TECHNICIANS UNDER THE MICROSCOPE:

A STUDY OF THE SKILLS AND TRAINING OF UNIVERSITY LABORATORY AND ENGINEERING WORKSHOP TECHNICIANS

P.A. LEWIS
DEPARTMENT OF POLITICAL ECONOMY
KING'S COLLEGE LONDON
AND
H. GOSPEL
DEPARTMENT OF MANAGEMENT
KING'S COLLEGE LONDON

GATSBY

GATSBY IS A FOUNDATION SET UP BY DAVID SAINSBURY TO REALISE HIS CHARITABLE OBJECTIVES. WE FOCUS OUR SUPPORT ON A LIMITED NUMBER OF AREAS:

PLANT SCIENCE RESEARCH

NEUROSCIENCE RESEARCH

SCIENCE AND ENGINEERING EDUCATION

ECONOMIC DEVELOPMENT IN AFRICA

PUBLIC POLICY RESEARCH AND ADVICE

THE ARTS

WE ARE PROACTIVE IN DEVISING PROJECTS TO ACHIEVE OUR AIMS. WE ARE ENTHUSIASTIC ABOUT SUPPORTING INNOVATION. WE ARE ANALYTICAL AS WE BELIEVE IT IS IMPORTANT TO UNDERSTAND THE OPPORTUNITIES AND PROBLEMS WE TACKLE. WE TAKE A LONG-TERM VIEW AS WE DO NOT THINK MUCH CAN BE ACHIEVED BY SHORT, ONE-OFF PROJECTS. WE ARE ALWAYS EAGER TO FORM PARTNERSHIPS WITH ORGANISATIONS WHO SHARE OUR GOALS.

The Gatsby Charitable Foundation
The Peak, 5 Wilton Road, London SW1V 1AP
T +44 (0)20 7410 0330 www.gatsby.org.uk

CONTENTS

	page
ACKNOWLEDGEMENTS	III
1. INTRODUCTION	1
2. RESEARCH METHODOLOGY AND DATA SOURCES	4
3. TECHNICIAN ROLES AND RESPONSIBILITIES	6
3.1 Definitions	6
3.2. The Size of the Technician Workforce	7
3.3. Types of Technicians and the Nature of Technical Support	9
3.3.1 General support technicians	10
3.3.2 Electronics and mechanical workshop technicians	10
3.3.3 Facilities technicians	11
3.3.4 Research laboratory technicians	12
3.3.5 Teaching technicians	12
3.3.6 Technical officers	13
3.4 The Organisation of Technical Support	14
4. WORKFORCE CHARACTERISTICS	18
4.1 Origins	18
4.2 Contract type	19
4.3 Labour turnover and length of service	19
4.4. Age profile	20
4.5 Qualifications	21
5. WORKFORCE PLANNING	26
5.1 Recruitment	26
5.2 Apprenticeships	28
6. WORKFORCE DEVELOPMENTS	32
6.1 Ongoing training	32
6.2 Appraisals and career progression	35
6.3 Technician registration	36
7. CONCLUSIONS	41
REFERENCES	43
APPENDICES	
Appendix 1: Summary of findings in the case of bioscience departments	45
Appendix 2: Summary of findings in the case of chemistry departments	46
Appendix 3: Summary of findings in the case of engineering departments	50
Appendix 4: Summary of findings in the case of physics departments	53

ACKNOWLEDGEMENTS

The research upon which this report is based was funded by the Gatsby Foundation. We thank the Foundation and, in particular, Daniel Sandford Smith, for their support. We are also extremely grateful to all of the interviewees, who generously gave up their time to speak to us and were unfailingly patient and helpful in answering our questions. Stephen Bach, Cathy Barlow, Peta Blevins, William Brown, Geoff Mason, Scott McIndoe, Andrew Shaw, Julie Tam, and Philip Toner provided very useful advice and assistance, for which we are also most grateful. Any errors are solely the responsibility of the authors.

1. INTRODUCTION

The UK's universities are amongst the country's most valuable and productive assets. They make a significant contribution to the growth of the British economy, most notably through the discovery and transfer of new scientific knowledge and through the education of students. Indeed, UK universities are internationally renowned for their research, lying second only to the USA in world rankings (Sainsbury of Turville 2007: 35-37, 43-45; DBIS 2009a: 5-9).

A vital, but neglected, part in such research is played by laboratory and engineering workshop technicians. Such technicians' duties include: the construction, maintenance and operation of the equipment involved in laboratory research; the preparation of the samples that constitute the raw material for experiments; the running of those experiments; and the recording, presentation and – on occasions – some of the analysis and interpretation of the data that is produced. In undertaking these tasks, technicians work closely with academic researchers and – as we shall see - make an indispensable contribution to the production of scientific knowledge. We will also see that, through formal and, in particular, informal contributions to the teaching of practicals skills, they help to educate students.

Notwithstanding the importance of technicians' contribution to research and teaching, studies of their skills and training are conspicuous by their absence both from the academic literature and from government documents. For, while there exist a handful of ethnographic studies of technicians, they focus mostly on questions of occupational identity, authority, and hierarchy, paying only limited attention to the issues of skills, training, and recruitment (Barley and Bechky 1994; Barley 1996; Barley and Orr [eds.] 1997; Toner *et al.* 2010). Similarly, recent policy documents outlining the government's science and innovation policy neglect the importance of skilled laboratory technicians (Sainsbury of Turville 2007: 95-116; DIUS 2009).[1] The omission is significant because recent reports from universities suggest that a shortage of technicians is hampering the work of UK-based researchers in university science and engineering departments (THES 2008, 2009; Unite 2008).

It is the lack of detailed research on the topic of technicians that this project seeks to remedy, by addressing three sets of key questions with new empirical data. First, what tasks do university technicians typically undertake and how are they organised? The issues that fall under this first broad question include: whether there are different kinds of technician, distinguished by the different duties that they are required to fulfil; how intimately technicians are involved in research and teaching (i.e. do they simply facilitate research and teaching that is carried out by other people, or do they make a more substantive contribution to those activities); and the way in which technicians are managed (in particular, whether the locus of managerial control lies primarily at the level of individual research groups or departments, or whether there have been efforts to pool technicians from a number of departments and manage them more centrally, for example at the level of the school).

The second set of issues concerns the type and level of skills that are *required* to carry out successfully the kind of tasks that technicians typically undertake, and the

1 For older attempts to remedy this omission, see The Royal Society (1998) and Evidence Ltd (2004).

type/level of skills and qualifications they *actually* possess. Three possibilities will be explored under this broad heading. First, as the term laboratory *technician* suggests, people occupying such roles may undertake tasks that require them to possess intermediate, and more specifically technician-level skills, pitched at around Levels 3-5 of the current National Qualifications Framework (NQF) and acquired through vocational training programmes such as apprenticeships. Second, it may be that – especially in relatively new fields of research – the type of tasks carried out by technicians now demand that such positions be filled by people whose skills lie at Level 6 or above in the NQF (i.e. by graduates, who have acquired their skills through academic rather than vocational training programmes). A third possibility is that, even when the difficulty of the tasks carried out by technicians requires them to possess skills pitched no higher than Level 5 in the NQF, they might nevertheless be more highly qualified (as for example would be the case if departments are hiring graduates to fill even relatively low-level technician positions) (cf. Mason 2001). One important objective of this project is to shed some light on these issues by ascertaining for each of the scientific disciplines under investigation the nature of the tasks they expect their technicians to undertake, and the type and level of skills technicians are both *expected* to possess and which they also typically possess in practice. Any discrepancies between the actual and ideal level of skills will be highlighted.

The third and final set of questions concerns how university science and engineering departments go about satisfying their need for suitably skilled technicians. Two main sources of skilled labour will be considered. First, departments might rely primarily on the external labour market, by recruiting workers who have acquired most if not all of the skills they need to be a university technician before taking up a position of that kind. For example, to consider two scenarios that the project will explore, engineering departments in universities situated in industrial areas may well find that their local external labour market offers a ready supply of experienced workers who already have the skills required to be a university workshop technician, while departments in the biological sciences whose research laboratory technicians need an undergraduate degree might rely on external labour markets for graduates that are national in scope. The second possible source of skilled labour involves universities meeting their need for skilled technicians via their own in-house training programmes. In particular, where universities require technicians to have craft or technician-level skills, they might make use of apprenticeship training schemes. These we define as training programmes for recent school-leavers that combine work-based learning, off-the-job training and technical education, are aimed at Levels 3–4 skills, are usually externally accredited, and are now often partially publicly funded (Ryan *et al.* 2007). Of course, these two sources of skills are not mutually exclusive, and universities may adopt a combination of recruitment and training in order to satisfy their need for skilled technicians. The project will investigate how departments strike a balance between recruitment and training and will highlight the key factors – such as the availability of suitably skilled workers on the external labour market – that shape their decisions.

The structure of the remainder of this report is as follows. Section 2 briefly considers the research methods and data sources used in the study. Section 3 examines in more detail the meaning of the term 'technician', before going on to consider the different types of technician that are found in university science and engineering departments, the size of the technician workforce, the kinds of tasks technicians normally undertake, and the way in which the provision of technical support is normally organised. Various key attributes of the technician workforce are explored in Section 4, most notably the 'origins' of the technicians (by which is meant whether they came to the university that currently employs them straight from school or from some other employer), their tenure, whether they have fixed-term or open-ended contracts of employment, and the age and qualifications profile of the technician workforce. Section 5 addresses the question of workforce planning, focusing in particular on how university departments rely on different sources of skilled labour in order to maintain the technical workforce they need to support research and teaching. Section 7 considers the provision of ongoing training for more established technicians, as distinct from apprentices and recent recruits, before going on to raise the broader issues of career progression for technicians and the possible impact of technician registration schemes. Section 8 summarises and draws conclusions. The main Sections just outlined focus on general issues and naturally abstract from some of the discipline-specific detail. More of the latter can be found in the Appendices, each of which provides a summary of the findings for one of the four disciplines considered in this study.

2. RESEARCH METHODOLOGY AND DATA SOURCES

In the absence of a large dataset covering the training and skills practices of university science and engineering departments, our chosen research strategy was to rely on case studies, which provide an opportunity to explore employers' assessments of their situation and prospects in contextualised detail.

