# Employers' Views of Postgraduate Physicists

Report by the Institute for Employment Studies to the Engineering and Physical Sciences Research Council

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IES aims to help bring about sustainable improvements in employment policy and human resource management. IES achieves this by increasing the understanding and improving the practice of key decision makers in policy bodies and employing organisations.

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# Executive Summary

## The Study

This study was commissioned by the Physics Programme of the Engineering and Physical Sciences Research Council (EPSRC). The study was intended to examine the views of those who employ postgraduate physicists as to both the quantity and quality of the current provision. In line with previous studies covering postgraduates of other disciplines, special emphasis was put on examining employers' requirements in terms of soft skills.

A total of 58 employers were interviewed face-to-face and by telephone using a semi-structured questionnaire. These interviews were supplemented by a review of the literature and an analysis of the available secondary data. Finally, a small number of questionnaires were completed by people who had recently completed a physics postgraduate training.

## The Postgraduate Physics Labour Market

There are a number of factors that complicate any examination of the labour market for physics postgraduates:

- There are relatively few physics postgraduates — only about 800 UK domiciled postgraduates leave physics departments each year and only about 200 new EPSRC physics programme studentship awards are made each year.
- Many postgraduate physicists, while being employed for their physics skills, enter posts where they are called engineers rather than physicists.
- Finally, many postgraduate physicists are employed by the software and financial services sectors on the basis of software and modelling skills acquired a part of their physics training.

Three sectors, optronics, silicon chip design and microwave radar, were identified as **growth sectors** and were experiencing problems recruiting sufficient postgraduate physicists. These growth sectors were being driven by increasing demand for Internet high-speed data communications, strong demand for silicon chips and growth in mobile telephony.

At the same time, software activities and modelling were identified as **growth skills**. These growth skills were particularly in demand in the financial services and high-tech manufacturing sectors.

Three areas were identified as **active areas** with active recruitment but no particular problems. These were low temperature physics, the financial services sector and the defence sector.

Finally, some **areas with potential** were identified; these were areas where respondents felt that future demand may occur as a result of scientific and economic developments. These included biophysics and nano-technology.

Some concern was expressed about the longer-term numbers of students coming through wishing to study physics at the postgraduate level. Factors here included a reduced interest in postgraduate study as a result of student debt, and a shortage of physics school teachers.

Given the small numbers of physics Masters entering the labour market very few employers had experience of them and therefore there were few strong views on the differences between Masters and Doctoral postgraduates.

## Employers' Views of Physicists Skills

Employers had no problems with the technical skills of physics postgraduates and in many ways, these skills were considered to be implicit in the postgraduate qualification.

Three skills were identified as important to the employers:

- communication skills
- team working, and
- problem solving.

These skills were often bundled together, in that a good team worker needed to be a good communicator. These two skills were considered problematic and often not well developed amongst postgraduates. The nature of PhD study, with the emphasis on the individual contribution to scientific knowledge, was seen as part of the problem.

On the other hand postgraduates, and especially physics postgraduates, were recognised to be excellent problem solvers and this was often the main competency sought when they were recruited.

A range of other skills were also mentioned as being difficult to find amongst new physics postgraduates. They included:

- time management
- business awareness
- self management
- customer orientation.

The smaller recruiting organisations were more likely to be involved in new product development, but their size meant that they put greater emphasis on flexibility. The larger organisations put greater emphasis on self-management and team working.

## Views of Academics and Recent Postgraduates

The main concern of academics as producers of physics postgraduates was with maintaining the numbers of suitably qualified first-degree graduates that wanted to undertake postgraduate study.

HESA data suggest that academia recruits almost one-third (30 per cent) of new physics postgraduates. The interviews and a small sample of questionnaire responses suggest that academics put greater emphasis on problem solving than do other employers. At the same time, they also place much less emphasis on communication and team working skills.

In many ways, the views of recent postgraduates as to the degree to which they felt various skills had been developed during their postgraduate training, was determined by the type of position they held. Those in academic positions felt that there was a good match between the skills they developed and their importance in their current post. Those employed outside academia for their physics skills tended to think there were deficiencies in their training covering customer orientation, business awareness and project management skills. Those who had entered positions where a postgraduate physics qualification was not a formal requirement tended to be more negative across the board about the training they had received.

## Secondary Data

A special analysis of the student and first destinations data collected by the Higher Education Statistics Agency (HESA) was undertaken. Although this data does not specifically refer to those students supported by the EPSRC physics programme, it is possible to examine postgraduates in physics departments who had had their fees paid by the EPSRC. This figure was slightly larger than the numbers known to be supported by the physics programme and reflects those supported by the materials and other programmes within the EPSRC.

The HESA data indicated that a wide range of sectors and occupations are entered by new postgraduates who were supported by EPSRC in physics departments. However, the financial services sector is perhaps less popular as a destination than is often believed.

## Conclusions and recommendations

It is felt that the EPSRC should initiate a debate covering the function of physics doctoral training. The importance of a wider range of soft skills amongst industrial recruiters than were currently developed needs to be recognised.

Further emphasis and support should be given to the Joint Research Councils Graduate Schools. These schools provide the sort of training in multi-disciplinary communication and presentation skills that are considered important by industrial recruiters.

Areas of growing demand for postgraduate physicists are largely driven by areas of product growth. These may be short lived, or the technologies may rapidly become mature, leading to a decline in demand. However, there are currently clearly some discrete areas of intense demand. They are also areas that, while new ground is being broken, are also relatively mature technically. This combination suggests that there may be scope to expand the numbers of supported Masters courses in the areas of optronics and microwave radio technology.

# 1. Introduction

This introductory chapter outlines the stated objectives of the study and the methods adopted to meet them.

## 1.1 The study brief

The study, as specified, was designed to:

- assess the extent to which the supply of postgraduate physicists from UK universities meets the employer requirements in UK academia, commerce and industry, in terms of the quality and relevance of the training provided, and their numbers
- consider the extent to which requirements for postgraduate training are affected by the supply of and demand for undergraduate training
- make recommendations regarding EPSRC's future role in the training of physicists, the number of postgraduate physicists being trained and potential improvements in training, which would further enable postgraduates to meet the needs of employers.

## 1.2 The IES and SPRU approach

The approach taken by the joint IES (Institute for Employment Studies) and SPRU (Science and Technology Policy Research) team had five main components apart from project management and reporting. These were:

- an initial survey of academic departments
- a literature and data review
- a survey of recent postgraduates
- employer face-to-face interviews
- employer telephone interviews.

### 1.2.1 The initial survey of academic departments

The initial survey of academic departments had two objectives:

- to identify departments where individuals could be interviewed as employers of recent postgraduates, and
- to encourage heads of departments to contact recent postgraduates to complete the experimental web based questionnaire.

### 1.2.2 The literature and data review

The literature and data review was aimed at both informing this report and assisting in identifying appropriate employers for interview.

### 1.2.3 The survey of recent postgraduates

An experimental approach was used to survey recent physics postgraduates. The approach was adopted because of the compressed timescale available for the study. The experimental approach adopted involved a downloadable questionnaire on the IES website and approaches to heads of physics departments urging them to contact their recent postgraduates to point them in the direction of the website. This approach was intended to replace the process whereby we obtained addresses of recent postgraduates from the heads of departments and then posted a paper questionnaire to them, or, if data protection rules did not allow the heads of department to release the addresses, asking them to post the questionnaires for us. The experimental approach was designed to reduce the burden on the heads of department and to speed up the process. However, in practice, the approach was not very successful. It was not clear what the problem was but it is assumed that there were insufficient incentives for the recently qualified postgraduates to download and complete the questionnaire.

Nevertheless, although there were insufficient questionnaires completed for statistical analysis, they can be treated as a series of case studies. The analysis is undertaken in Chapter 5 of this report.

### 1.2.4 Face-to-face employer interviews

A total of 160 employers were identified as potentially employing physics postgraduates, and likely interviewees identified. Letters outlining the study and its objectives were sent to these people. The letters were followed up later by a telephone call in an attempt to secure interviews.

In all, 24 face-to-face interviews were carried out with employers. The interviews were semi-structured using a discussion guide aimed at eliciting information on:

- the nature of the employing organisations and changes to the organisation over the last ten years which have influenced employment patterns
- the overall number of employees
- the numbers of scientists and engineers employed and, in particular, the number of physicists as well as postgraduate physicists
- the pattern of demand over the last five years and probable pattern of demand over the next five and ten years
- the skills and physics sub-disciplines sought by the employers
- the trends by skill, or sub-discipline, and possible factors influencing future changes in the pattern of demand
- the detailed descriptions of the two most important skills sought by the employers, as well as an estimate as to which skill recent physics postgraduates had the most problems acquiring
- whether these skills should, or could, be taught as part of the postgraduate courses
- what training was necessary for new postgraduate recruits and what role the universities might have in CPD
- the general labour market for physics postgraduates and what factors, including institutional developments, were likely to affect the future of the labour market
- finally, the employers were asked if they could identify any further possible interviewees and then thanked for their participation in the study.

A further 34 employers were interviewed by telephone using an abbreviated version of the discussion guide. In some cases, especially where the employers were employing physics postgraduates in a non-physics capacity, the interviews were by necessity very abbreviated.

In total, 58 employers were spoken to about their employment of physics postgraduates over the course of the study. The names of those organisations that were interviewed, and were willing to be identified in the report, are given in Annex 1 to this report.

### 1.2.5 Sectoral breakdown of the interviews

The employers that were interviewed were categorised using the ESPRC strategic sectors. We discovered a wide range of overlap of the categories, with the most common overlaps being a combination of 'Technical and Consultancy Service' or 'Small and Medium Sized Establishment' (SME) with other categories. The full breakdown is given in Table 1.1. This shows that all the EPSRC sectors were covered. Equally, when this table is examined

**Table 1.1: EPSRC sectors covered by employer interviews**

| EPSRC sectors | Number |
|---|---|
| Bulk Products & Materials | 5 |
| Communications & Media | 4 |
| Computers & Computing | 4 |
| Defence | 3 |
| Electrical & Electronic | 13 |
| Financial Services | 2 |
| Machinery & Equipment | 17 |
| Pharmaceuticals & Healthcare | 4 |
| Retail & Distribution | 4 |
| Technical & Consultancy Services | 38 |
| Transport | 2 |
| Utilities | 3 |
| SME | 13 |

*Source: IES EPSRC physics skills survey*

in conjunction with the HESA data on sectors of employment of recent physics postgraduates in Chapter 5, a relatively good match is found.

## 1.3 Structure of this report

The remainder of this report is structured into five more chapters covering in turn:

- the postgraduate physics labour market
- employers' views of physicists skills
- views of academics and recent postgraduates
- secondary data
- conclusions and recommendations.

# 2. The Postgraduate Physics Labour Market

This chapter examines the nature of the labour market for postgraduate physicists. The EPSRC sectoral categories and the available secondary data suggest a number of typologies. The first distinction that can be made is between jobs where the physicists are employed as physicists and those jobs where they have been employed for the other skills that they have acquired as part of their post-graduate training.

## 2.1 Employers of physicists as physicists

There is a range of employers who employ postgraduate physicists on the basis of their physics skills. A simple typology breaks these down into three categories:

- high-technology manufacturers
- higher education, and
- public sector and utilities.

