA, Edexcel and EMTA), the institutions, LECs/TECs, and the educational funding bodies, together with the regional development agencies and government departments. We are confident that it will help develop the expertise required to support the upcoming period of growth.

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References

- 1 Edexcel — An awarding and examining body in the UK and overseas. Edexcel College Qualifications are used by the supported FE colleges in England and Wales.
- 2 Scottish Qualifications Authority — Responsible for College Qualifications and Vocational Qualifications in Scotland. It has its own awards and offers others from NTOs, such as EMTA.
- 3 Engineering and Marine Training Authority — The National Training Organisation (NTO)

for engineering. Responsible for identifying, defining and updating employment-based standards of competence. Vocational Qualifications are based on these standards.

- 4 P. Hemment and C. Dyson, 'A University Network for the Silicon Industry', in *Proc. EWME 2000*, Aix-en-Provence, May 2000.