As far as was possible, the case study organisations were chosen so as to represent different combinations of the factors that are likely to be important influences on employers' decisions about whether to rely primarily on recruitment or training, including: the duties that technicians are required to perform, and the skills they need to do so, in different fields of scientific endeavour and in different kinds of university; the nature of the relevant labour markets, as indicated both by whether they are primarily local or national in scope, and also by whether they are for workers with very general skills (and so might be expected to be populated by a large number of employers) or for highly specialised skills (of the kind that only a small handful of employers demand); and the scope for recruitment (reflecting the availability of workers with the requisite skills on the external labour market).

The goal was to select what were, as far as possible, closely matched case studies that were similar in most ways but which differed in particular attributes of interest (e.g. same discipline, same type of university, but different local labour market conditions), and to use comparisons between them to highlight key influences on the skills and training strategies adopted by universities in the case of their technicians. So, for example, cases were selected: to include both engineering and biological sciences (on the basis that the former might be more likely to recruit workers from local industry, while the latter might rely on national markets for graduates); to include both pre- and post-1992 universities (because of the potentially different duties and therefore skills required of technicians in those universities); and also to include different locations (and, therefore, potentially different local labour market conditions).

Interviews took place in two stages. The first stage involved 31 interviews with various 'sector-level' organisations that have an interest in science and engineering, higher education, and vocational education and training. These included: government departments (e.g. Department of Business, Innovation and Skills); sector skills councils (e.g. SEMTA, Life Long Learning UK); various learned societies (e.g. the Royal Society, the Royal Society of Chemistry, the Institute of Physics, the Royal Academy of Engineering, and the Society of Biology); the technicians' organisation, HEaTED; funding bodies (e.g. the Science and Technology Facilities Council); the National Apprenticeship Service; the Engineering Professors Council; the New Engineering Foundation; the UK Deans of Science; the Science Council; and Universities HR. Interviews conducted at this stage of the project were used both to obtain background information on the key issues that confront universities in their efforts to provide high quality technical support, and also to inform the choice of case study universities and departments.

The second round of interviews centered on the case studies themselves. Studies were carried out at 45 university departments, drawn from 4 disciplines, namely chemistry, engineering, physics and the biological sciences (the latter broadly understood to involve a range of sub-disciplines including biochemistry, pharmacology, plant sciences and zoology). The university cases were drawn from 18 different universities (14 pre-1992, four post-1992), situated in the following regions of England: the south; the midlands; the north; and north-west. The university cases were supplemented by studies of two large, non-university physics research laboratories. Information was collected through semi-structured interviews with academics, technicians and technical service managers at each of the case study organisations, using an interview schedule that was piloted in the early cases. A summary of the types of departments, and the number of interviews, can be found in Table 2.1.

Table 2.1: Number of different kinds of case study departments and interviews

	Number of pre-1992 cases	Number of post-1992 cases	Total number of interviews	Number of academics interviewed	Number of technicians / technical services managers interviewed[b]
Biological sciences	9	4	28	11	18
Chemistry	10	1	17	8	14
Engineering	8	4	26	14	20
Physics[a]	8	1	13	7	13

a: In addition, there are two interviews, involving one academic and five technicians/technical services managers at the two non-university physics research laboratories

b: 10 interviews were also carried out with human resource management and staff development personnel from five universities

A total of 96 interviews were carried out at the 47 case study organisations. A majority of the interviews took place face-to-face, at the case study department, with just seven interviews taking place by telephone. Interviews averaged around 90 minutes in length. As far as possible, interview notes were written up on the same day as the interview took place and responses were coded to assist in the discovery of patterns. Where coding revealed any gaps in the data that had been collected, these were filled by posing questions using telephone or e-mail follow-up.

The information collected from interviews was supplemented by some primary data, obtained from internal university reports and planning documents and also by secondary data, obtained from websites and documents deriving both from universities and from sector-level bodies (e.g. HEFCE). Background statistical data was obtained from the Higher Education Statistics Agency staff records and is used – in Section 3.2 in particular – to set the case studies in their broader context and also to provide a 'check' on the conclusions drawn from the cases.

3. TECHNICIAN ROLES AND RESPONSIBILITIES

3.1 DEFINITION

A technician is a person who is skilled in the use of particular techniques and procedures to solve practical problems, often in ways that require considerable ingenuity and creativity. Technicians typically work with complex instruments and equipment, and require specialised training, as well as considerable practical experience, in order to do their job effectively (Barley and Orr 1997: 12-15; OECD 2002: 92-94; Technician Council 2011).

In the case of university laboratory and engineering workshop technicians, the practical problems in question typically arise when research projects reach the stage at which empirical data are required in order to help build or test the theories and models that are being developed. At that point, it is typically the technician, rather than the academic scientist or engineer, who actually interacts *with* the material world (where the latter is defined broadly so that it encompasses both physical and biological phenomena). Rather than directly encountering the material world themselves, academic scientists and engineers tend to remain confined to a symbolic world of theories, models, numbers and hypotheses that *represent* the material world, leaving it to their technicians to preside over the interaction with material reality through which empirical evidence is gathered. As we shall discuss in more detail below, by preparing materials and samples, operating instruments, designing and building experimental apparatus and rigs, conducting experiments, and helping to collate and sometimes also to interpret results, technicians translate aspects of the material world into symbolic forms such as numbers, spectra, images, etc., thereby providing the raw data that scientists and engineers use to develop and test their theories, models, and designs. Viewed thus, technicians can be seen to work at the interface between the material world and the symbolic world inhabited by academic scientists and engineers, serving in effect as the bridge that connects the two. In doing so, technicians facilitate the work of the scientists and engineers whom they support (Barley and Bechky 1994: 88-92, 115-16; Whalley and Barley 1997: 47-50).

In universities, as we shall see in Section 3.3 below, the term 'technician' is used to refer to a variety of different roles, only some of which involve the provision of specialised support for research along the lines just described. Other technicians support teaching, a task that may also demand that they possess significant practical knowledge of the experimental techniques and instruments upon which students are being trained. A third set of technicians provide more general support for research and teaching by helping to sustain the infrastructure within which those activities take place. Before elaborating on these categories, however, we shall first of all consider the overall size of the technician workforce in the case study departments visited for this project.[2]

2 This study does not include the ICT technicians who provide personal or network computer support in universities.

3.2. THE SIZE OF THE TECHNICIAN WORKFORCE

A summary of the mean numbers of academic staff, postdoctoral researchers, various kinds of student, technicians and technical officers[3] found in departments from each of the 4 disciplines included in this study can be found in Table 3.1, along with an indication of the average ratio of academics to technical staff for each discipline.

Table 3.1: Summary of the attributes of the departments visited for this study, by discipline

Mean number of: Discipline	Academics	Postdocs	Undergraduates	PhD	Technicians	Technical Officers	Average ratio of academics to technicians[a]
Biological sciences (13 departments)	52	67	552	92	37	3	1.3 (pre-1992)[b] 1.9 (post 1992)
Chemistry (11 departments)	42	60	470	145	20	5	1.8 (pre-1992) 1.4 (post-1992)
Engineering (12 departments)	133	121	1340	367	53	4	2.7 (pre-1992) 2.0 (post-1992)
Physics (9 departments)	57	87	364	150	32	2	2.8 (pre-1992) 14 (post-1992)

a: In calculating the average ratios of technicians to academics across the departments in the sample, (i) 'technicians' includes 'technical officers' and (ii) departments are weighted according to the number of academics they contain. The unweighted averages are as follows: bioscience - 1.5; chemistry – 1.8; engineering – 2.3; and physics – 3.3.

b: Given that technicians in post-1992 universities tend to concentrate almost exclusively upon teaching support rather than research support, ratios for pre- and post-1992 universities are presented separately.

Almost all of the departments from all four disciplines visited said that cuts in funding had led to significant reductions in the number of technical staff over the past 10-15 years, either in absolute terms or relative to the number of academics and students for whom support is required.

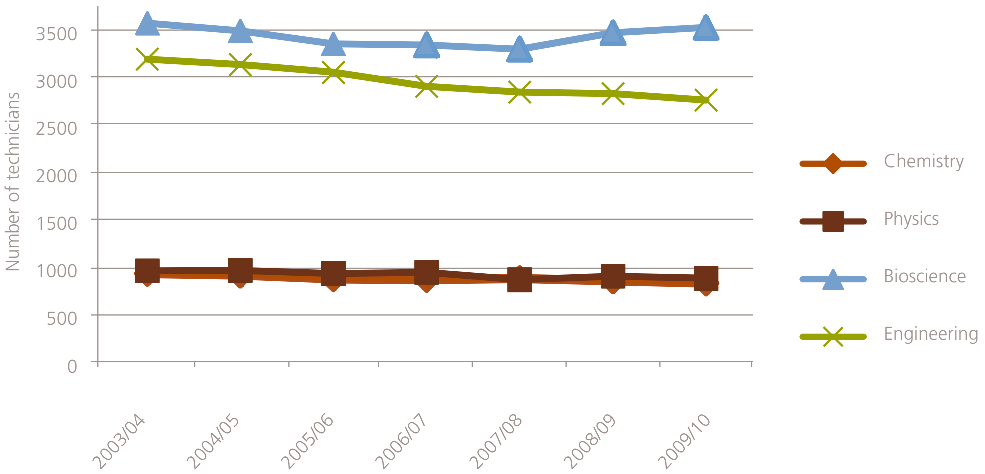
Support for such claims is provided by Figures 3.1 and 3.2, which present HESA time series data on the absolute numbers of technical staff, and on ratio of academic staff to technical staff, in each of the four disciplines considered in this study for all UK universities between 2003/04 and 2009/10. While the data provided by HESA are not strictly comparable with those collected from the case studies, because the HESA data include ICT, building support and medical technicians as well as the laboratory and workshop technicians upon which the case studies reported here concentrate, they do corroborate the picture painted by interviews of falling technician numbers, both in absolute terms and relative to the numbers of academics for whom support is required.