### 2.1.1 High-tech manufacturing

A wide range of high-tech manufacturing companies employ physicists for their physics skills, although they are often called engineers. The numbers of physicists employed as engineers posed some problems for the study as this tended to make physicists invisible. The high-tech companies employing physicists ranged from silicon chip designers through laser, fibre optic and super-conducting magnets users, to radio and engine designers. Even in the period immediately after obtaining their postgraduate qualification, the HESA first destinations data indicate that the majority of postgraduates enter this sort of employment. Given that some postgraduates do not pursue an academic career beyond an initial post-doctoral position, in practice the proportions entering high-tech industrial employment are greater than even the HESA data of postgraduate destinations suggest.

### 2.1.2 Higher education employment

The HESA data in Chapter 5 reveal that academia is the largest single type of employment found by doctoral graduates. However, only 30 per cent of doctoral graduates entered employment in the higher education sector. Since the EPSRC had a better understanding of this sector, less emphasis was put on interviews in this sector than these numbers would indicate.

### 2.1.3 Public sector and utilities

Some public sector organisations employ large numbers of postgraduate physicists, such as the Defence Evaluation and Research Agency (DERA) and the Met Office. Other bodies such as BNFL, AEA Technology, the National Physical Laboratories (NPL) and the National Grid Group, although now technically not in the public sector, have a public sector history and employ relatively large numbers of physicists. Despite the public sector nature, increasing commercial or 'best-value' pressures on employment in this area means that the skills profiles are becoming increasingly similar to those required by the high-tech industries.

## 2.2 Employers of physicists in other functions

Two main areas where postgraduate physicists were employed in non-physics functions, but where their postgraduate training was important, were identified. These were:

- software writing, and
- financial services.

More intensive efforts were required to interview employers in these areas that were known to be employing physics postgraduates in other capacities. As the employers were not directly employing physicists, it was more difficult to engage their interest in the study. However, when we spoke to these types of companies the questioning focused on why physicists were employed rather than those trained specifically for their areas.

As already mentioned, many employers called their physics recruits engineers which creates the impression that these people are being employed for non-physics skills. However, it became clear during the course of the interviews that despite the name, this group were being employed for their physics skills.

## 2.3 Labour market dynamics

The interviews were also designed to identify those areas, sectors or sub-disciplines that were facing change or shortages. For the purposes of this labour market dynamics analysis, the labour market is broken down into the following four categories:

- growth sectors
- growth sub-disciplines
- active areas
- potential areas.

These categories are developed on their relationship to policy rather than any other internal coherence. Equally, since the categories mix sectors, disciplines and research areas, they overlap somewhat.

## 2.4 Growth sectors

Growth sectors are sectors where there is growing demand for postgraduate physicists, largely as a result of growth in demand for the products of the sector and as a result of increasing physics inputs to the products.

### 2.4.1 Optronics

Optronics covers the interface between optics and electronics. With the recent growth in the Internet, there has been a rapid growth in demand for high speed and high bandwidth data communications that can only be offered by optical fibres. Physicists are involved with designing higher capacity optical fibres, more effective and smaller lasers, as well as optical amplifiers and switches. Other areas of optronic research include new and larger optical receptors and novel display technologies.

Companies operating in this market report active recruitment and increasing recruitment problems, with many recruiting overseas and complaining about problems obtaining work permits. The companies range from very small university spin-offs to large R&D establishments of large multi-national companies. Since academic physics is still driving advances in this area, great emphasis is put on maintaining contact with academic developments. However, only the largest organisations are involved with CPD, using it largely as a retention tool. Where CPD is offered the links are more usually with professional bodies such as the IEE and the IoP rather than universities.

### 2.4.2 Silicon chip design

The silicon chip market appears to operate on a five-year cycle and is just beginning another upswing, which has led to a recent growth in demand for chip designers. As the chips become smaller, with higher component density, it has become increasingly necessary to take into account quantum effects in their design. This in turn has led to a greater need for postgraduate physicists to be involved in the process. As with optronics, the interviewees reported increasing recruitment problems and a rise in overseas recruitment.

### 2.4.3 Microwave frequency radio

The rapid growth in mobile cellular telephony, and the increasing demand for both channels and bandwidth, is fuelling increasing activity in the area of microwave frequency radio. Simultaneously, there is increasing pressure to reduce the visual and environmental impact of mobile phone antennae. Employers in this admittedly small and rather discrete market indicated increasing problems recruiting physicists to address these issues.

## 2.5 Growth skills and sub-disciplines

Growth skills and sub-disciplines are defined as those skills that are acquired as part a postgraduate physics training that are in increasing demand.

### 2.5.1 Software

Physics experimental equipment often requires extensive control software or data-logging software. Both of these are areas of specific shortages, while physics postgraduates are noted for their flexibility and ability to program complex algorithms. This means that there is a growing demand for physics postgraduates with these skills.

### 2.5.2 Modelling

Increasingly, engineering design is a virtual process with extensive use of computer modelling techniques. Turbulent flow analysis and other modelling techniques from physics are therefore increasingly in demand by high-technology engineering companies such as engine or aeroplane designers. A repeated comment from these employers is that the flexibility of physicists makes them more attractive than other disciplines that might use or teach these techniques.

## 2.6 Active areas

Active areas are defined as those where recruitment is occurring but there are no specific reports of recruitment difficulties.

### 2.6.1 Low temperature physics

Those using the application of low temperature physics, especially low temperature superconductivity and superconducting magnets, are recruiting. However, the area is dominated by the design and production of MRI scanners and this technology is now maturing.

### 2.6.2 Financial services

Related to the area of modelling is a demand from the financial services sector for market modelling and risk analysis activities. One of the standard methods of risk analysis in the derivatives market involves solving partial differential equations, while some of the market analysis techniques used in share dealing relate to data reduction and analysis techniques from physics. Since the financial services sector pays exceptionally attractive salaries, despite the steady demand, there is no real problems filling the vacancies.

### 2.6.3 The defence sector

The defence sector employs large numbers of physicists, mainly in the form of DERA and the Met Office, but also within defence sector suppliers and contractors. Here, the increasing requirement for weaponry with high-technology attributes such as stealth, intelligence and accuracy is leading to the maintenance of the number of physicists recruited despite the end of the Cold War.

## 2.7 Areas with potential

During the course of the interviews, especially with the academics, two areas were identified as having future potential for significant industrial application. Currently we could find no evidence of significant recruitment in these areas. However, this might change in the near future.

### 2.7.1 Biophysics

The human genome project is rapidly deriving the amino acid sequence of many biologically and medically critical proteins. The problem is understanding their mechanism and actions. This is often dependent on understanding their three dimensional structure. Determining the three dimensional structure involves complex biophysics. Although to an extent this is a known and understood activity, it is believed that the massive growth of sequence knowledge derived from the human genome project will in turn lead to a growth in this area.

### 2.7.2 Nano-technology

Nano-technology is dependent on being able to manipulate matter at the nano ($10^{-9}$ metre) level. Apart from improving electro-mechanical and electro-chemical interfaces on silicon chips, this technology is expected to have a wide range of other applications. At this stage, commercial applications are still to be developed, but increasing academic and commercial research activity is occurring in this area.

## 2.8 Other issues impacting on demand

Overall, no institutional, legal or regulatory changes were expected to impact on the demand for postgraduate physicists. However, there was a range of concerns which it was felt might impact on the future supply of physicists.

### 2.8.1 A decline in demand for postgraduate study

Some universities, but it should be stressed not all, had experienced a drop in demand for postgraduate study. It was felt that rising debt amongst first-degree graduates and increasing job opportunities for them, combined with relatively low stipends was deterring students from postgraduate study. It was hoped that the recent changes to the way EPSRC funds for studentships is handed out might change this.

### 2.8.2 Increasing science and university budgets

It was hoped that recent government announcements of increased funding for the science and university budgets might mean that academic careers become more attractive. It was felt that this in turn might reduce the numbers of postgraduates available for non-academic employment.

### 2.8.3 Physics school teachers

Concern was expressed by both academic and non-academics about the declining number of qualified physics teachers in secondary schools. It was felt that this might lead to both a decline in the numbers studying Physics 'A' level and to a decline in interest in the subject amongst school leavers and university entrants. This in turn might lead eventually to a decline in the numbers studying physics at a postgraduate level.

## 2.9 Masters versus doctoral students

There are relatively few Masters students in the physics area with the bulk of postgraduates obtaining doctorates. This means that apart from a few areas, very few employers have any experience of recruiting Masters graduates. Masters tend to be recruited by larger organisations looking for people to perform relatively routine tasks in an area where the technology is relatively mature. Doctoral graduates were seen as having both the intellectual capacity and the specific knowledge to drive forward innovation. The historically low numbers of Masters graduates means that they have tended to be considered alongside first-degree graduates. Areas such as optronics, where there is little first-degree provision, have begun to appreciate the skills provided by Masters graduates. Given the current intense demand in this area, there is scope for further support.

## 2.10 Employers' links with universities

Employers reported two main rationales for maintaining links with universities:

- to keep abreast of new developments in their field so as to be able to incorporate these developments in new or refined products
- to identify potential doctoral or post-doctoral level recruits who are working in relevant areas.

There were a few cases where employers were providing materials, equipment or other inputs into courses. Those employers who engaged in these types of activities said they were very fruitful and often meant that the physics department produced more appropriate recruits.

## 2.11 Continuing professional development

Properly structured programmes of Continuing Professional Development (CPD) were found only in the largest organisations. Where CPD programmes were found they tended to relate to those run by the Institute of Physics (IoP) or the Institute of Electrical Engineers (IEE) and there was minimal involvement by universities in terms of course provision.

# 3. Employers' Views of Physicists' Skills

This chapter examines the views of employers of the skills they require in physics postgraduates and the extent to which the educational and funding systems are providing people with these skills.

## 3.1 Physics skills and 'soft' skills

When employers were asked about the skills they required, without prompting, they responded with a mixture of technical and 'soft' skills. When prompted, virtually all the employers said that they assumed that the technical skills would be associated with study at a postgraduate level. The distinctions in terms of technical skills were made between the different physics sub-disciplines. The 'soft' skills such as team working or communications skills were considered more variable and not necessarily addressed as part of postgraduate study. Therefore, the main basis for deciding to recruit an individual was in terms of their complement of soft skills.

This did not mean that the technical or physics skills were unimportant to employers, if anything the reverse was the case. Employers greatly prized the technical and physics skills and, especially within the growth areas, would like to recruit more. However, as these technical and physics skills were largely taken as given they were not the focus of the interviews.

## 3.2 Soft skills that are important

A wide range of soft skills was considered important. When the interviews were analysed, 'communication' was mentioned the most often as being important. This was followed by 'problem solving' and 'team working'. Table 3.1 gives the number of times each skill was mentioned and then presents this as a percentage of the interviewees. (As interviewees gave a variable number of skills, the percentages do not add up to a hundred.) As there are important differences by type of interviewee, the table also gives the same information for a range of categories.