As Figure 3.1 shows, the absolute number of technicians employed in UK universities has declined in all four disciplines over the period 2003/04 to 2009/10. The decline has been most pronounced in engineering, where the number of technical staff fell from just under 3200 in 2003/04 to around 2750 in 2009/10, a reduction of around 14%. The number of technical staff in chemistry departments declined by around 11% over the same period, falling from around 930 in 2003/04 to about 830 in 2009/10. Physics displays a similar pattern to chemistry, with the number of technical staff falling by around 8% over the period in question, from

3 The role of 'technical officer' is discussed in Section 3.3.6 below.

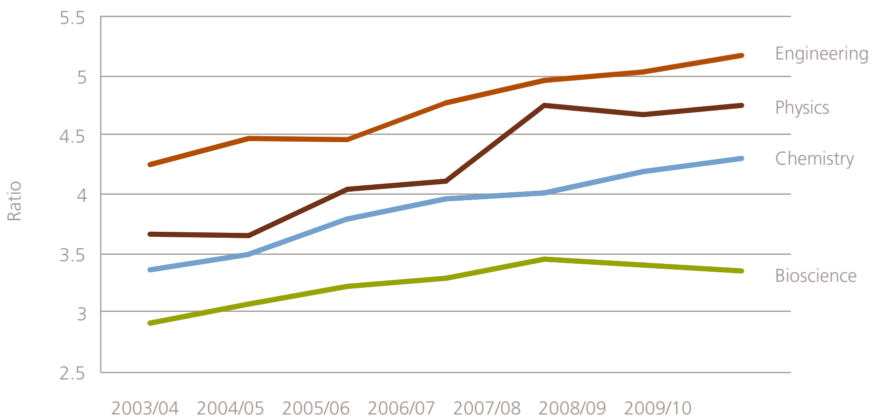
about 960 in 2003/04 to around 880 in 2009/10. The smallest decline came in biosciences, where technician numbers fell between 2003/04 and 2007/08 but recovered thereafter, so that they declined by just 1% over the period as a whole (from 3560 in 2003/04 to around 3520 in 2009/10). The data presented in Figure 3.2 reveal that the unweighted ratio of academics to technicians increased in all four disciplines between 2003/04 and 2009/10, from around 2.9 to 3.4 in the case of biosciences, from about 3.6 to 4.4 in the case of chemistry, from roughly 4.3 to 5.2 in the case of engineering, and from approximately 3.7 to 4.8 in the case of physics.

Figure 3.1: Total number of technicians in bioscience, chemistry, engineering, and physics in UK higher education, 2003/04-2009/10[a]



a: Source: HESA Staff Record 2003/04-2009/10. The figures refer to the full time equivalent number of laboratory, engineering workshop, building, ICT and medical (including nursing) (SOC Code 3A) technicians in each of the following cost centres: bioscience (cost centre 10); chemistry (cost centre 11); physics (cost centre 12); and engineering (including general engineering [cost centre 16], chemical engineering [cost centre 17], mineral, metallurgy and materials engineering [cost centre 18], civil engineering [cost centre 19], electrical, electronics and computer engineering [cost centre 20], and mechanical, aero and production engineering [cost centre 21]). Comparable data are unavailable before 2003/04.

Figure 3.2: Number of academics per technician in bioscience, chemistry, engineering and physics in UK higher education 2003/04-2009/10[a]



a: Source: HESA Staff Record 2003/04-2009/10. The data are the unweighted average of the total full time equivalent number of academic professional staff (SOC Code 2A) in each of the disciplines to the total full time equivalent number of laboratory, engineering workshop, building, ICT and medical (including nursing) (SOC Code 3A) technicians that discipline. The ratios were calculated from HESA data for the following cost centres: bioscience (cost centre 10); chemistry (cost centre 11); physics (cost centre 12); and engineering (including general engineering [cost centre 16], chemical engineering [cost centre 17], mineral, metallurgy and materials engineering [cost centre 18], civil engineering [cost centre 19], electrical, electronics and computer engineering [cost centre 20], and mechanical, aero and production engineering [cost centre 21]). Comparable data are unavailable before 2003/04.

Interviews suggested that the deterioration in the ratio of academic staff to technicians reported by interviewees, and corroborated by the HESA data, has led to some difficulties with providing adequate support for teaching and research. In particular, around one quarter of the departments visited for this study stated that, because their technical staff are now working at full capacity, they struggle to cover when staff are absent either for training or due to illness.[4] One interviewee elaborated on the nature of the problem as follows:

> *We're skating on thin ice – if people are away ill, or on a conference, or on training ... it's a nightmare ... If the academic department is an engine, then technicians are the engine oil that keeps the department running smoothly. Low technician numbers now mean that the department is in danger of seizing up.*

Despite this, most interviewees stated that the decline in the size of the technical staff had not had a significant impact either on their ability to conduct research, or on the amount of practical work undertaken by their students. There were, however, two notable exceptions to this broad finding. First, representatives of four biological sciences departments said that the volume of practical work undertaken by students *had* suffered somewhat because of limited technical support, with students carrying out fewer practicals than before. Second, academics in five of the post-1992 universities also reported concern about the level of *research* support they received. This reflects the fact that while technical support in post-1992 universities has until recently been devoted mostly to teaching, they now require additional technical support in order to meet the increasingly demanding targets they are being set for research and external consultancy, as well as to support the increasing amount of support required for their burgeoning undergraduate and – in particular – MSc programmes.

3.3. TYPES OF TECHNICIAN AND THE NATURE OF TECHNICAL SUPPORT

A number of different types of technician may be distinguished. It should be noted at the outset that the descriptions outlined below are meant to portray 'ideal types' that indicate the broad features of different kinds of technician rather than provide an exhaustive account of all the nuances and variations that arise in the case of real technicians' jobs. As a result, there will inevitably be cases where particular technicians do not fall neatly into one of the categories just outlined. To take just three examples: in some cases, teaching support is provided, not by dedicated teaching technicians, but by technicians who occupy 'mixed' or 'hybrid' roles that involve them supporting both teaching and research; second, it may be unclear whether technicians who specialise in the use of instruments that are used by a relatively small number of groups should count as research laboratory or analytical services technicians; and, especially in smaller departments, some of the duties that elsewhere might be undertaken by specialist infrastructure technicians may be carried out by research laboratory technicians. Notwithstanding these limitations, it is hoped that the broad categories listed here provide a reasonably accurate approximation to the kinds of technicians found in universities. It is also worth noting at this juncture that the different types of technician distinguished below are not all present in every university, let alone every department. In particular, most of the technicians who work in post-1992 universities tend to support teaching, with only a relatively small fraction of

4 The paucity of spare technical capacity may have consequences for the kind of technician training that departments provide, for reasons that will be discussed in Sections 5.2 and 6.1 below.

their time being allocated to research support, so that the majority of technician posts in those universities will tend to occupy roles that most closely resemble the teaching support positions described below.[5]

3.3.1 General support technicians

General support technicians – also variously referred to as 'infrastructure', 'stores' or 'floor' technicians – provide general support for teaching and research by carrying out basic duties such as warehousing, waste disposal, washing glassware, sterilising instruments, dealing with gas and liquid nitrogen cylinders, and preparing basic solutions and chemicals. By doing so, such technicians help to provide the conditions in which teaching and research take place. Given the generic nature of the tasks they carry out, such technicians tend to be found in departments from all four of the disciplines considered here, though in post-1992 departments such roles may be combined with teaching support.

3.3.2 Electronics and mechanical workshop technicians

These technicians tend to be involved in the repair, maintenance, modification, design, construction, testing and operation of the instruments and experimental apparatus used in research and teaching. Perhaps unsurprisingly, workshop technicians tend to be more numerous, as a percentage of the total technician workforce, in engineering and physics departments than in chemistry and – in particular – biological science departments.[6]

When they are working with researchers in particular, such technicians usually do not work from detailed technical drawings of the kind of instrument or apparatus required to bring the experimental part of the projects they are supporting to a successful conclusion. On the contrary, academics often provide technicians with no more than a rough sketch of the kind of instrument or apparatus required to solve the technical problems that arise in the course of their research. It is then up to the technicians to draw on their knowledge and practical expertise of electronics and mechanical engineering – their knowledge of the properties of different kinds of material and their understanding of what particular tools can be used – along with their general problem-solving skills in order to design and build the requisite instrument, electronic component, or experimental rig. As one interviewee from a physics department put it, when it comes to the practical task of building and operating scientific equipment, 'technicians are a repository of deep, long-standing knowledge of what works and what doesn't work'.[7] One technical services manager described the contribution made by workshop technicians as follows:

> *Academics don't know precisely what [experimental rig or piece of apparatus] they want and the design changes as they talk about it with the technicians ... Academics have the conceptual ideas and technicians translate them into practical solutions, perhaps even modifying the original idea a bit within the broad constraints of the research project.*

As this quotation suggests, the process through which the final design of the experimental apparatus or instrument emerges is perhaps best described as a

5 Detailed accounts of the kind of technicians found in departments from different disciplines can be found in the sector summaries provided in the Appendices to this report.

6 As we shall see, many biological science departments in particular no longer have their own mechanical and electronics workshops.

7 In keeping with the definition of a 'technician' given in the Introduction, which mentioned ingenuity and creativity as common attributes possessed by technicians, this reference to 'problem-solving skills' indicates that in the case of university technicians the notion of 'skill' is often thought to involve an ability to improvise – by modifying existing instruments and apparatus, as well as by developing new pieces of equipment – in order to meet the novel challenges that arise in the course of research projects (cf. Scarselletta 1997: 187, 207; Evidence Ltd 2004: 17).

dialogue or iterative process in which academics and technicians work as a team in order to develop the instrument or experimental apparatus required to give practical effect to researchers' ideas. Through such informal interaction with academics, workshop technicians – like the analytical services technicians mentioned earlier – make an invaluable, if all-too-often unheralded, contribution to scientific research.[8]

To put this point slightly differently, far from it being the case that the academics' knowledge subsumes that of the technicians, with academics having all the knowledge possessed by the technicians and more besides, there is a genuine *division* of labour and knowledge between the two groups, with the skills and knowledge possessed by each group complementing that of the other: the technicians have more of the hands-on, technical knowledge required to bring the project to a successful conclusion; while the academics possess more of the relevant abstract, theoretical scientific knowledge (with neither party being entirely ignorant of the other's speciality); and the knowledge of the two groups is pooled in order to bring the research project at hand to a successful conclusion. Because the knowledge of both groups is required to accomplish that goal, the technicians and academics tended to think of themselves as engaging in what one academic described as 'professional collaboration', on reasonably equal terms, in order to get the job done. In other words, the dialogue or interaction through which the final design emerges requires genuine teamwork that sees both parties bring their own knowledge and expertise to bear on the project, thereby making their own distinctive contribution to bringing it to fruition (cf. Barley and Bechky 1994: 91, 116-120; Barley and Orr 1997: 44-45, 51-52).[9]

3.3.3 Facilities technicians

Facilities technicians primarily support research. However, rather than being associated with one specific research group, facilities technicians tend to provide services that are drawn on by a number of different groups. Two different categories of facilities technician may be distinguished.