**Table 3.1: Specific skills mentioned as important by category of interviewee**

| | All | | SME | | Non SME | | Academics | | Technical & Consultancy Services | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| Communication | 23 | 37.1 | 7 | 50.0 | 16 | 39.0 | | | 19 | 45.2 |
| Problem solving | 21 | 33.9 | 5 | 35.7 | 12 | 29.3 | 4 | 57.1 | 13 | 31.0 |
| Team working | 19 | 30.6 | 3 | 21.4 | 16 | 39.0 | | | 14 | 33.3 |
| Motivation and enthusiasm | 10 | 16.1 | | | 8 | 19.5 | 2 | 28.6 | 6 | 14.3 |
| Initiative/proactivity | 9 | 14.5 | 3 | 21.4 | 4 | 9.8 | 2 | 28.6 | 4 | 9.5 |
| Flexibility and adaptability | 8 | 12.9 | 2 | 14.3 | 5 | 12.2 | 1 | 14.3 | 6 | 14.3 |
| Time management | 8 | 12.9 | 2 | 14.3 | 5 | 12.2 | 1 | 14.3 | 5 | 11.9 |
| Managing own development | 7 | 11.3 | 1 | 7.1 | 4 | 9.8 | 2 | 28.6 | 4 | 9.5 |
| Interpersonal skills | 6 | 9.7 | 3 | 21.4 | 3 | 7.3 | | | 5 | 11.9 |
| Business awareness | 6 | 9.7 | 4 | 28.6 | 2 | 4.9 | | | 5 | 11.9 |
| Computer literacy | 5 | 8.1 | | | 5 | 12.2 | | | 4 | 9.5 |
| Customer orientation | 4 | 6.5 | 1 | 7.1 | 3 | 7.3 | | | 2 | 4.8 |
| Leadership | 4 | 6.5 | | | 3 | 7.3 | 1 | 14.3 | 2 | 4.8 |
| Planning and organisation | 3 | 4.8 | 2 | 14.3 | | | 1 | 14.3 | 2 | 4.8 |
| Numeracy | 3 | 4.8 | 1 | 7.1 | 2 | 4.9 | | | 2 | 4.8 |
| Risk taking/entrepreneurship | 1 | 1.6 | 1 | 7.1 | | | | | 1 | 2.4 |
| *Total interviewees* | *58* | *100.0* | *14* | *100.0* | *41* | *100.0* | *7* | *100.0* | *42* | *100.0* |

*Source: IES/EPSRC survey of postgraduate physics employers*

For the purposes of this analysis, SMEs are defined as establishments with less than 250 employees and no parent company. Academics also have a distinctive profile, as do the companies engaged in 'Technical and Consultancy Services'.

Another way of looking at this data is graphically, as in Figure 3.1. This shows that the first three important skills are separated from the other skills in terms of the numbers of interviewees that mentioned them. Importantly, these three skills:

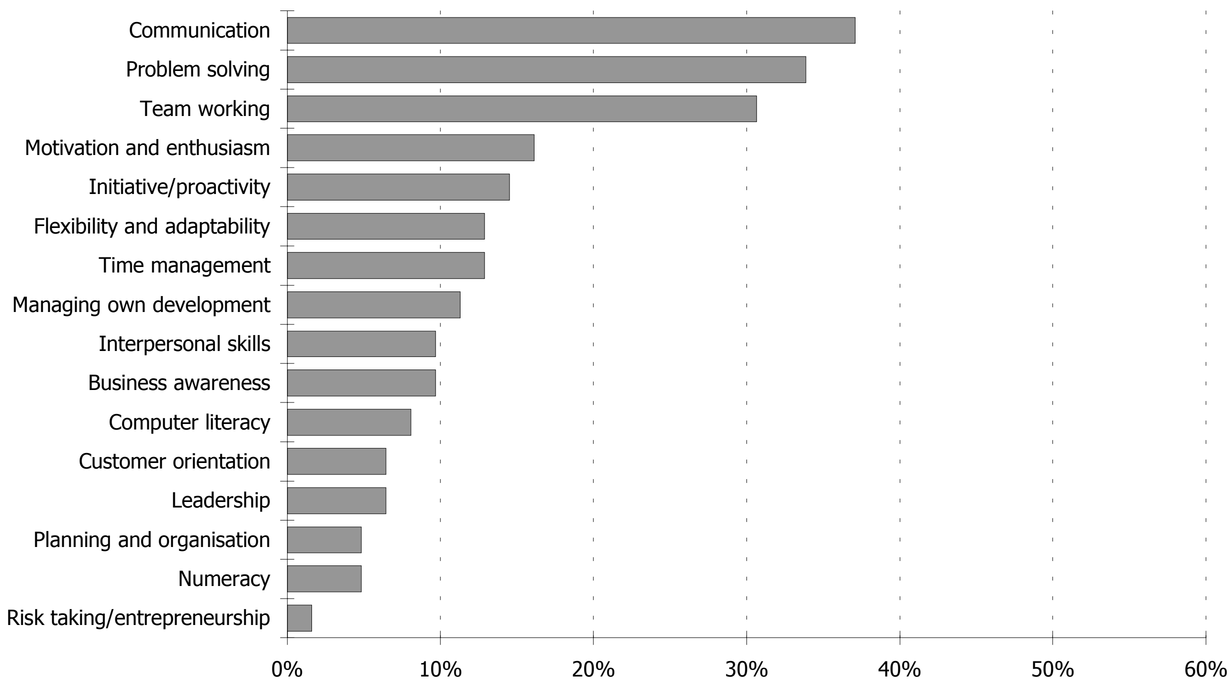
- communication
- problem solving, and
- team working

were treated in different ways by the various types of recruiters of physics postgraduates, and are expanded upon below.

### 3.2.1 Communication skills

Communication skills were not only mentioned the most often, but when the interviewees were asked to expand on their most important skill it was also selected most often. As in previous

**Figure 3.1: Percentage of all interviewees mentioning specific skills**




*Source: IES/EPSRC survey of postgraduate physics employers*

studies of postgraduates soft skills (Jagger, 2000) when expanded upon it became clear that the skills required are embedded in a complex matrix of skills and cannot be seen in isolation. For instance, this description of someone who was a good communicator by a recruiter for a large public sector organisation, employing many physicists, includes listening and organisational skills under the communication umbrella:

> *'They are good at listening to other people, they always seem interested and enthusiastic and are very organised and clear when giving advice or talking about their projects.'*

Similarly, this description of a good communicator by a small silicon chip developer includes team-working skills:

> *'Can present well, is clear and understandable and is concise and to the point in his reports. Also gets on well within their small team.'*

This description of a good communicator by a small research consultancy also includes customer orientation and time management:

> *'They can communicate clearly to everybody, especially customers. They can set well thought out objectives and meet the deadlines of these objectives.'*

For an important skill, the extent to which communication was singled out as a skill lacking amongst postgraduate recruits was worrying. Most interviewees felt that the rounded communication skills well embedded in other skills and attributes were very difficult to teach. However, there was widespread agreement that the basics such as presentation could, and should, be taught as part of the postgraduate training. One interviewee commented favourably on the recent developments in engineering postgraduate training which he felt was improving the communication skills of new postgraduate engineers. These include the creation of the Engineering Doctorate (EngD), which has a much larger taught component than the traditional doctorate and is modelled in part in the German engineering doctorate.

### 3.2.2 Problem solving

In many ways the problem solving skills of physics postgraduates, especially PhDs, are what they are recruited for. Often, even when these skills were not explicitly mentioned, they were considered implicit in the Doctoral qualification. Problem solving skills were therefore rarely seen as problematic and rarely expanded upon. Employers were looking for people able to solve their problems and their customers' problems and the approach used was important, as this technical consulting organisation explained:

> *'…has the ability to both use the standard scientific step by step approach to problems, but also has the ability to make the often intuitive leap to a solution.'*

Sometimes these problems were not even physics problems; the importance was the ability to arrive at a solution. For example, this optical components research and development organisation described a good problem solver in this way:

> *'… talked to people a lot – the relevant people who might have an answer to the problem. Communicated well with people who were part of the problem and through this was able to identify what the problem was. Was sure to be around when they needed help and had a deep understanding of what they were doing. Communicated well with them not just by discussing work with them but took an interest in the people themselves. When they couldn't fix a problem they knew who to turn to fix it. They were prepared to put effort into fixing a problem. They didn't walk away from it. They always went the extra mile. They didn't go home until it was fixed.'*

### 3.2.3 Team working

Team working was an important skill mentioned by recruiters as something new postgraduates often had problems with. However, it was recognised that the PhD requirement to make an individual contribution to knowledge often meant that this would be poorly developed. It was also felt that this skill was relatively easy for the employers to teach so long as the communication basics were there. The importance of communication skills for team working is shown by this description from a large public sector organisation:

> *'He was very co-operative. He liked people. He was enthusiastic and engendered enthusiasm in others. For instance, he was doing some work on interactivity in websites. He got very excited about its possibilities. He showed others how they could display the results of experiments on the screen so they were accessible to other people. It opened their eyes and they were carried along on a wave of enthusiasm. He could impart information in a non-patronising, interesting way. He could comprehend complex information and communicate it in a way that was understandable to his audience.'*

Similarly, this description from a large research and manufacturing organisation also emphasises communication skills as part of team working:

> *'Prepared to recognise that you need a breadth of skills in a team. Doesn't expect to know everything theirself. Happy to take advice from other specialists and prepared to be wrong theirself. Good at coaching other members of the team.'*

### 3.2.4 Other specific skills requirements

Other important skills for physics postgraduates that were also difficult to find amongst new postgraduates included:

- time management
- business awareness
- self management, and
- customer orientation

Where these were mentioned it was often in terms of comparing the culture of academic organisations with commercial organisations. As such, postgraduates were seen as coming from a culture where problems were addressed for as long as it took to solve them and students focused in on their thesis topic. This was contrasted with a commercial environment where multiple problems had to be solved within a timeframe and cost, specified by the needs of the business and their customers.

## 3.3 Skills requirements by type of organisation

As already mentioned, different types of organisation had differing skills priorities and views on the skills shown by new postgraduates. The main categories that emerged from the analysis were:

- SMEs
- large companies
- research based organisations, and
- academics.

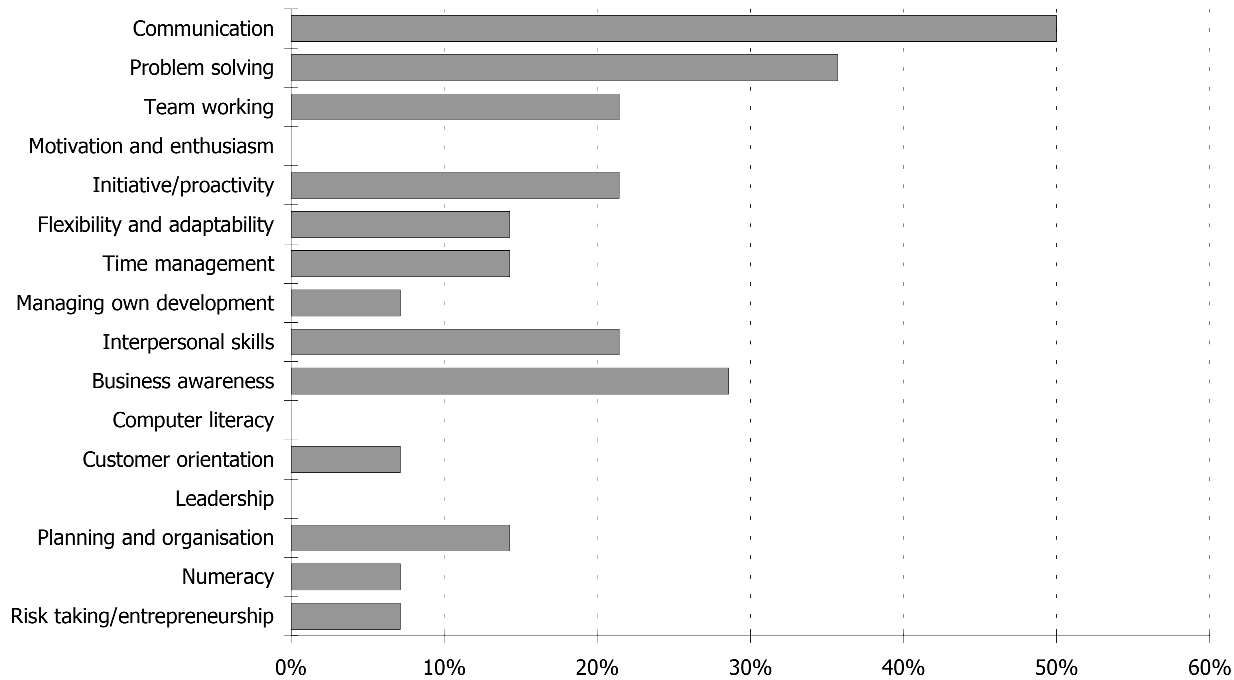
Of these groups, only the academic category was exclusive, as there were SME research based organisations and large research based organisations.

### 3.3.1 Skills requirements of SMEs

SMEs (small and medium sized establishments) are defined as establishments with fewer than 250 employees and are not a subsidiary of a larger organisation. However, many of the organisations that we interviewed had fewer than 25 employees. These very small firms are often university spin-offs and contain a high proportion of postgraduates. So despite their size they can account for a large proportion of the postgraduates recruited annually.

Most of these SMEs were involved in developing a new product or process, but some were involved in marketing products, while others offered consultancy or venture capital to other physics based companies. The size of these organisations, often without defined career structures, meant that less emphasis was put on team building and managing skills. Therefore, there was less emphasis on 'team working', 'motivation and enthusiasm', 'managing own development' and 'leadership'. However, as these were often start-up companies there was greater emphasis on the commercial skills such as 'communication', 'interpersonal skills', 'business awareness' and 'planning and organisation'. Despite these differences, the SMEs put as much emphasis as other organisations on the core doctoral level skill of 'problem solving'.

**Figure 3.2: Percentage of SME interviewees mentioning specific skills**




*Source: IES/EPSRC survey of postgraduate physics employers*

The SMEs tend to require their technical staff to be very flexible and this appears to be a particular feature of physics postgraduates. Their training involves complex mathematics and often specific high-technology equipment that needs customised software. This often allows physicists to operate in a wide range of roles. The following comment from a company of 25 with six physics PhDs, illustrates this point:

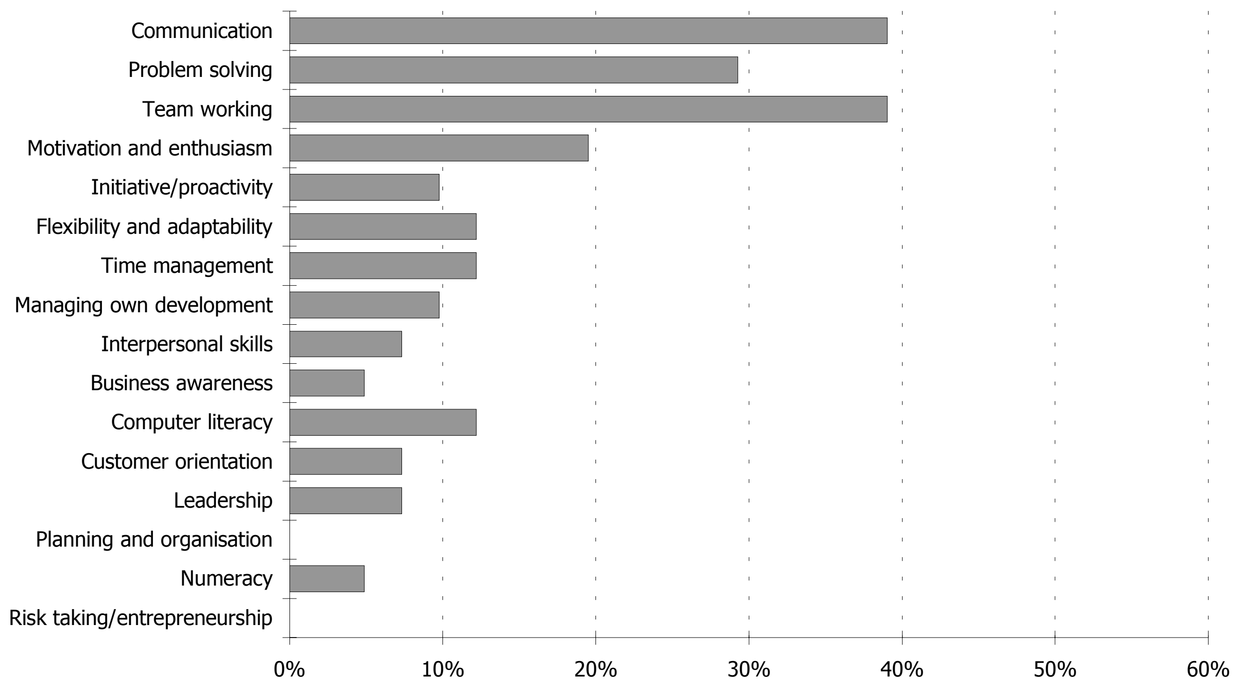
> *'We do employ a lot of PhDs, but the extra qualification is not really necessary. It shows a level of attainment and the ability to problem solve, but it isn't really necessary for this job in this company. This is because the company is so small you have to be very flexible and there are so many things to do — not all of them are particularly physics orientated.'*

## 3.3.2 Skills requirements of large companies

Large companies put greater emphasis on 'team working' and 'computer literacy' than average, and less on 'initiative/ proactivity' and 'business awareness'. These organisations are much more likely to use their physics postgraduate recruits as part of large multi-functional teams. They are also much more likely to report that they believe they can teach new recruits business skills, so they put less emphasis on this in selection. The lower score on 'initiative/proactivity' may indicate a need for people to fit into large organisations and not rock the boat.

Despite the importance attached to team working, many large employers are unsure whether the postgraduate course is the

**Figure 3.3: Percentage of large companies interviewees mentioning specific skills**




*Source: IES/EPSRC survey of postgraduate physics employers*

environment within which to teach it. For example, here are the comments of one large employer:

> *'I don't think you can teach teamwork. When they do a university course they are among their peers from the same discipline. Teamwork is about working together with people who are from other disciplines and that includes non-technical people like people in sales and marketing.'*

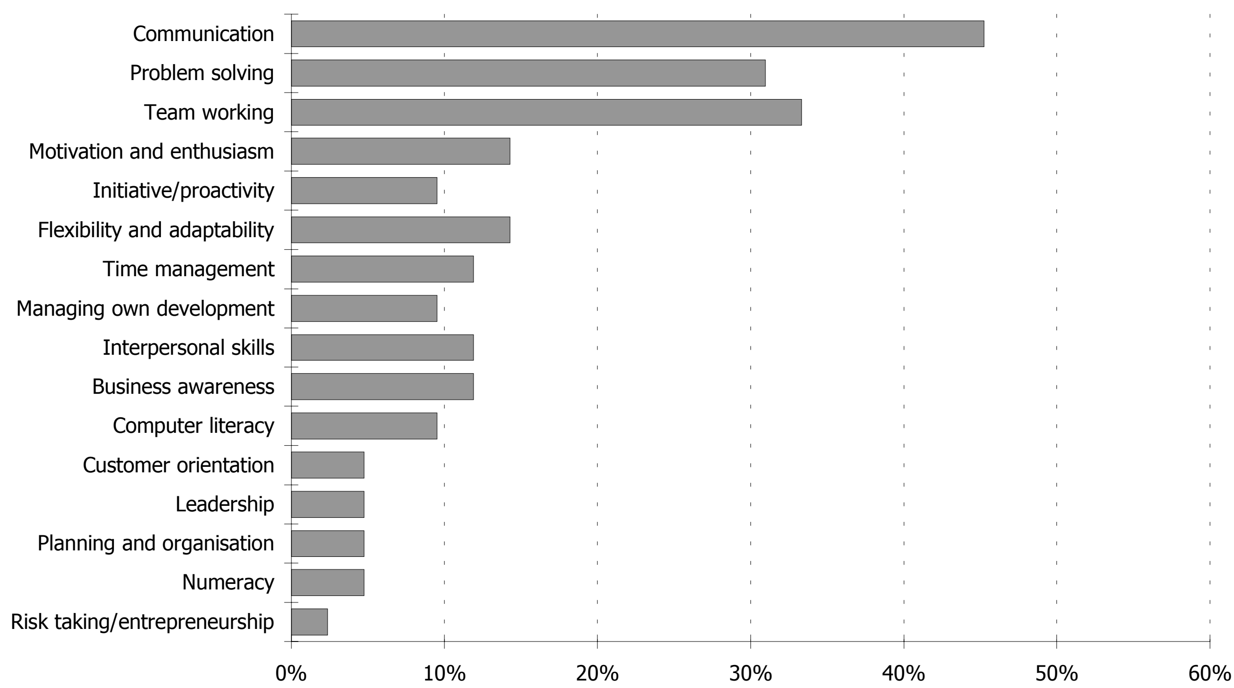
### 3.3.3 Skills requirements for research

Research based organisations or 'Technical and Consulting Services' (TCS) are the traditional type of employer of postgraduate physicists. It is therefore worthwhile separating out this group for analysis. Surprisingly, as a whole this group puts less emphasis on problem solving. In many ways, it would be expected that these organisations would put more emphasis on this, but it appears that the emphasis is more on communicating the solution to the problem. The size and maturity of companies appear to be the important factor. The small companies are more likely to have a novel idea or problem they are addressing with the emphasis on problem solving. The larger or more mature companies are more likely to be applying existing knowledge, and here communication especially with other functions within the organisation and with clients become more important.

### 3.3.4 Skills requirements of academics

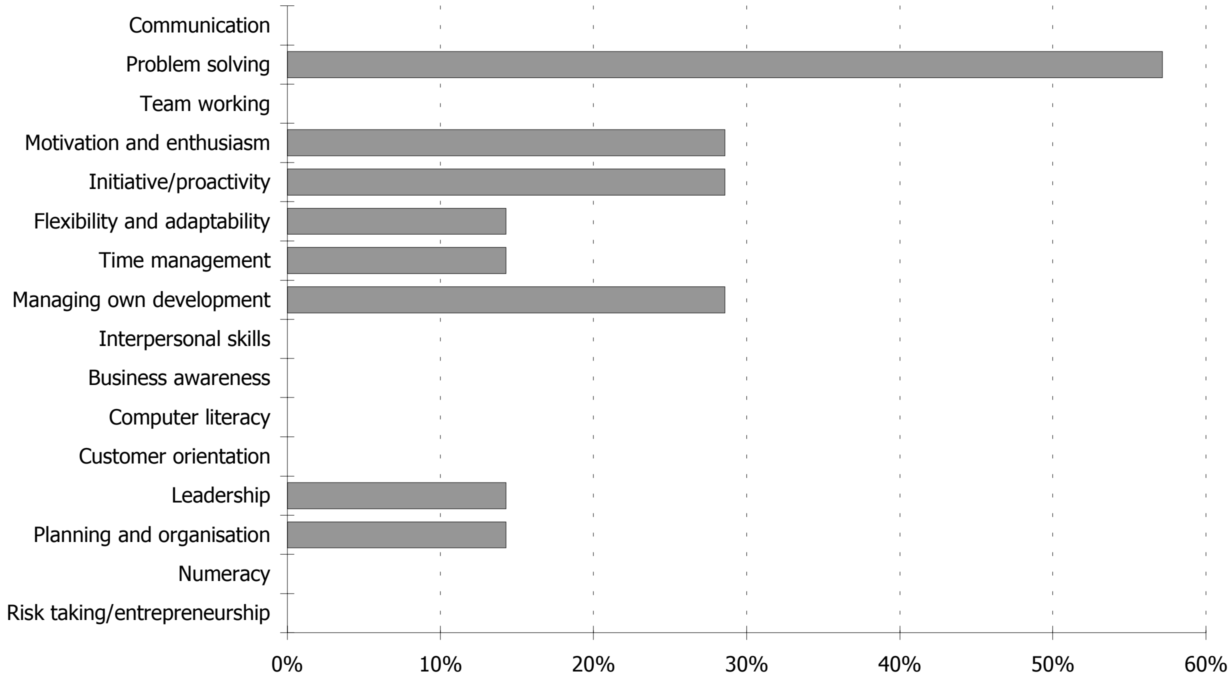
Perhaps the most interesting pattern of skill requirements comes from the academics. Admittedly, as the emphasis was on non-

**Figure 3.4: Percentage of TCS interviewees mentioning specific skills**




*Source: IES/EPSRC survey of postgraduate physics employers*

**Figure 3.5: Percentage of academic interviewees mentioning specific skills**




*Source: IES/EPSRC survey of postgraduate physics employers*

academic employment, relatively few academics were interviewed. However, some quite striking divergences from the pattern of important skills amongst commercial organisations can be seen.