First, analytical services technicians specialise in the use of scientific instruments or experimental techniques that generate the data used by researchers. Examples include NMR spectroscopy, mass spectrometry, electron microscopy, and X-ray crystallography. Over the years, such technicians have often developed considerable practical expertise in the use of such instruments and techniques, on the basis of which they are able to provide scientists with important advice about how to prepare their samples for analysis, about how to 'optimise' the instruments so that they are appropriately set up for the piece of analysis being undertaken, and also about how to interpret the data that are generated (cf. Barley and Bechky 1994: 89). One technical services manager described the contribution of her analytical services technicians as follows:

> *'They will know the instrument inside and out, they will know its foibles, how to push it to its maximum performance ... That comes through experience, not formal training.'*

This quote indicates that, as in the case of the workshop technicians, the division of labour between the analytical services technicians and the academics they support is based on a corresponding division of knowledge, with the technicians possessing

8 For similar findings in an Australian context, see Toner *at al.* (2010).

9 Interviewees from around half of the departments visited indicated that there are occasions when – if technicians have made a substantial contribution to a research project – they may be included on the list authors of research papers. This practice seemed to be especially prevalent in the following cases: analytical facilities and research laboratory technicians in the biological sciences and chemistry; workshop technicians in physics when papers focused on the properties of novel instruments to whose design and construction the technicians had contributed; and technical and experimental officers in general.

more of the tacit, context-dependent, practical know-how required to use the instruments to get the results the academics need. In this way, as one interviewee put it, the analytical services technicians 'give the academics real insight into how the kit should be used to get the results they want'.

A second kind of facilities technician specialises in providing what might be best described as the raw materials used by researchers in their experiments, including technicians who work in clean rooms, greenhouses and animal houses. One or both types of facilities technician are found in departments drawn from all four of the disciplines considered in this study.

3.3.4 Research laboratory technicians

As their name suggests, these technicians support the research that takes place in the research groups to which they have been allocated. Typical duties include preparing the equipment and materials used in experiments, carrying out the relevant experimental procedures, and compiling and – especially in the case of more senior research technicians – analysing the data yielded by those experiments. In this way, as noted earlier, research laboratory technicians constitute the bridge between the material world and the scientists and engineers who are investigating it, drawing on their specialist contextual knowledge of how to apply the relevant experimental techniques to the samples on which they work to furnish scientists with the data they require to carry out their research.

In addition, research laboratory technicians often take responsibility for health and safety issues, for inducting new PhD and postdoctoral students into their laboratory and teaching them how to use instruments and carry out experimental procedures, and for various administrative duties such as budgeting, ordering supplies, keeping accounts, and organising rotas of tasks to be carried out by research group members. Although technicians of this kind are found in all four of the disciplines considered in this study, they tend to be especially numerous in chemistry and the biological sciences.

3.3.5 Teaching technicians

In every department, across all four of the disciplines covered in this project, technicians support teaching by preparing the materials, experimental apparatus and instruments required for student practical classes. In addition, they usually remain in the laboratories while practical classes are under way both in order to deal with any technical problems that might arise and also to help ensure that there are no breaches of health and safety regulations. There is, however, considerable variation when it comes to the issue of whether technicians merely *support* teaching in the ways just described or whether they also actually *teach* the students by demonstrating how to carry out experimental procedures and use scientific instruments and by supervising student projects. This variation arises both between departments in different universities and disciplines, and also between what technicians' formal job descriptions say they do and what they do in practice.

In most of the pre-1992 physics, chemistry and biological science departments visited for this study, technicians' formal duties are confined to providing support for teaching, with the teaching itself being carried out by academics and PhD student demonstrators. By way of contrast, in most of the engineering departments considered here, whether they are located in pre-1992 or post-1992 universities, at least some of the technicians are formally involved in teaching students, either through demonstrating how to use various pieces of equipment or by assisting with projects. The same is true of the departments of chemistry, physics, and biological science that are situated in post-1992 universities, where the majority of technician time is devoted to supporting teaching rather than research and where technicians' formal duties extend beyond simply facilitating practical classes to carrying out some of that practical teaching themselves. Even in those pre-1992 departments where technicians are not formally involved in teaching, they often do so unofficially, either by providing informal assistance to students in laboratory classes (in the case of teaching technicians) or by helping students who are working on projects to learn how to use scientific instruments and carry out experimental procedures (in the case of research and analytical facilities technicians).

The findings reported here provide only limited support for the claim, aired in a recent report commissioned by HEFCE, that 'the technician role is increasingly growing to include the demonstration of concepts and theory, and is ultimately moving towards an active teaching role, away from "pure technicians" roles' (PA Consulting 2010: 29). While, as we have seen, technicians certainly are involved, both formally and informally, in teaching, in the vast majority of cases their role tends to be confined to the demonstration of various practical skills rather than involving – as the passage just quoted seems to suggest – the teaching of 'concepts and theory.' This ought not to be surprising, because (as will be discussed in Section 4.5 below) many of the technicians who are involved in teaching – and, indeed, a majority of those occupying specialist teaching technician positions in pre-1992 universities – have only vocational qualifications and are therefore unlikely to possess the knowledge of scientific principles required to teach students about the theoretical concepts that underpin their practical work. Moreover, even in those (mostly post-1992) universities where technicians are intimately involved in teaching and may – because they often possess undergraduate degrees – have sufficient theoretical knowledge to be able to discuss the conceptual foundations of the practical work being undertaken by students, such teaching is not the only claim on their time. On the contrary, the evidence gathered for this project suggests that the technical resources available to post-1992 departments of science and engineering are being stretched increasingly thinly, both because of rising staff-student ratios and also because technical staff are increasingly being required to support research and consultancy as well as teaching. In that context, it is not immediately obvious that there is scope for technicians to take on a larger role in teaching.

3.3.6 Technical officers

Technical officers – also known as 'scientific officers' or 'experimental officers' – occupy intermediate positions in university departments, lying above technicians in the academic hierarchy but below academics. Perhaps the most obvious manifestation of this is the fact that, prior to the move to a common pay spine for all university staff in 2005, technical officer posts were to be found on 'academic-related' pay scales, whereas technician posts were situated on the pay scales for 'non-academic' staff. The intermediate position of technical officers is also reflected in their skills and duties, which resemble those of technicians in some ways whilst being more like those carried out by academics in others. Technical officers tend to specialise in the use of particular instruments and experimental techniques, such as NMR spectroscopy, X-ray crystallography, electron microscopes and mass spectrometry, and they resemble technicians in providing a service to researchers, drawing on their expertise in the use of those techniques and instruments to provide academics with advice on how to conduct their experiments. In doing so, technical officers – like analytical facilities technicians – have an important input into research projects. However, in other respects technical officers are more like academics than technicians: like academics, they are often involved both in the design and management of research projects and also in the analysis and interpretation of the data that emerge from them; and, in virtue of both the important contribution they make to both practical and analytical sides of research projects, technical officers are also like academics in often being listed amongst the authors of scientific papers.

The intermediate position occupied by technical officers also manifests itself both in the attributes of the people who occupy such roles, and also in the variety of routes that the incumbents of such positions have followed in order to reach them. The ability to offer high quality research support of the kind that technical officers are expected to provide usually requires a mixture of technical and academic skills: it presupposes considerable expertise in the use of the relevant instruments and techniques, often honed over many years of experience, and in that respect demands the kind of practical know-how possessed by technicians; but it also demands a sound knowledge of the relevant physical, chemical or biological principles, of a kind usually acquired through an academic rather than a vocational qualification. Hence, technical officers tend to possess at least an undergraduate degree, whilst many have an MSc or PhD. It is important to note that older technical officers in particular may have been promoted up through the technician ranks in recognition of their technical skills, acquiring an undergraduate degree *en route* via day release and any advanced degrees they possess in virtue of the work they have done as a technical officer. More recently, however, technical officers have tended to follow an academic rather than a vocational path, assuming their position after completing undergraduate and postgraduate degrees.

Technical officers are found only in pre-1992 universities. They appear to be more common in chemistry and engineering than in biological sciences and physics. All 10 pre-1992 departments of chemistry visited for this study, along with all eight pre-1992 departments of engineering, have at least one technical officer. In contrast, technical officers are to be found in only four of the eight pre-1992 departments of physics and in three of the nine pre-1992 departments of biological science. Whilst some departments are phasing out technical officer positions, allowing the term – and its equivalents – to be used for people who currently bear it but not making new appointments to such positions, other departments are continuing to appoint technical officers.

3.4 THE ORGANISATION OF TECHNICAL SUPPORT

In most of the pre-1992 universities considered here, technical support tends to be organised at the departmental level. The vast majority of the departments of biological science, chemistry, engineering and physics in the pre-1992 universities visited have their own research, facilities, teaching and general support technicians, who are managed within the relevant department.[10] More specifically, teaching and general support technicians are typically pooled and controlled at the department level, as they support the work of the department as a whole. Those technicians who are allocated to particular facilities or pieces of equipment that are used by a number of research groups – such as NMR, mass spectrometry, clean rooms, animal

10 The one exception to this finding is a small department situated within a larger faculty of biological science. While the department has a few of its own general support and research laboratory technicians, the technicians who provide analytical services such as DNA sequencing, proteomics, and electron microscopy, as well as the mechanical and electronics workshop technicians, have been pooled in central, faculty-level facilities.

houses and horticultural facilities – also tend to be managed at the departmental level. On the other hand, day-to-day control of technicians who provide more specialised forms of technical support may be devolved to the relevant research groups, especially if those technicians are funded via external grants. However, the days when HECFE-funded technicians would be allocated to provide direct research support for specific academics appear to be long gone, with research laboratory technicians who are HEFCE-funded usually being allocated to one or more groups rather than to individual academics.