Academics put far greater emphasis on 'problem solving', 'motivation and enthusiasm', 'Initiative/proactivity' and 'managing own development'. At the same time no academics mentioned 'communication', 'team working', or 'interpersonal skills'. In many ways, the skills that are considered important are a critique of the culture within academic departments. That managing one's own development should figure so highly is perhaps a worrying sign, given the existence of the concordat on researchers' careers where the departments are meant to take greater responsibility. It is also revealing that the two important areas where employers complain that postgraduates are inadequate ('communication' and 'team working) do not feature on the academics' agenda.

# 4. Views of Academics and Recent Postgraduates

Academics have a dual role in the labour market for physics postgraduates: they both produce the postgraduates and employ a significant proportion of the output. Therefore, this chapter examines first the views of academics as producers, then academics as employers, and finally the views of some recent postgraduates.

## 4.1 Academics as producers of postgraduates

The main concern of academics, as producers of postgraduates, was maintaining the flow of suitably qualified and trained first-degree graduates who wanted to study for a postgraduate qualification. There were a series of concerns that flowed back from the decision to undertake postgraduate study.

### 4.1.1 First degree graduate debt

As a result of the introduction of loans, graduates are increasingly indebted by the time they complete their first-degree study. This indebtedness and the relatively low stipends that were available, compared with the sort of salaries a good first degree graduate can attract, meant that fewer graduates were choosing postgraduate study. The recent decision to free up how the EPSRC student support can be spent was welcomed. This enables higher, shorter stipends to be combined with part-time teaching, or research posts, or a range of similar options to make postgraduate, especially doctoral, study more attractive.

### 4.1.2 First degree output

Another concern is that there is a decline in the numbers of people obtaining first degree physics qualifications. However, as Table 4.1 shows, numbers of first-degree physics graduates, as well as first class first-degree physics graduates, despite fluctuating has remained constant. However, the numbers have not increased in line with the increase in overall student numbers. Equally, the numbers obtaining first class degrees are fairly close to the numbers of new first year postgraduate students.

**Table 4.1: UK physics first degree graduates**

| | 1994-95 | 1995-96 | 1996-97 | 1997-98 |
|---|---|---|---|---|
| Physics first degrees | 2,480 | 1,998 | 2,440 | 2,320 |
| 1st class physics 1st degrees | 465 | 343 | 438 | 466 |
| 1st class as a percent of total | 18.8 | 17.2 | 18.0 | 20.1 |

*Source: HESA (various years) Students in Higher Education Institutions*

### 4.1.3 Maths and physics in schools

A concern linked to the numbers entering physics study at first-degree level is the numbers studying physics and maths at 'A' level, and the syllabuses of these 'A' levels. There is some evidence of a drop in Physics amongst the proportion of successful 'A' level candidates in England (Table 4.2). However, this is a decline in relative numbers, and in absolute terms the numbers gaining Physics 'A' levels has been rising. A similar pattern can be observed with Mathematics 'A' Levels.

## 4.2 Academics as employers

Academia represents probably the single largest initial employer of postgraduate physicists. The HESA data suggest that about 15 per cent of physics PhD graduates enter university funded posts, while about another 15 per cent enter post-doctoral research positions.

### 4.2.1 Skill requirements of academia

The reported skill requirements for academic appointments were covered in Chapter 3. In brief, there is great emphasis on problem solving and motivation and enthusiasm. This is contrasted with non-academic employers who put much greater emphasis on communication and team working skills.

### 4.2.2 Changing research careers within academia

During the interviews, the academics acknowledged that the increase in large international teams co-operating on research projects is putting an increasing premium on communication and

**Table 4.2: Successful 17 year old GCE 'A' level examination candidates in England**

| | 1993/94 | 1994/95 | 1995/96 | 1996/97 | 1997/98 | 1998/99 |
|---|---|---|---|---|---|---|
| Mathematics | 37,012 | 38,367 | 41,681 | — | 44,734 | 44,054 |
| Mathematics as a per cent of any | 23.3 | 23.9 | 24.8 | — | 23.7 | 23.4 |
| Physics | 22,081 | 22,065 | 24,705 | — | 23,714 | 23,770 |
| Physics as a per cent of any | 13.9 | 13.7 | 12.9 | — | 12.6 | 12.6 |
| Any Subjects | 158,976 | 160,816 | 168,110 | — | 188,897 | 188,086 |

*Source: DfEE (various years) GCSE/GNVQ and GCE A/AS/ADVANCED GNVQ Results for Young People in England* team working skills within academia. Similarly, the increasing competition for research funding and the need to find industrial sponsorship is putting increasing emphasis on the commercial skills of budgeting, time management, customer orientation and presentation. At the same time, many of those who start an academic research career subsequently leave academia for industrial opportunities. This means that, overall, only a very small minority of physics postgraduates has a sustained academic career.

## 4.3 Views of recent postgraduates

A postgraduate is likely to assess the usefulness of experiences and skills acquired during PhD study in relation to his or her present activities. Those continuing academic employment are likely to feel differently than those working outside of academia. Equally, assessment of the relevance of skills obtained during a doctoral training will be influenced by whether or not a PhD is a requirement of their employment.

This section collates and analyses the views of fifteen physics PhD postgraduates who responded to the online survey. The analysis is broken down into three groups:

- those pursuing an academic career — seven responses
- those in non-academic employment where a physics PhD was helpful for entry — five responses
- those in non-academic employment where a physics PhD was not a requirement — three responses.

Given the small number of cases, no attempt has been made to make a statistical analysis. Instead, the aim is draw out some pertinent themes about how, and in which areas, the postgraduate physics training prepared these individuals for the labour market.

### 4.3.1 Postgraduates in academic professions and involved in further academic study

Of the seven individuals making up the 'academic' group, two are university research fellows, three are in postdoctoral positions and a further two are research associates. Three of the group had EPSRC funding for their PhD, two had overseas funding, and one each had a Commonwealth Scholarship and a university bursary.

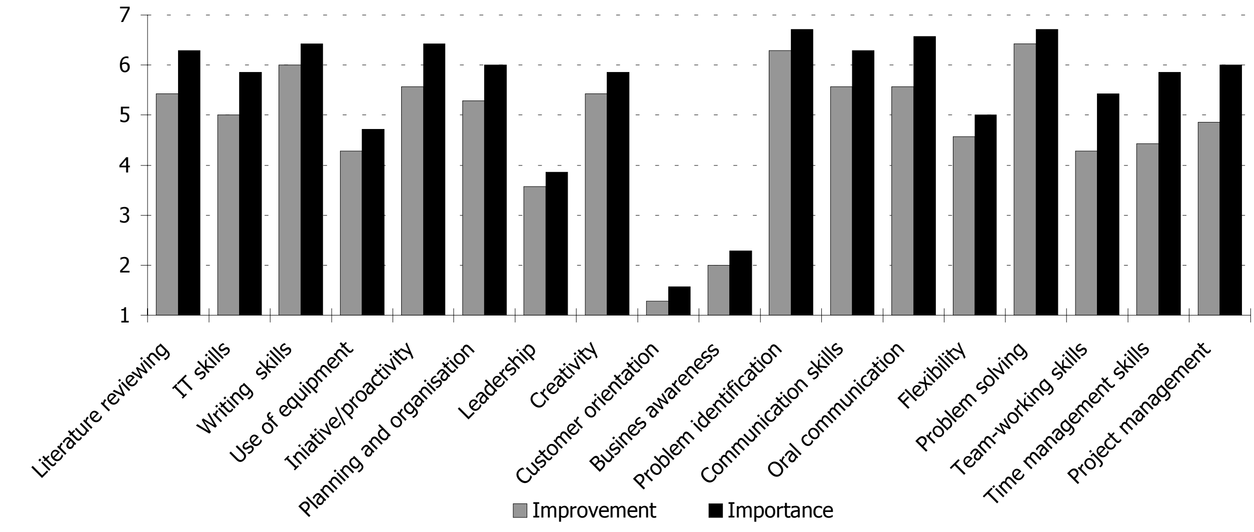
Reflecting the type of work, all of this group were on fixed-term or short-term full-time contracts where a PhD was a formal entry requirement. Overall, there was a pretty good match between the skills gained as part of their doctoral training and those required in their current activity.

The seven postgraduates involved in 'academic' activities, as well as the other case studies, were asked to rank a range of skills in terms of the degree to which their capabilities in each area had improved over the duration of the PhD. The possible responses ranged from one ('not all') to seven ('great improvement'). The respondents were then asked to rank, in a similar fashion, the degree to which each skill was of importance to their current job — one being 'unimportant' and seven being 'essential'. From a comparison of the 'importance' and 'improvement' measures, we can assess whether the skill acquisition from the doctoral training has been 'matched' by its relevance to the job. Figure 4.1 gives an average of the seven responses from the 'academic' group for each skill, in terms of both measures.

Perhaps unsurprisingly, given that PhD study and the post-graduates involved in 'academic' activities operate in the same sphere, Figure 4.1 demonstrates little difference between the degree of improvement in a skill and its importance to the job. For the most part, where skills are deemed very important (scoring six to seven), such as 'use of test/analytic equipment', or 'problem solving', they are roughly matched in terms of skill improvement. Where something is not important, for example 'customer orientation', or 'business awareness' the skill improvement is similarly low.

There are, however, areas where a slight 'skills gap' is evident between the high importance of a skill and the individual's improvement in this area. Three areas identified by the postdoctoral researchers as being of importance to their current employment were 'team working', 'time management' and 'project management' skills, but in both the improvement was noticeably lower. These examples suggest that PhD study does not fully equip students with the skills required for a post-doctoral research career.