Matters are a little more complicated when it comes to the electronics and mechanical workshop technicians. All but one of the pre-1992 departments of physics considered here has retained their own mechanical and electronics workshops, albeit with rather fewer technicians than in the past. The same is true of all the pre-1992 departments of engineering visited, save for those situated within large, multi-department faculties of engineering, where some of the individual departmental workshops have been amalgamated. Centralisation of workshops has been rather more extensive in the case of chemistry, where three of the ten pre-1992 departments visited now share a workshop with neighbouring departments of physics or biological science. The largest changes appear to have come in the biological sciences: four of the nine departments visited no longer have their own workshops, relying instead either on the services provided by other departments or on outsourcing; while two of the other five departments have been reduced in size to the point where they have just one workshop technician. The moves towards centralising workshop facilities, and reducing the number of technicians employed in those that remain, have been driven by a variety of factors, most notably: a desire on the part of universities to avoid duplication and exploit the benefits of economies of scale; the need to reduce salary and space costs; and changes in technology which in at least some instances have made it easier and more economical to outsource work than do it in house.[11]

The topic of the centralisation of workshops elicited much comment from interviewees, many of whom emphasised that, as well as facilitating cost savings and the exploitation of scale economies, it may also give rise to significant problems. In particular, interviewees argued that the importance of the informal interaction between academics and technicians who have a common language and share an understanding of the nature of the technical problems that arise within their discipline militates against attempts to centralise workshops. The reason, interviewees argued, is to be found in issues of expertise and control. Consider first the issue of expertise. The point here is that technicians who specialise in providing support for a particular discipline are more able to develop the relevant expertise – the specialised knowledge and practical skills required to solve the kind of technical problems that arise in that discipline – than those who service other disciplines. So centralisation may be problematic if it leads to a dilution of the pool of technical expertise available to departments. Of course, it is not inevitable that such expertise will be lost if workshops are centralised, so long as those central workshops still contain technicians who are dedicated to supporting the relevant discipline.

This, though, raises a further set of issues, namely those concerning the control of the technicians in shared workshops. Many interviewees argued that, if a department has a dedicated mechanical workshop, then its academics are likely to enjoy more scope to re-prioritise and re-specify jobs, as the iterative

11 Also see Evidence Ltd (2004: 11).

nature of much research support demands, than if they have to rely on a shared workshop. Even if, say, a physics department has a dedicated 'physics' technician working within a shared workshop, the question arises of what will happen if that technician is working on a task from some other department when a new job from physics arises. Who will have the final word in how that technician's time will be allocated? And, if the physics job is not prioritised, will it be allocated to some other technician who might not understand the physicists' requirements so well, or will there be a delay until the 'physics' technician is free? Moreover, who will be held accountable for such decisions? The danger, which some interviewees argue is amply illustrated by their experience of the centralisation of other support functions, is that the centralisation of technical support will lead to a blurring of the lines of accountability and, consequently, a decrease in the quality of technical support. The kind of difficulties that can arise were vividly described by one interviewee who had experience of a shared workshop:

> *People don't like the shared workshop ... It gives rise to blurred lines of reporting and accountability, with technicians not knowing who they report to or where they fit in, and also causes communication problems ... Nobody 'owns' them [the technicians], talks to them, knows where their priorities lie in terms of workload ... [and] the person who shouts loudest gets to use them.*

The point is that if shared workshops are to work well, then it is imperative that they are managed so as to ensure that tasks are allocated, and jobs prioritised, in a way that sustains high quality, responsive technical support for all of the relevant departments (an imperative that is likely to become even more important as competition for research grants and consultancy income increases in the future). What is required, therefore, are clear lines of responsibility that make it obvious who establishes the order in which jobs are carried out and who is accountable for ensuring the delivery of high quality support to the appropriate deadlines. Given that it is likely to be harder to achieve the requisite managerial structure within a large, shared facility than within a single department, there is likely to be a trade-off between exploiting the undoubted benefits of centralisation (e.g., ensuring that technicians are fully utilised and exploiting the benefits of economies of scale), on the one hand, and giving departments access to high quality support that is tailored and responsive to their needs, on the other. It is beyond the scope of this study to identify precisely how the balance between these competing concerns ought to be struck. However, given that – according to at least some interviewees – workshop technicians' contribution to research in particular is not always well understood or appreciated by senior management, it is important to highlight the existence of these issues.[12]

Unsurprisingly, given the financial circumstances currently confronting universities, a number of departments and faculties visited are either in the midst of, or are about to embark upon, reviews of technical services. Typically, the aim of the reviews is to identify situations where technical resources are under-utilised or where there are unexploited economies of scale. Such opportunities may be found within departments, where exploiting them might for example involve taking technicians out of one research group and pooling them at the departmental level. They might also arise within larger, multi-department faculties. For example, one university is considering whether the duties of the general support technicians employed in its science and engineering departments

12 For a similar point, see Toner *et al.* (2010: 32-33).

are sufficiently similar for that aspect of technical support to be taken out of departments and provided them by a central, faculty-level pool of technicians.

Centralised approaches to the provision of technical support are more common amongst the post-1992 universities visited for this study. Each of the 10 post-1992 departments visited for this study is embedded within a larger, multi-departmental faculty. In every case, technicians were pooled and managed at the faculty level, being available to provide technical support for a number of departments within that faculty. The aim of such an approach is of course to exploit the benefits of economies of scale and to make it easier for technical services managers to reallocate technicians to where they are most needed, thereby – it is hoped – facilitating a more flexible, responsive, and efficient use of scarce technical resources. The creation of such common pools of technicians is, of course, facilitated by the fact that there is a smaller diversity of technician roles in post-1992 departments than in their pre-1992 counterparts, the reason being that most of the technicians in post-1992 departments currently spend the majority of their time supporting teaching rather than more specialised research activities. However, differences in the kind of technical support required by different disciplines remain and, as a result, the common pool of technicians is often divided into teams that support particular disciplines within the faculty. Because those disciplines are usually associated with particular departments, there often remain relatively strong links between particular groups of technicians and specific departments. As things currently stand, therefore, the management of technical services in post-1992 universities is not as centralised as it might first appear, with departments in practice often retaining a significant measure of day-to-day control over 'their' technicians.

4. WORKFORCE CHARACTERISTICS

In this section of the report we consider various attributes of the technician workforce, most notably: their origins, in the sense of where they were before they became technicians in higher education; whether they are on open-ended ('permanent') or fixed-term contracts; the length of time they have worked in their department; their age; and their qualifications.

4.1 ORIGINS

There is considerable uncertainty about the route through which the current members of the technician workforce came into the sector (that is, about the 'origins' of those technicians) (see, for example, PA Consulting 2010: 50). While it proved to be difficult to gain accurate data on this issue, most departments were able to offer rough estimates of the proportions of their current technician workforce who came to the department straight from school and were developed in-house via some kind of traineeship/apprenticeship scheme and the proportion who were recruited from the external labour market.[13]

A majority of the technical workforce in all four disciplines have been recruited from industry rather than trained in-house. All 12 of the engineering departments visited for this study estimated that at least 70% of their technicians were recruited from the external labour market, mostly from industry, with six of those departments putting that figure at over 90%. In a similar vein, seven of the nine physics departments visited for this study indicated that over 60% of their current technicians had been recruited, again mostly from industry. The picture is similar in bioscience and chemistry. All 10 of the bioscience departments that returned usable data indicated that at least 70% of their current technicians had been recruited externally, while a majority of the chemistry departments suggested that at least 60% of their technicians had been hired after having received their initial training elsewhere rather than come to the department straight from school. The sources from which such external recruits were drawn were slightly more varied in bioscience and chemistry than in the case of physics and engineering: while industry was a prominent source of recruits for bioscience and chemistry departments, they also drew – to a greater extent than their counterparts in physics and engineering – on technicians who had previously worked in other university departments (accounting for 20-30% of the current workforce in some departments); while six out of the 10 bioscience departments who were able to provide data estimated that 20-30% of the current workforce were recent graduates, having been recruited soon after completing an undergraduate degree.[14]

Those members of the technician workforce in all four disciplines who were not recruited externally tend to be more mature workers who were trained via old university apprenticeship training schemes. The latter typically involved on–the-job training in the university, with trainees being rotated through a number of laboratories or workshops, combined with off-the-job training via day release at a

13 People were classified by being recruited from the external labour market if they received their basic grounding in the skills required for their role as a technician somewhere other than in the department for which they currently work. Thus, for example, workshop technicians are counted as external recruits if they obtained their basic training in electronics and/or mechanical engineering via an apprenticeship taken in industry or in another university rather than in their current department.

14 A notable exception to this general reliance on recruitment is to be found in one of the non-university physics research laboratories, which has long run its own high-quality apprenticeship scheme. As a result, it estimates that around half of its current (comparatively large) technician workforce was trained in-house.

local college (leading to vocational qualifications such as an HNC or City and Guilds). However, by the 1990s most of these traineeship schemes had been closed down (also see Royal Society 1998: 6 and Evidence Ltd 2004: 14). The reductions in the technician workforce that were taking place in many departments in the 1980s and 1990s militated against taking on trainees, as also did the propensity for apprentices to leave the university in search of higher pay once they had completed their training. However, as we shall see in Section 5.2 below, recent years have seen a revival of interest in apprenticeship training schemes in two of the four disciplines, namely physics and engineering, as concerns about an ageing workforce, coupled with the limited availability of suitably qualified recruits on the external labour market, have prompted some departments to take on apprentices once again.

4.2 CONTRACT TYPE

The vast majority of the technicians in the departments visited here are on open-ended ('permanent') rather than fixed term contracts. The precise proportion varies from a low of around 80% in bioscience departments to a high of about 90% in the physics departments visited for this study. It is important to note that the positions occupied by some of the technicians who are on open-ended contracts are financed at least in part via income obtained through external research grants. This is an approach that many universities are encouraging departments to adopt as they attempt to reduce their reliance on diminishing HEFCE funding.