**Figure 4.1: Average improvement in skills during doctoral training and the importance of these skills in current academic occupation**




*Source: IES/EPSRC survey of recent physics postgraduates*

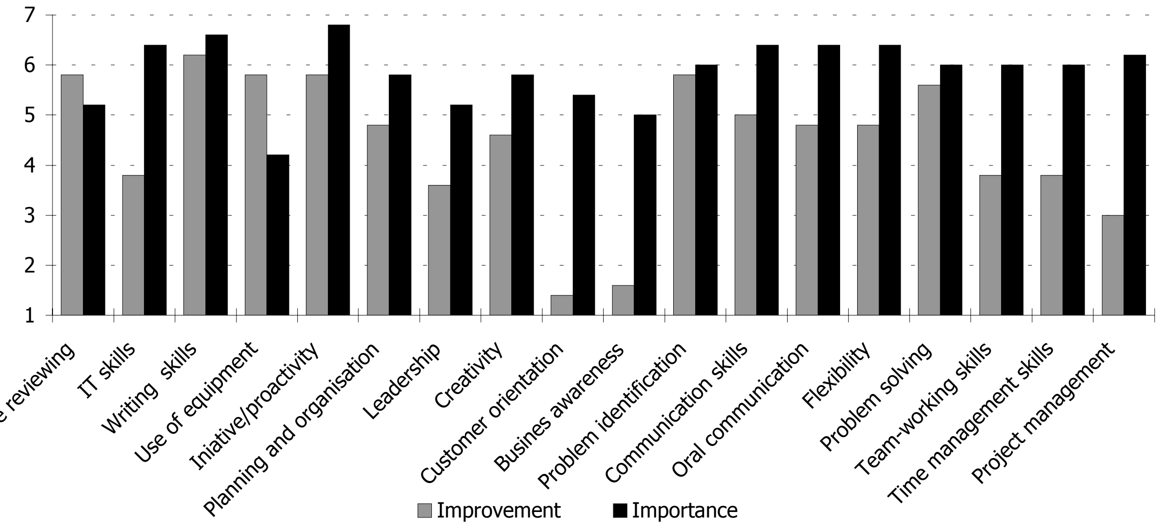
### 4.3.2 Post-graduates in professions for which a PhD is helpful to entry

The group comprises of an 'applications support consultant', a 'technology risk consultant', a 'development technologist', a 'database manager' and another who did not give their job title. All five state that 'a PhD was helpful for entry' into their jobs. In contrast to those in the academic group, two of the five, the 'marketing manager' and the 'technology risk consultant', did industrially sponsored PhDs, and all five have permanent employment contracts.

The same questions were asked for those in the previous group, and the averages of answers given captured in Figure 4.2. Figure 4.2 demonstrates that these individuals were less happy with their training in relation to the skills that were currently important. Unsurprisingly, this is particularly true of 'business awareness' and 'customer orientation', where skill improvements are at similar low levels to those in the 'academic' grouping, but deemed very important in the respondents' jobs. The development technologist states that she would like: '*…more business/ commercial training – not necessary for the PhD itself, but [it] makes someone with a PhD more employable*'. In addition, she feels that training on assertiveness and negotiation would have been useful for her commercial role. It is pertinent that for all five training, both formal and informal, received *since* PhD completion, is deemed more important to their current jobs than the PhD itself.

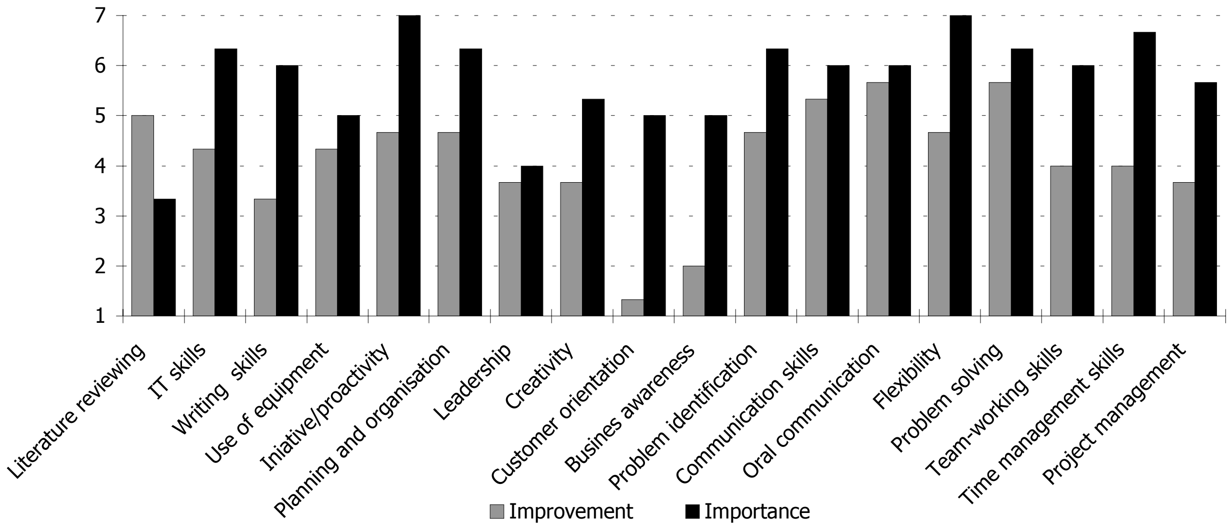
Project management, time management and team working skills were also identified by the five as areas of great importance, for which there was not a similar level of skills acquisition. It is also noticeable, from Figure 4.2, that the five rate the more academic

**Figure 4.2: Average improvement in skills during doctoral training and the importance of these skills in current occupation where the PhD helped entry**




*Source: IES/EPSRC survey of recent physics postgraduates*

**Figure 4.3: Average improvement in skills during doctoral training and the importance of these skills in current occupation where the was PhD not required**




*Source: IES/EPSRC survey of recent physics postgraduates*

skills acquired, such as 'use of test/analytic equipment, at a lower level than do their 'academic' peers.

### 4.3.3 Postgraduates in professions for which a PhD is a not a formal requirement

Of the three in the group where their PhD was not a formal employment requirement, two specify their current job. One works in the legal arena, providing scientific information as an 'assistant to expert witness in a patent litigation case', the other as a 'marketing manager' in the civil service. All three earn above £20,000 pa, the assistant to expert witness earning above £25,000.

As Figure 4.3 shows, on average this group has the greatest skill gaps. Given that their current occupations are not dependent on their postgraduate training, perhaps it should be expected that there is a divergence between the skills acquired during their training and their current occupation. However, 'customer orientation' and 'business awareness' are skills where there is the greatest difference between their importance in the job and the skill acquisition resulting from PhD study. The three skills where there was the smallest divergence were 'communication skills', 'oral communication' and 'problem solving'.

# 5. Secondary Data

This chapter presents the available data covering the labour market for postgraduate physicists. There are problems in matching much of the available data that covers physics as a departmental discipline with the remit of the EPSRC physics programme. Despite these problems a lot of valuable detail about the labour market, for those with postgraduate physics qualifications, can be obtained. Equally, a lot of information about physics postgraduates who received financial support from the EPSRC can be found.

## 5.1 Data sources

A range of data sources is available, some quite specific to the remit of the EPSRC physics programme area. Other data sources are more general, but have the advantage of more detailed information.

### 5.1.1 EPRSC administrative date

EPSRC collects data as a function of providing financial support for postgraduate students. Table 5.1 presents these data and shows that numbers of Doctoral and Masters awards have been rising gradually over the last three years. The relatively new category of project based studentships has shown the most rapid growth. Overall, there are almost four times the number of Doctoral studentships compared with Masters studentships, while quota awards outnumber the Project, CASE and EngD awards by about the same ratio.

**Table 5.1: Number of awards in the EPSRC physics programme 1998-2000**

| | 1996-97 | 1997-98 | 1998-99 | 1999-2000 |
|---|---|---|---|---|
| Quota Doctoral Awards | 103 | 149 | 118 | 136 |
| Project, CASE and EngD | 22 | 46 | 43 | 37 |
| Masters | 37 | 37 | 38 | 40 |
| All Awards | 162 | 232 | 199 | 213 |

*Source: EPSRC personal communication and EPSRC Annual Report 1999/2000*

### 5.1.2 EPSRC first destinations data

The EPSRC also collect summary data on the first destinations of EPSRC supported students. This data source appears to suffer from a relatively low response rate, but has the advantage that it relates to the EPSRC programme areas.

### 5.1.3 HESA student data

HESA, the Higher Education Statistics Agency, collects data on student numbers, as well as their subject and level of study. Additionally, data are collected on the individual students gender, domicile, previous qualifications and main source of support as well as the main source of their fees.

### 5.1.4 HESA first destinations data

In addition to the student data, and potentially linked to all the details in the individual student record, HESA collates data collected by the institutions on the first destinations of graduates from full-time study. This first destinations data includes information of the main activity of the graduate and details of any employment. For those in employment, information is collected about the location, and employer's nature of business, as well as the occupation entered for those entering employment.

### 5.1.5 Other data sources

Normally, when examining specific labour markets other sources can be used such as the Labour Force Survey and the Population Census. However, the relatively small number of physics postgraduates, combined with the current occupational classification which does not separately identify physicists, means the LFS cannot be used. At the same time, the most recent Population Census was undertaken in 1991 which means that the data are currently nine years out of date and of marginal value.

## 5.2 Nature of the postgraduate physics labour market

Before examining the nature of the postgraduate physics labour market, it is necessary to define the labour market.

### 5.2.1 Defining the physics labour market

This study focuses on employers of those postgraduates within the remit of the Physics Programme of the EPSRC, those who were funded by the Programme and those who potentially could have been funded by the Programme. However, it is recognised that employers do not know, or need to know, the boundaries of the Programme's remit. Therefore, the study has also examined the broader physics community as well.

Many postgraduates who have been supported by the Physics Programme enter employment where they are employed for skills they additionally possess apart from their physics skills. Many employers value the problem solving, software, or mathematical modelling skills that postgraduate physicists acquire as part of their training. Therefore, the study also examined the views of these non-physics based employers of physicists.

### 5.2.2 Number of physics postgraduates

Table 5.1 showed that the EPSRC's Physics Programme provided 213 new awards in 2000, with the majority covering Doctoral study. These relatively small numbers poses a problem for the study in that it implies that there are also relatively few physics postgraduates entering employment. This in turn means that there are relatively few organisations employing postgraduate physicists.

To acquire a better understanding of the number and nature of physics postgraduate students, a special analysis of data collected by the Higher Education Statistics Agency (HESA) was obtained. Basic data on the number of postgraduate students in physics departments are presented in Table 5.2. Using a broader definition of physics postgraduate that includes all those studying in physics departments gives 1,166 first year students in 1998-99, compared with the 199 students getting new EPSRC awards in the same year.

### 5.2.3 The number of overseas students

Of the total of 1,116 first year students in UK physics departments, the HESA data in Table 5.2 show that only 800 are UK nationals. Indeed, the HESA data also suggests that of those first years in 1998-99 for whom EPSRC was paying their tuition fees, over ten per cent were non-UK nationals. In all, 21 first year Doctoral students, five MRes, 11 MSc students from the EU and one Doctoral student from the rest of the world had their tuition fees paid by EPSRC (Table 5.3). This figure of 10.1 per cent non-UK nationals is up from 3.7 per cent in 1994-95. This rise in non-UK

**Table 5.2: Number of first year students in physics departments, 1998-99, by level of postgraduate study and domicile**

| Domicile | Doctorate degree mainly by research | Masters degree mainly by research | Masters degree not mainly by research | Grand Total |
|---|---|---|---|---|
| UK | 369 | 187 | 244 | 800 |
| Other EU | 82 | 44 | 84 | 210 |
| Other Overseas | 86 | 29 | 41 | 156 |
| Grand Total | 537 | 260 | 369 | 1,166 |

*Source: IES and a special analysis of HESA student statistics*

**Table 5.3: Number of first year students in physics departments with EPSRC paying fees, 1998-99, by level of postgraduate study and domicile**

| Domicile | Doctorate degree mainly by research | Masters degree mainly by research | Masters degree not mainly by research | Grand Total |
|---|---|---|---|---|
| UK | 181 | 75 | 70 | 326 |
| Other EU | 21 | 5 | 11 | 37 |
| Other Overseas | 1 | — | — | 1 |
| Grand Total | 203 | 80 | 81 | 364 |

*Source: IES and a special analysis of HESA student statistics*

nationals receiving EPSRC support may in turn indicate a decline in the numbers of UK nationals deemed worthy of the support.