4.3 LABOUR TURNOVER AND LENGTH OF SERVICE

Labour turnover is universally reported as being very low, with many departments reporting turnover rates of less than 5% and almost all rates under 10% per annum.[15] Tenures of over 20 years are common amongst technical staff. In the words of one technical services manager, once technicians have arrived in a department 'hardly any leave until retirement.'[16]

Interviews indicated that low labour turnover and the presence of long-serving members of technical staff was a mixed blessing. The benefits are clear: over their many years of service, such staff often have very substantial reserves of expertise and practical know-how, and are therefore able to make vital contributions to overcoming the technical challenges that arise in the course of scientific research. One interviewee expressed this point by saying that technicians 'provide much of the "institutional memory" in departments, by saying [when faced with a particular technical problem], "Don't try that, it didn't work, try this"'. Given especially that much of this knowledge is *tacit* – it is practical knowledge about *how* to do things, which it may be very hard to articulate explicitly in the way required for it to be rapidly transferred to new recruits – the presence of experienced technicians is extremely valuable resource to departments (Royal Society 1998: 9-10; Evidence Ltd 2004: 52). However, representatives from a number of departments of biological science and engineering in particular indicated that the presence of a large cohort of older technicians may have drawbacks. In particular, if the skills possessed by those staff are no longer so relevant to the discipline they are meant to be supporting, having been marginalised by changes either in the kind of science that is being done or in the technology that is being used, then low turnover and long tenure may be problematic, because it can lead to the

15 A recent survey found that the turnover rate for technical staff, including IT staff, in UK universities was 7% (HECFE 2010: 80).

16 A 2009 survey of technicians found that around 50% had worked for their current institution for over 10 years, with around 25% having done so for over 20 years (HEaTED 2009: 4, 8).

technicians in question being less and less useful to the department, especially if they are either unwilling or unable to retrain.

This issue was mentioned by the representatives of some engineering departments, who lamented the fact that older technicians in particular do not have enough mechatronic skills (that is, with the ability to integrate mechanical and electronic components so as to be able to measure and control the performance of the systems in which they are embedded). But the problem appears to be most acute in the case of the biological sciences, where some interviewees argued that the rapid pace of change in the techniques used in biological research over the past 20 years has left a number of technicians with skills that are peripheral to their departments' needs (cf. Barley and Bechky 1994: 120-21). The challenge involved in finding something useful for such technicians to do, and the additional burden that their presence places on technical services that are working at or near full capacity, is a source of concern for technical service managers and academics alike. While the early retirement and voluntary severance schemes that have been employed in many universities in the past few years have helped to alleviate the problem to some extent, higher rates of turnover might help departments to prevent such situations from developing, with new recruits usually having up-to-date skills and a greater willingness to learn. In the words of one academic: 'It's useful to have some continuity, but a bit of healthy turnover is good too.' We shall return to this issue in Section 6.2 below.

4.4. AGE PROFILE

Notwithstanding the fact that many of the universities visited for this project have implemented early retirement and voluntary severance schemes over the past few years, the average age of the technicians in the chemistry, engineering, and physics departments visited for this study is around 50 years of age (see Table 4.1). Put another way, roughly half of the technicians in the departments in those three disciplines visited for this study are due to retire within the next 15 years. Matters are slightly different in the biological sciences departments considered here, where a tendency to recruit relatively young graduates for research technician posts in particular has led to a younger demographic profile, with an average age of around 40 and somewhere in the region of 40-45% of the workforce likely to retire within the next 15 years.

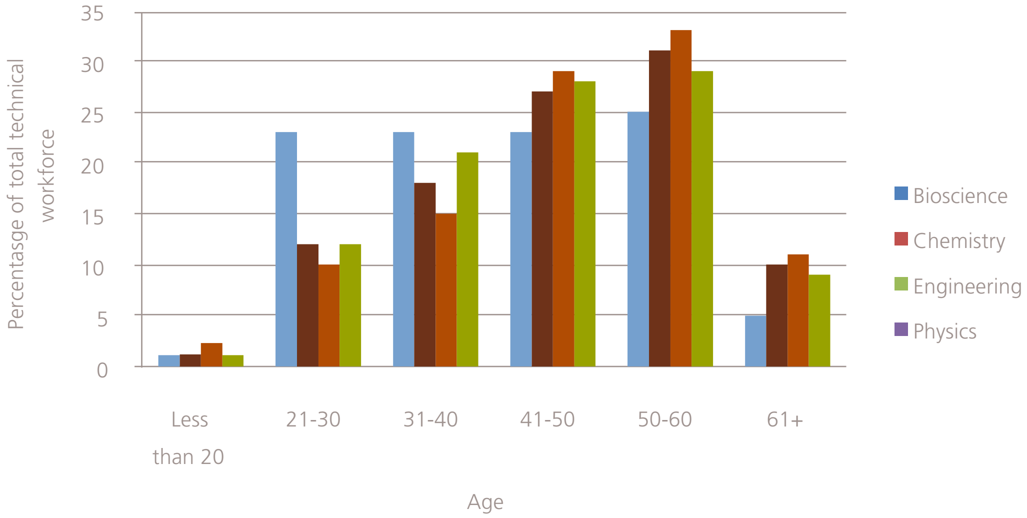
Table 4.1: Average age, and percentage of the technician workforce aged over 50 in the case study departments, by discipline

	Biological sciences	Chemistry	Engineering	Physics
Average age	41	48	51	48
Fraction aged over 50	43%	46%	48%	55%

Support for such claims is provided by Figure 4.1, which presents HESA staff record data on the age profile of the technical workforce in each of the four disciplines considered in this study for all UK universities in the year 2009/10.

a: Source: HESA Staff Record 2003/04-2009/10. The data cover the following cost centres: bioscience (cost centre 10); chemistry (cost centre 11); physics (cost centre 12); and engineering (including general engineering [cost centre 16], chemical engineering [cost centre 17], mineral, metallurgy and materials engineering [cost centre 18], civil engineering [cost centre 19], electrical, electronics and computer engineering [cost centre 20], and mechanical, aero and production engineering [cost centre 21]). The data includes building, ICT and medical (including nursing) technicians as well as laboratory and engineering workshop technicians (SOC Code 3A).

Figure 4.1: The age profile of the technical workforce, by discipline, in 2009-10[a]



While the data collected from the case studies carried out for this project, and that available from HESA, are not strictly comparable – because the HESA data includes building, ICT and medical technicians, who were excluded from the current study – on the whole the broad pattern is similar, with biosciences having a younger workforce (with significantly more technical staff in their 20s in particular). The HESA data indicate that the fraction of the total technician workforce that is aged over 50 and due to retire within the next 15 years is in the region of 30% in the biosciences, 40% in chemistry, 45% in engineering, and 40% in physics.[17]

Age profiles of the kind described for the chemistry, physics, and engineering departments in particular have been the cause of much concern, voiced both interviewees and also by other commentators on the sector (Evidence Ltd 2004: 14-15; THES 2008, 2009). While some of the more apocalyptic talk about a 'demographic time bomb' might be exaggerated, it is undoubtedly true a succession planning issue is emerging that must be addressed if the future of technical support in the sector is to be assured. Quite how serious the problem is depends, of course, not only upon the age profile of the current technician workforce but also upon how easily suitably skilled replacements for retirees can be found. That in turn raises two additional issues: the kind of skills that departments need their technicians to have; and the ease with which workers possessing the requisite level of skills can be obtained from the external labour market. We shall examine the first of those issues immediately below. The second issue will be considered in Section 5. Having examined both issues, we shall then be in a position to consider the scale of the succession planning problem and the appropriateness of the strategies through which departments are attempting to deal with it.

4.5 QUALIFICATIONS

A broad-brush summary of the qualifications possessed by people occupying various kinds of technician role in each of the four disciplines considered in this study can be found in Table 4.2:

17 The discrepancies between the estimates of the percentage of technical staff who are due to retire over the next 15 years derived from the case studies and from HESA data may well reflect the fact that the latter includes some types of technician, most notably ICT technicians, who were excluded from the current project and who are likely to be younger than the laboratory and engineering workshop technicians upon whom the case studies focused.

Table 4.2: Qualifications typically associated with particular technician roles in pre-1992 universities (by discipline)

	Biological sciences	Chemistry	Engineering	Physics
General support	Vocational/GCSEs	Vocational/GCSEs	Vocational/GCSEs	Vocational/GCSEs
Research	Vocational/BSc	Vocational/BSc	Vocational	Vocational
Facilities	Vocational/BSc	Vocational/BSc	Vocational	Vocational
Workshop	Vocational	Vocational	Vocational	Vocational
Teaching	GCSEs/vocational/ BSc	GCSEs/vocational/ BSc	Vocational	Vocational
Technical officer	PhD/BSc	PhD/BSc	PhD/BSc	PhD/BSc

In the case of pre-1992 universities, the clearest and most straightforward picture arises in the case of general support technicians, mechanical and electronics workshop technicians, facilities technicians, and technical officers. The qualifications typically possessed by people occupying such roles tend to be very similar across all the four disciplines considered for this study. General support technicians, who are typically found only in pre-1992 universities, typically have no more than vocational qualifications, such as BTECs, ONCs and HNCs, and they may well have no formal qualifications beyond those acquired at school (though they may, of course, have considerable experience in their role). The vast majority of mechanical and electronics workshop technicians – whether they work in pre-1992 or post-1992 universities – have vocational qualifications in electronics and mechanical engineering, usually HNCs, HNDs, and City and Guilds, with just a very small minority having an undergraduate degree. Analytical facilities technicians tend either to have vocational qualifications such as HNCs or undergraduate degrees. Those analytical facilities technicians who are vocationally qualified tend to be the older ones, while those who have degrees are more likely to be relatively young. Those technicians who work in facilities such as clean rooms, greenhouses, and animal houses usually have vocational qualifications. As noted earlier, technical officers in all four disciplines tend to have at least an undergraduate degree, with most possessing PhDs.