### 5.2.4 EPSRC and other funding bodies support

The source of tuition fees appears to be a more reliable indicator of Research Council support than the alternative HESA field 'main source of funds'. Data on the source of tuition fees for first year students in physics departments for 1998-99 are given in Table 5.4. EPSRC support, as measured by the payment of tuition fees, covered 364 students (or 31 per cent) of the first year students.

This figure is greater than the 199 new studentships provided by the EPSRC Physics Programme that year. This disparity can largely be explained by the numbers of students supported by

**Table 5.4: First year students in physics departments in 1998-99 by level of postgraduate study and source of tuition fees**

| Tuition Fees (Major Source of) | Doctorate degree mainly by research | Masters degree mainly by research | Masters degree not mainly by research | Grand Total | Funding source as a per cent of all students |
|---|---|---|---|---|---|
| British Academy | — | — | 1 | 1 | 0.1 |
| Biotechnology & Biological Sciences Research Council (BBSRC) | — | 7 | — | 7 | 0.6 |
| Medical Research Council (MRC) | 3 | 4 | — | 7 | 0.6 |
| Natural Environmental Research Council (NERC) | 10 | 7 | 3 | 20 | 1.7 |
| Engineering & Physical Sciences Research Council (EPSRC) | 203 | 80 | 81 | 364 | 31.2 |
| Particle Physics & Astronomy Research Council (PPARC) | 68 | 30 | — | 98 | 8.4 |
| Research Council - not specified | 3 | 7 | — | 10 | 0.9 |
| Other Source | 236 | 121 | 274 | 631 | 54.1 |
| No fees | 8 | 1 | 8 | 17 | 1.5 |
| Not known | 6 | 3 | 2 | 11 | 0.9 |
| *Grand Total* | *537* | *260* | *369* | *1,166* | *100.0* |

*Source: IES and a special analysis of HESA student statistics* other EPSRC programmes, such as the materials programme, in Physics departments.

Table 5.4 shows the broad range of sub-disciplines within physics departments, as indicated by the degree to which physics students are able to attract funds from the other Research Councils. PPARC supported a further 98 students, or 8.4 per cent; NERC 20; MRC seven; BBSRC seven and the British Academy one, while a further ten were supported by unspecified Research Councils. Interestingly, only 17 students had their fees waived by their universities, leaving the majority of students (54 per cent) paying their fees from a non-institutional source.

## 5.3 ESPRC first destination data

Apart from data on the number of students, EPSRC also collects, directly from the departments receiving studentships, data on the first destinations of the students they have supported. The response rate for this survey is generally low and it is also unclear whether the response is representative. However, data covering students supported by the physics programme who finished studying in 1998 and submitted by September 1999 are given in Table 5.5. This shows that of those obtaining a Masters, a quarter were engaged in further training, five per cent were not employed and the remaining 70 per cent who entered employment were split equally between the private and public sectors. PhD graduates were most likely to have entered fixed-term academic appointments or be employed in the private sector.

## 5.4 HESA first destinations data

A special analysis of the First Destinations Statistics (FDS) collated by HESA (the Higher Education Statistics Agency) was obtained. The funding agencies have put a lot of pressure on universities to

**Table 5.5: Percentage breakdown of EPSRC physics programme FDS for students submitting by September 1999 having finished studying in 1998**

| | **Masters** | **PhD** |
|---|---|---|
| Private sector | 35.0 | 34.5 |
| Government and other public sector | 35.0 | 3.4 |
| Teacher training | 0.0 | 0.9 |
| Permanent Academic appointment | 0.0 | 2.6 |
| Fixed term Academic appointment | 0.0 | 39.7 |
| Further training | 25.0 | 3.4 |
| Other employment | 0.0 | 4.3 |
| Not employed | 5.0 | 11.2 |
| *Total with known destinations* | *100.0* | *100.0* |

*Source: EPSRC First Destinations Data*

increase the quality and response rate of the First Destination Data (FDS) collected by HESA from the institutions. This means that there are relatively high response rates and relatively reliable information.

Table 5.6 presents HESA FDS data covering those obtaining postgraduate qualifications in physics. This suggests that a far smaller percentage of doctoral students are undertaking further study according to the HESA data (1.1 per cent) than the EPSRC data (3.4 per cent, see Table 5.5). The reason for this discrepancy is that the EPSRC data include those still writing up their theses. This is because the baseline for the EPSRC data collection is the end of the student support, whilst the HESA data is collected after the students have gained their doctoral qualification. The HESA data therefore provide a much better record of what happens to those with these qualifications.

Importantly, the HESA data also show that a smaller percentage of both the Doctoral and Masters graduates are unemployed. The data also show over one in five (21.3 per cent) of the Doctoral graduates entering overseas employment. As these data include a large number of overseas students returning overseas this is as expected. However, large numbers of EPSRC-funded doctoral graduates also move overseas to post-doctoral or other employment.

It is possible with the HESA FDS to distinguish the outcomes within physics for those whose tuition fees were paid by EPSRC.

**Table 5.6: Main activity of physics postgraduates as of December 31 for those graduating in the year before 31 July 1998**

| | Doctorate degree mainly by research | | Masters degree mainly by research | | Masters degree not mainly by research | | Grand Total | |
|---|---|---|---|---|---|---|---|---|
| **Main Activity** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| UK paid full-time employment | 231 | 65.6 | 5 | 21.7 | 69 | 37.3 | 305 | 54.5 |
| UK paid part-time employment | 3 | 0.9 | — | — | — | — | 3 | 0.5 |
| UK self-employed | 2 | 0.6 | — | — | 1 | 0.5 | 3 | 0.5 |
| UK unpaid employment | 1 | 0.3 | — | — | — | — | 1 | 0.2 |
| Employment overseas | 75 | 21.3 | 4 | 17.4 | 10 | 5.4 | 89 | 15.9 |
| Other employment in UK (category and/or mode not reported) | 11 | 3.1 | 1 | 4.3 | 6 | 3.2 | 18 | 3.2 |
| Undertaking study or training | 4 | 1.1 | 11 | 47.8 | 57 | 30.8 | 72 | 12.9 |
| Not available for employment or training | 6 | 1.7 | 1 | 4.3 | 10 | 5.4 | 17 | 3.0 |
| Assumed to be unemployed | 8 | 2.3 | — | — | 4 | 2.2 | 12 | 2.1 |
| Others | 11 | 3.1 | 1 | 4.3 | 28 | 15.1 | 40 | 7.1 |
| *Grand Total* | *352* | *100.0* | *23* | *100.0* | *185* | *100.0* | *560* | *100.0* |

*Source: IES and a special analysis of HESA first destination statistics*

**Table 5.7: Main activity of physics postgraduates with tuition fees paid by EPSRC as of December 31 for those graduating in the year before 31 July 1998**

| | Doctorate degree mainly by research | | Masters degree not mainly by research | | Grand Total | |
|---|---|---|---|---|---|---|
| **Main Activity** | N | % | N | % | N | % |
| UK paid full-time employment | 40 | 67.8 | 29 | 65.9 | 69 | 67.0 |
| UK paid part-time employment | 1 | 1.7 | — | — | 1 | 1.0 |
| Employment overseas | 12 | 20.3 | — | — | 12 | 11.7 |
| Other employment in UK (category and/or mode not reported) | 3 | 5.1 | — | — | 3 | 2.9 |
| Undertaking study or training | 1 | 1.7 | 12 | 27.3 | 13 | 12.6 |
| Not available for employment or training | 1 | 1.7 | 2 | 4.5 | 3 | 2.9 |
| Assumed to be unemployed | 1 | 1.7 | 1 | 2.3 | 2 | 1.9 |
| *Grand Total* | *59* | *100.0* | *44* | *100.0* | *103* | *100.0* |

*Source: IES and a special analysis of HESA first destination statistics*

As already discussed, this group is not directly comparable with those supported by the Physics Programme. However, the two groups are analogous. Table 5.7 presents these HESA data and shows that broadly the pattern for EPSRC supported students in physics is similar to that for all physics students. However, the percentage of students entering employment overseas is greater than the proportion of overseas students supported by EPSRC.

Another, difference is that a smaller percentage (27.3 per cent) of those Masters graduates supported by EPSRC entered further study or training, compared with 30.8 per cent of all the physics Masters students.

## 5.5 The occupations entered by postgraduate physicists

The HESA FDS contains information covering the occupations of those entering UK employment. This data source is coded using the Standard Classification of Occupations (SOC 90) which provides quite fine detail. Table 5.8 presents the data in the most disaggregated form possible.

The most important feature of the data for the graduates is the number of different occupations entered, especially amongst Doctoral graduates. This flexibility of physics postgraduates was a feature of the employer interview although distinct differences appear between Doctoral and Masters graduates

The most important single category for both PhD and Masters graduates was, as might be expected, 'Physicists'. However, even if 'Other natural scientists' is added, less than one-third of all those entering employment were in this category. Amongst the Doctoral graduates, the second most common occupation, at 15

**Table 5.8: Occupations entered by postgraduates who entered UK employment after studying physics and with their tuition fees paid by EPSRC, 1998/99**

| | Doctorate | | Masters | | Grand Total | |
|---|---|---|---|---|---|---|
| **SOC 90 Code and description** | **N** | **%** | **N** | **%** | **N** | **%** |
| {1261} Data processing managers | 1 | 1.7 | — | — | 1 | 1.0 |
| {1262} Computer operations managers | 1 | 1.7 | — | — | 1 | 1.0 |
| {1400} Transport managers n.e.c. | 1 | 1.7 | — | — | 1 | 1.0 |
| {2014} Botanists | 1 | 1.7 | — | — | 1 | 1.0 |
| {2020} Physicists, geologists and meteorologists | — | — | 2 | 4.5 | 2 | 1.9 |
| {2021} Physicists | 11 | 18.6 | 10 | 22.7 | 21 | 20.4 |
| {2090} Other natural scientists n.e.c. | 8 | 13.6 | — | — | 8 | 7.8 |
| {2132} Electronic engineers: telecommunications | — | — | 1 | 2.3 | 1 | 1.0 |
| {2140} Software engineers | 2 | 3.4 | 2 | 4.5 | 4 | 3.9 |
| {2160} Design and development engineers | 2 | 3.4 | 7 | 15.9 | 9 | 8.7 |
| {2170} Process and production engineers | 1 | 1.7 | — | — | 1 | 1.0 |
| {2181} Planning engineers | 1 | 1.7 | — | — | 1 | 1.0 |
| {2192} Patents examiners, agents and officers | 1 | 1.7 | — | — | 1 | 1.0 |
| {2195} Other professional engineers | — | — | 3 | 6.8 | 3 | 2.9 |
| {2302} University and higher education lecturers | 9 | 15.3 | — | — | 9 | 8.7 |
| {2332} Secondary school teachers n.e.c. | 2 | 3.4 | — | — | 2 | 1.9 |
| {2522} Statisticians | — | — | 1 | 2.3 | 1 | 1.0 |
| {2531} Management consultants | 1 | 1.7 | — | — | 1 | 1.0 |
| {3003} Medical laboratory technicians | 2 | 3.4 | — | — | 2 | 1.9 |
| {3201} Systems analysts (including analyst-programmers) | 1 | 1.7 | — | — | 1 | 1.0 |
| {3202} Computer programmers | 4 | 6.8 | — | — | 4 | 3.9 |
| {3203} Computer/IT consultants | 1 | 1.7 | — | — | 1 | 1.0 |
| {3460} Medical technicians, dental auxiliaries | — | — | 1 | 2.3 | 1 | 1.0 |
| {3612} Sharedealers | 1 | 1.7 | — | — | 1 | 1.0 |
| {3641} Operational research officers | — | — | 1 | 2.3 | 1 | 1.0 |
| {3961} Industrial safety officers | 1 | 1.7 | — | — | 1 | 1.0 |
| {4100} Accounts and wages clerks, book-keepers, other financial clerks | — | — | 1 | 2.3 | 1 | 1.0 |
| {5160} Metal working production and maintenance fitters | 1 | 1.7 | — | — | 1 | 1.0 |
| Not known | 6 | 10.2 | 15 | 34.1 | 21 | 20.4 |
| *Grand Total* | *59* | *100.0* | *44* | *100.0* | *103* | *100.0* |

*Source: IES and a special analysis of HESA first destination statistics*

per cent of the total, were 'University and higher education lecturers'. However, this would include those entering university-funded research positions.

For Masters graduates the second largest category, at 16 per cent, was 'Design and development engineers'. This reflects the many comments we received along the lines of: 'once physics becomes commonplace, it is called engineering'. Another aspect of the high-tech skills acquired by physics postgraduates is the importance of a range of software and IT occupations. However, Doctoral graduates predominated in these software and IT based occupations with 16.9 per cent entering them. Despite anecdotal evidence from previous research (*eg* Lascelles, 1998) of large numbers entering the financial services sector, this is not reflected in the HESA FDS data for physicist supported by the EPSRC. Of the 59 Doctoral graduates covered, only one became a 'Management Consultant' and a further individual became a 'Sharedealer'. This may reflect a recent downturn in recruitment of physics postgraduates by the financial services sector, following a decline in futures trading. On the other hand, the HESA data may not fully capture this flow.

## 5.6 Sectors employing physicists

HESA also collects data on the sector of employment as part of the FDS record. Table 5.9 (overleaf) shows that as in terms of occupations, EPSRC-supported physics doctoral graduates are flexible and enter a wide range of sectors. Again, for the Doctoral graduates, the most important sector is higher education. With the Masters graduates, the picture is complicated by the numbers where the sector of employment was not known. However, the two most important categories for Masters graduates were 'Defence activities' (presumably DERA) and 'R&D on natural science and engineering'.

The other sectors employing Doctoral graduates reflect the occupations they enter, with high-tech manufacturing and the software sectors taking relatively large proportions. Masters graduates reported a fairly similar profile but additionally entered the construction and telecommunications sectors. The financial services sector recruited only two Doctoral graduates, confirming the picture gained from the occupational data.

**Table 5.9: Sectors entered by postgraduates who entered UK employment after studying physics and with their tuition fees paid by EPSRC, 1998/99**

| | Doctorates | | Masters | | Total | |
|---|---|---|---|---|---|---|
| **SOC 90 Code and description** | **N** | **%** | **N** | **%** | **N** | **%** |
| {1510} Manufacture of food products | 1 | 1.7 | — | — | 1 | 1.0 |
| {2210} Publishing | 2 | 3.4 | — | — | 2 | 1.9 |
| {2330} Processing of nuclear fuel | 1 | 1.7 | — | — | 1 | 1.0 |
| {2460} Manufacture of other chemical products | 1 | 1.7 | — | — | 1 | 1.0 |
| {2600} Manufacture of other non-metallic mineral products | 1 | 1.7 | — | — | 1 | 1.0 |
| {2900} Manufacture of machinery and equipment n.e.c. | 1 | 1.7 | 1 | 2.3 | 2 | 1.9 |
| {3000} Manufacture of office machinery and computers | 1 | 1.7 | — | — | 1 | 1.0 |
| {3100} Manufacture of electrical machinery & apparatus n.e.c. | — | — | 1 | 2.3 | 1 | 1.0 |
| {3210} Manufacture of electronic components | 3 | 5.1 | 2 | 4.5 | 5 | 4.9 |
| {3220} Manufacture of television and radio transmission equipment and telephone apparatus | 1 | 1.7 | 2 | 4.5 | 3 | 2.9 |
| {3300} Manufacture of medical, precision and optical instruments, watches and clocks | 2 | 3.4 | 1 | 2.3 | 3 | 2.9 |
| {3530} Manufacture of aircraft and spacecraft | 1 | 1.7 | — | — | 1 | 1.0 |
| {4010} Production and distribution of electricity | — | — | 1 | 2.3 | 1 | 1.0 |
| {4520} Building of complete constructions or parts thereof | — | — | 3 | 6.8 | 3 | 2.9 |
| {6420} Telecommunications | 1 | 1.7 | 3 | 6.8 | 4 | 3.9 |
| {6511} Banks | 1 | 1.7 | — | — | 1 | 1.0 |
| {6600} Insurance and pension funding, except social security | 1 | 1.7 | — | — | 1 | 1.0 |
| {7200} Computer and related activities | 2 | 3.4 | — | — | 2 | 1.9 |
| {7220} Software consultancy and supply | 4 | 6.8 | — | — | 4 | 3.9 |
| {7260} Other computer related activities | — | — | 1 | 2.3 | 1 | 1.0 |
| {7310} R&D on natural sciences and engineering | 4 | 6.8 | 5 | 11.4 | 9 | 8.7 |
| {7411} Legal activities | 1 | 1.7 | — | — | 1 | 1.0 |
| {7414} Business and management consultancy activities | 1 | 1.7 | — | — | 1 | 1.0 |
| {7420} Architectural and engineering technical consultancy | 1 | 1.7 | — | — | 1 | 1.0 |
| {7430} Technical testing and analysis | — | — | 1 | 2.3 | 1 | 1.0 |
| {7510} Central, regional and local government and admin | 1 | 1.7 | — | — | 1 | 1.0 |
| {7522} Defence activities | 2 | 3.4 | 6 | 13.6 | 8 | 7.8 |
| {8000} Education | 1 | 1.7 | — | — | 1 | 1.0 |
| {8020} Secondary education | 2 | 3.4 | — | — | 2 | 1.9 |
| {8030} Higher education | 18 | 30.5 | — | — | 18 | 17.5 |
| {8510} Human health activities | — | — | 1 | 2.3 | 1 | 1.0 |
| {8511} Hospital activities | 1 | 1.7 | — | — | 1 | 1.0 |
| {9999} Not Known | 3 | 5.1 | 16 | 36.4 | 19 | 18.4 |
| *Grand Total* | *59* | *100.0* | *44* | *100.0* | *103* | *100.0* |

*Source: IES and a special analysis of HESA first destination statistics*

# 6. Conclusions and Recommendations

There is a range of policy conclusions that can be derived from the analysis of the literature, secondary data and the interviews with employers.

## 6.1 Growth areas

The interviews revealed two areas where there appeared to be current shortages of postgraduate physicists. These were:

- optronics — where an Internet driven requirement for high-speed data communications is driving recruitment. The requirement was for a few highly appropriately qualified doctorates and, more generally, in a few localities (mainly associated with a few large R&D establishments) for Masters level recruits
- microwave and radio frequency areas — where the growth in mobile telephone capacity and bandwidth is driving recruitment. Here the requirement was more limited to appropriately qualified doctorates to work in R&D areas.

The interviews also identified four areas of relatively high activity where supply is apparently currently keeping pace with demand:

- low temperature superconductivity — which is being driven by the market for MRI scanners
- the financial services sector — where the high salaries on offer to those with the background that enables critical forms of analysis is maintaining the supply
- the software sector — also offers relatively high salaries to physics postgraduates, and increasing automation and software driven applications of physics is putting an increasing emphasis on software skills by industrial recruiters of postgraduate physicists
- the defence sector — where the increasing R&D content of weaponry is maintaining demand for physicists.

Two further areas were identified as having medium-term potential for industrial exploitation of academic research and a consequent growth in industrial employment. These were:

- biophysics, and
- nano-technology.

However, currently these areas were not creating an unmet employment demand.

## 6.2 Soft skills

Industrial employers put much greater emphasis on the ability to communicate at all levels, and on teamwork, than academics. These were also the skills that employers generally felt were most lacking in recent postgraduates. The larger industrial employers were more interested in whether the individual had the required competencies rather than whether they had a PhD or not. However, partly as they were relatively rare, Masters graduates were less in demand amongst academic and smaller industrial recruiters.

### 6.2.1 The nature and role of the PhD

In many ways, the nature of the PhD, with its requirement for an individual contribution to the body of science, requires the skills that the academics prize and devalues the skills that the industrial employers value. There is an increasing need for a debate as to the primary function of a PhD; and whether it is an advanced technical training or solely an apprenticeship for an academic career. The lessons learnt in engineering that led to the Eng Doc or engineering doctorate may be relevant. The Eng Doc is seen as an advanced technical training and a preparation for a high-level industrial engineering career rather than an academic career.

## 6.3 Recommendations

Deriving from the policy conclusions above are a series of recommendations.

### 6.3.1 A debate over the function of a physics PhD

The EPSRC should initiate a debate covering the function of physics doctoral training and how the academic community should respond to the requirements of the bulk of employers of physics PhDs. Here, the importance of a wider range of soft skills amongst industrial recruiters than appear to be currently provided by the universities, needs to be investigated.

### 6.3.2 Graduate schools

Further emphasis and support should be given to the Joint Research Council’s Graduate Schools. These schools, by providing multi-disciplinary training in communication and presentation skills, provide many of the skills considered important by the non-academic recruiters of PhDs.

### 6.3.3 Response to growth areas

Areas of growing demand for postgraduate physicists are largely driven by areas of product growth. These may be short-lived, or the technologies may rapidly become mature, leading to a decline in demand. However, there are currently clearly some discrete areas of intense demand. They are also areas that, while new ground is being broken, also have relatively mature technical areas. The combination of an immediate demand and the relative technical maturity suggests that there may be scope to expand the number of supported Masters courses in the areas of optronics and microwave radio technology.

# Bibliography

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# Annex 1: Organisations Interviewed by the Study

Alrad Instruments Ltd
ARM
BAe Systems
Bio-Rad Microscience Ltd
BNFL Magnox Generation
BOC Edwards
Bookham Technology
British Nuclear Fuels
Caburn-MDC Ltd
Corning R&D
Cryrogenic Ltd
Crystalox Ltd
DERA Sensors & Electronics
Dynex Semiconductors
EA Technology
GKN Technology Ltd
GSI Lumonics
Heriot-Watt University
Hewlett Packard Laboratories
Imperial College
KeyMed
Leica Microsystems Lithography Ltd
Loughborough Surface Analysis Ltd
Marconi Caswell
Merck NB-SC UK
Met Office
The National Grid Company plc
National Physical Laboratory
Oxford Magnet Technology Ltd
Oxley Development Company Ltd
Queen Mary University of London
Reuters Ltd
Rutherford Appleton Lab
Rolls-Royce plc
Schlumberger Cambridge Research
Schroeders Unit Trusts
Scientific Generics Ltd
Sentec
Staplethorne Ltd
Thales Optronics (UK)
University College London
University of Birmingham
University of Leeds
University of Sussex

*Plus another 12 who did not wish to be identified.*