Matters become slightly more complicated when it comes to research laboratory technicians. In physics and engineering most of the incumbents of research laboratory technician roles are vocationally qualified.[18] In departments of chemistry and biological science, however, while older research laboratory technicians tend to be vocationally qualified, usually possessing HNCs in the relevant discipline, younger technicians tend to have undergraduate degrees. This tendency was attributed both to technological changes and also to differences in the availability of workers with different educational backgrounds. Many interviewees in pre-1992 biological science and chemistry departments argued that the development of high throughput sampling and other types of automated experimental procedure have reduced the need for technicians to carry out experimental procedures manually. The paradigm is DNA sequencing, which twenty years ago could not be done at all, then for a period could be done

18 Two possible exceptions to this general finding are worth noting. First, some physics departments indicate that the nature of the work undertaken by their electronics technicians requires them to have an undergraduate degree. Second, those engineering departments whose research involves the application of traditional engineering principles to subject-matter usually studied by one of the other sciences, as for example occurs in bio-engineering and chemical engineering, seem often to employ technicians who are qualified to at least degree level BSc in the relevant science in order to provide subject-specific input into the design of experiments and the analysis of data.

only with considerable manual input from technicians, but which has now been automated, considerably reducing the amount of technician support required. The premium is increasingly on technicians who can contribute to the design of experiments, write the relevant software, and then help to analyse the data that are produced. Since the requisite programming, data-handling, and analytical skills are most likely to be acquired in the course of a university education, rather than via vocational training, it is unsurprising that chemistry and biological science are increasingly relying on graduates to fill research technician posts. Graduates are also said to have a better grasp of the scientific principles underlying the research they are supporting than their vocationally educated counterparts and, as a result, they are said to be more autonomous – to need less supervision and less detailed experimental protocols – to be less likely to make mistakes, and to be more able to deal with emergent problems.[19]

Many interviewees in biological science departments in particular also argued that the rapid *pace* of change in the biological sciences makes it especially desirable to recruit graduates for research support roles. The reason is that, thanks both to their grasp of underlying scientific principles and also to the general intellectual skills developed during the course of their degree, (good) graduates are said to be more able to familiarise themselves with new areas of research and new experimental techniques than people with only vocational qualifications. This is not to say that it is impossible for someone who is vocationally qualified to display the requisite flexibility, but rather that – as the interviewees saw things – people with degrees are more likely to be able to do so. Interviewees from a majority of the pre-1992 department of biological sciences indicated that an undergraduate degree is now a prerequisite for someone wishing to fill a research technician position.

The increasing use of graduates to fill research technician roles in chemistry and biological science departments was also attributed by some interviewees simply to a decline in the number of vocationally educated people applying for such positions. As will be discussed in more detail in Section 5.1, departments in those disciplines that advertise for technician posts of all kinds are almost invariably inundated with applications from people who are qualified to degree level or higher, with the pool of applicants tending to contain only a small proportion of people with vocational qualifications. The ready availability of graduates, coupled with the changing demands of the research technician role outlined above, makes it unsurprising that departments of chemistry and biological science nowadays tend to appoint people with BScs to research technician positions. Given the data available here, however, it is impossible to be sure of the relative importance of these two factors (that is, how far the increasing use of graduates really does reflect the increasing demands of the research technician role and how much of it stems simply from the greater availability of graduates on the external labour market).

The greatest variation in qualifications between different pre-1992 universities is to be found in the case of teaching technicians. In those cases where technicians' official duties are confined to *supporting* teaching rather than actually undertaking that teaching themselves, teaching technicians tend to have vocational qualifications, though there are some departments of biological science and chemistry in particular whose teaching technicians have no qualifications beyond GCSE/O-level.

19 For similar observations, see Royal Society (1998: vii, 6).

Where technicians *are* formally involved in teaching, helping to instruct students in how to use scientific instruments and carry out experimental procedures, they tend to be qualified at least to vocational level and – in some departments of chemistry in particular – to possess undergraduate degrees. This reflects the common view amongst interviewees from those chemistry and biological science departments whose technicians *were* formally engaged in teaching that either an HNC plus considerable experience or a BSc was required to do the job properly.

A similar story emerges from the post-1992 departments visited for this study. As noted earlier, the vast majority of technicians' time in those departments is spent supporting teaching rather than research. Moreover, rather than simply facilitating the efforts of academics and PhD student demonstrators, the technicians who support laboratory classes tend more often than not to be actively involved in teaching students the relevant practical skills. In the case of the post-1992 physics and engineering departments, most of those technicians have vocational qualifications, the one exception being a department of engineering most of whose technicians have undergraduate degrees. A majority of the technicians working in the post-1992 department of chemistry visited for this study were qualified to at least BSc level, with the remainder having HNCs in chemistry. Like their counterparts in those pre-1992 universities whose technicians took an active role in teaching students practical techniques, interviewees from the department in question believed that technicians who are directly involved in teaching students ought to have either a BSc or an HNC and substantial experience. At least two thirds of the technical workforce in each of the four post-1992 departments of biological science visited for this study had an undergraduate degree, with many also having either an MSc or a PhD. While representatives of these departments indicated that they believed a person taking a teaching technician post ought to have at least a BSc or HNC with substantial experience, they did not suggest that it was necessary for such technicians to have an advanced degree.

Interviewees almost invariably said that, for the most part, the skills and qualifications possessed by their technicians were a good match to their departments' needs. There were, however, a few exceptions to this general picture of satisfaction with the skills profile of the technical workforce. Interviewees from around half the engineering departments visited for this study, as well as from some of the physics departments and research laboratories, said that they would like to have more technicians with mechatronic skills. Representatives of three other engineering departments also stated that they would like to have more technicians who are well versed in 3-D design and CAM-CAD packages. More generally, engineering departments reported that they would like to have more technicians who are multi-skilled, and who as a result are able to respond flexibly to the varying demands of researchers they support. Moreover, as noted above, interviewees from some biological sciences departments also indicated that the skills of some of their older technicians were no longer relevant to the kind of worker they were supposed to be doing. Finally, moving from cases where technicians have too low a level of skills to situations where they are arguably over-qualified, interviewees from some post-1992 departments of biological science argued that those technicians who have an MSc or PhD, which in two cases amounted to almost half of the technical workforce, are over-qualified for their role and therefore do not make anything like full use of their skills in carrying out their duties.

Having now considered both the age and qualifications profile of the technician workforce in each of the four disciplines under consideration here, we are now ready to move on to consider the strategies through which departments are attempting to address the workforce planning issues that confront them. We consider first the role of recruitment, before going on to examine the potential for apprenticeship training to contribute to the renewal of the technician workforce.

5. WORKFORCE PLANNING

5.1 RECRUITMENT

There is a stark contrast between availability on the external labour market of the kind of workers that biological science and chemistry departments are trying to recruit, on the one hand, and the availability of those sought by engineering and physics departments, on the other.

There was considerable agreement amongst representatives of the biological science and chemistry departments visited for this study about the state of the external labour market for technicians. Interviewees from all 13 biological science departments, and from nine of the 11 chemistry departments, said that they currently receive very large numbers of applications for research, teaching, analytical facilities, and general support technician positions. The abundant supply of skilled labour is attributed in part to the fact that chemical and pharmaceutical companies such as Pfizer, GSK and Astra-Zeneca, as well as university departments, have been making people redundant and thereby releasing them on to the labour market. It is also said to reflect the large numbers of science graduates currently being produced by UK universities. The existence of such sources of supply implies that many departments currently receive more than 50 applications for each post, with some reporting ratios of over 100 applications per post. Indeed, several interviewees remarked that even advertisements for relatively low level teaching support posts attract interest not only from large numbers of graduates but also from people with advanced degrees and postdoctoral experience.

It is of course true that not all of these applicants are appointable. For example, some graduates lack the practical skills required successfully to fill a research or analytical facilities role. Other applicants – especially young graduates and people with advanced degrees – may fail to appreciate either the mundane, repetitive nature of much teaching support work, or the fact that research laboratory technicians provide a service to scientists and support their projects rather than devising and implementing their *own* research agenda. Nevertheless, even when such unsuitable applicants have been ruled out, biological science and chemistry departments are left with many strong candidates from which to choose, so that it is relatively easy for them to find high quality people to appoint. In the words of one academic in the biological sciences who recently received 160 applications for a research technician post, 'We were overwhelmed by good applicants.'

Of course, while new recruits will have received their basic training outside of the department that hires them, and may also have substantial work experience, they will need to be inducted into their new surroundings. Additional 'upgrade' training may also be acquired in order to equip them with some of the more specialised skills they will need in order to become fully productive in all aspects of their new role. It is for this reason that people who are recruited to fill research laboratory technician posts in the chemical and biological sciences typically receive on-the-job training in the relevant experimental techniques, and in the use of the relevant instruments, either from an academic or an experienced technician. This reliance on informal, uncertificated training is to some extent inevitable, interviewees said, because many of the techniques used in research laboratories are relatively new and therefore have not been absorbed into external, formally certificated training programmes or industrial laboratories.[20]

The abundance of skilled labour available for hire implies that when biological science and chemistry departments are deciding how to deal with succession planning, or refresh the skills of their technician workforce, they are able, to a considerable extent, to rely on external recruitment. One consequence of this is that, as we shall elaborate in the next section, no chemistry department, and just one department of biological science, in the sample considered here currently has an apprenticeship programme for its research, analytical facilities, or teaching technicians.

The only kinds of technicians that chemistry departments *do* struggle to find are those who work in electronics and mechanical workshops.[21] Just over half of the chemistry departments visited for this study had experienced difficulties in recruiting such technicians. Significantly, this is consistent with the experience of the physics and engineering departments included in this study, a majority of which have found it difficult to recruit good workshop technicians from the external labour market. More specifically, seven of the 10 engineering departments who had recent experience of attempting to recruit technicians, and six of the nine physics departments, reported only a low-to-moderate availability of suitably skilled workers on the external labour market. The departments in question, which are to be found in all of the regions covered in this study, had struggled to find good people to fill technician posts in the past few years, sometimes having to re-advertise posts and even then not always filling them. In the words of one interviewee who is involved in the recruitment of electronics and mechanical workshop technicians, 'It's not easy, and it's getting worse ... You have to be lucky to get a good one'.

Interviewees attributed the paucity of good recruits to two factors. The first is the salary paid by universities, which is said to be low relative to that available in industry, making it hard for departments to attract young technicians in particular, who can ill afford to take the low wages on offer.[22] The second factor is the long-term decline of many of the traditional industries that used to train engineering and electronics technicians in the past. The closure of firms in those industries, along with the significant scaling back of the training programmes in those companies that remain, has led in turn to a reduction in the number of suitably qualified and experienced technicians entering the pool from which universities attempt to draw. As one technical services manager put it, 'The well's run dry' (also see Royal Society 1998: 6).

In stark contrast to their counterparts in chemistry and the biological sciences, therefore, science and engineering departments cannot be confident of obtaining the skilled labour required to sustain a high-calibre technical workforce simply by relying on hiring technicians from the external labour market. Consequently, the last three-four years have seen something of a revival of interest on the part of physics and engineering departments in apprenticeship training schemes, which – as

20 The same is often true of recruits to physics and engineering department mechanical workshops, where technicians are required to work either with materials or to degrees of precision that they may well not previously have encountered. Consequently, even recruits who have had a good apprenticeship and several years of industrial experience are unlikely to have had the chance to acquire all the relevant skills before arriving in their department and will therefore need additional 'upgrade' training in order to be able to carry out some of their duties. As in the case of biology and chemistry technicians, the requisite training is usually provided informally, on the job by more experienced colleagues.

21 As noted earlier, most of the biological science departments considered for this study are significantly reducing the size of their mechanical and electronics workshops, so recruiting workshop technicians is not a significant concern for them at present.

22 HEFCE reports that the median and mean technician salaries in 2008-09 were £27,410 and £28,460 respectively (HEFCE 2010: 50).

we will see – are now beginning to be viewed by many engineering and physics departments as an important element of their approach to workforce planning.

5.2 APPRENTICESHIPS

The evidence gathered for this project suggests that the last three to four years have witnessed the beginnings of a revival of interest in apprenticeship training schemes amongst university engineering and physics departments. Six of the 12 engineering departments, along with three of the nine physics departments, have either recently begun – or are about to begin – running an apprenticeship scheme for their technicians. Two other departments of engineering, and one other physics department, are formally considering starting such a scheme. In these respects, matters appear to have changed since the late 1990s and early 2000s, when few universities were taking on apprentices (The Royal Society 1998: 6; Evidence Ltd 2004: 14-15). One of the two non-university research laboratories also has a long-standing, well-established apprenticeship programme through which it has trained a large proportion of its current technician workforce.

The rationale for such developments is twofold. First, apprenticeship training is viewed as a means of succession planning that will enable hard-pressed technical service managers to continue to provide high-quality technical support in the face of the twin problems posed by an ageing technician workforce, many of whom are due to retire within the next 15 years, and the difficulty of obtaining suitably skilled replacements via the external labour market. As one technical services manager from a physics department that has recently begun to take on apprentices put it, 'We need to grow our own; otherwise we'll have a skills shortage.' Second, apprenticeships are thought of as a way for departments to update the skills of their technical workforce so that they are well tailored to the researchers' current requirements. This means that apprentices may for example take a mixture of units in electronics and mechanical engineering, so that they acquire the mechatronic skills by which so many departments now set great store. In this way, apprenticeships provide a vehicle not merely for succession planning, narrowly understood as involving the replacement of retirees with similarly skilled younger workers, but also for workforce planning in a broader sense that encompasses an attempt to anticipate an organisation's future skills needs and then find a means of satisfying them.

The nine departments of physics and engineering, and the non-university research laboratory, that have decided to take on apprentices have adopted similar, though not completely identical, approaches to running their scheme. In every case, the apprentices have been recruited under the auspices of the government's Advanced Apprenticeship programme. All nine departments have delegated formal responsibility for organising the apprenticeship to an external training provider (in seven cases, a local further education college, in one case a private training provider, and in one a group training association), though in some cases departments have had to work hard to ensure that the colleges deliver the quality of support required for the apprenticeship programme to be a success.[23]

23 In particular, some departments expressed reservations both about the quality of teaching on the college courses taken by the apprentices and also about the effectiveness with which the provider notified the department of any problems with its apprentices (e.g. cases where apprentices were either struggling with their college course or simply failing to attend it). For similar findings about the need to invest time and effort in ensuring appropriate college provision, in the case of apprenticeship schemes involving private sector employers, see Unwin and Fuller (2004: 17-18).

It is the external training providers that hold the apprenticeship training contract with the Skills Funding Agency and, as a result, are in direct receipt of the government training subsidy. The government funding covers both the fees for the college courses through which the apprentices receive their off-the-job training and also the cost of the assessment of their practical skills required for the award of the NVQ part of the apprenticeship training framework. That leaves the universities having to pay the apprentices' wages, typically £12,000-£13,000 per annum, and also to cover the costs of overseeing the scheme and providing the on-the-job training. In some cases, those costs are split between the relevant department and the central university. In others, the department covers the entire cost.

Apprentices from both the engineering and the physics departments are usually studying for qualifications in mechanical and electrical/electronic engineering. Apprentices typically start at level 2, working towards an ONC and an NVQ2, before progressing to a level 3 NVQ and an HNC. The departments provide the apprentices with the requisite on-the-job training and work experience by rotating them through different workshops and laboratories, exposing them to a wide variety of tasks, materials and equipment, and thereby developing their flexibility. The off-the-job training required for the ONC and HNC comes from a local further education college, which apprentices attend either via day release (in the case of seven departments) or via block release for the first year of the apprenticeship followed by day release thereafter (in two cases).

The number of apprentices taken on by each department is low, averaging just one or two per annum in each university. Comparisons of apprenticeship activity between different employers and at different times are potentially clouded by differences in skilled employment, with larger employers taking on more apprentices simply because they have to sustain a larger technician workforce. A simple way of allowing for such differences is to calculate the ratio of the number of apprentices currently in training to the number of skilled employees within the relevant occupation (in this case, technicians). This indicator, known traditionally as the apprentice–journeyman ratio, can be used to compare the rate or intensity of training across employers. The intensity of training averages about 3% across the three physics departments that offer apprenticeships, and is around 5% in the case of the five departments of engineering. Those figures would be expected to rise over time if – and, as we shall see, it is an *if* – departments, most of whom have only recently started taking on apprentices, continue to do so and therefore ultimately have apprentices in all three or four years of their training programmes.

All of the departments of engineering and physics that have taken on apprentices are intimately involved in the process through which apprentices are selected. The departments in question are typically looking for young people aged between 16 and 20 who have passed four to five GCSEs at grades A-C, with English and a science at grade C and mathematics at grade B. Some departments set practical tests for shortlisted candidates. The quality of applicants appears to be mixed: while most departments stated that they received enough good applicants to fill all the apprentice training places on offer, two departments of engineering had struggled to do so. In all nine cases, the apprentices were given a fixed term contract of employment, coterminous with their apprenticeship. The departments in question hope and expect that the apprentices will be kept on at the end of the training programme, subject to satisfactory performance.

Of the 12 departments of engineering and physics who do not take on apprentices, five *have* seriously considered doing so. However, despite acknowledging the potential for apprenticeship to serve as a tool for workforce planning, these departments ultimately decided against becoming involved. The main reasons were twofold. First, two departments in particular baulked at the financial implications of the wages they believed newly qualified apprentices would have to be paid. Those departments may revisit their decision not to participate in apprentices in the not-too-distant future. Second, some departments were concerned that, because their technical staff are already working at full stretch, their experienced technicians simply do not have time required to provide the on-the-job training required by the apprentices. As the technical services manager in one of those departments put it, 'We don't have the capacity ... [and] would need to take on an extra trainer to do it'.[24]

Those engineering departments who have not seriously contemplated taking on apprentices tend to be those who either still have a relatively young workforce or who find it relatively straightforward to hire workers from the external labour market. In other words, in those cases the two main factors that have motivated other departments' interests in apprenticeships, namely an ageing workforce and the difficulty of recruiting good workers from the external labour market, are not present. The absence of one or both of these factors also accounts in large measure for the fact that only one of the 24 departments of chemistry and biological science visited for this study are currently running an apprenticeship programme for their general support, research laboratory and analytical facilities technicians. As noted earlier, the data gathered for this project indicates that the average age of technicians in the biological sciences is only just over 40, as is the percentage of the technician workforce due to retire over the next 15 years. Consequently, as a technical services manager from a department of biological science pointed out, 'Age is not a problem ... Not all university departments have a succession planning problem.' Moreover, to the extent that new recruits *are* required, it is very easy for departments of biological sciences to acquire them from the external labour market. In the words of another interviewee from the biological sciences, 'Given the ready supply of graduates, we don't need apprentice laboratory technicians.' Much the same is true of chemistry departments as well. While the technicians in departments do have an average age in the late 40s, and while around 45% of them are due to retire in the next 15 years, the abundance of skilled labour on the external market means that departments feel able to address any succession planning issues that arise simply by recruiting suitably skilled workers from the external labour market. As a result, they make no use of apprenticeships for their general support, research laboratory, and analytical facilities technicians, preferring to rely on external recruitment as their major vehicle for workforce planning.[25]

The evidence reported here provides little support for the view, mooted in some policy documents, that what is required in order to stimulate interest in Apprenticeships amongst universities is a new apprenticeship framework

24 For a similar point, see IoP and RSC (2010: iii).

25 The only exception to the pattern is to be found in pre-1992 departments of biological science whose technicians have a comparatively high average age (in the late 40s). In anticipation of forthcoming retirements, the department has recently recruited two apprentice teaching technicians. Like their counterparts in engineering and physics, the apprentices are being trained under the auspices of the government's Advanced Apprenticeship scheme, and are studying for a level 3 qualification (BTECs in Applied Science). In other key respects – the use of a local FE college to hold the training with the Skills Funding Agency, for example, and the fact that the apprentices currently have three year, fixed-term contracts of employment – the training programme resembles those described for the apprentices in engineering and physics.

specifically tailored to the requirements of university laboratory and engineering workshop technicians (see, for example, HEFCE 2010: 79-80). On the contrary, virtually all of the departments who expressed an interest in apprenticeships were quite content with the existing apprenticeship frameworks. The evidence gathered here suggests that the problem lies, not in the apprenticeship frameworks *per se*, but rather in the factors noted above, such as: (i) the difficulty of finding further education colleges that are willing to offer the courses required for the off-the-job part of the apprenticeship; (ii) the problem of finding enough time for established technicians to provide the on-the-job training for the apprentices; and (iii) the fact that, especially in disciplines such as chemistry and the biological sciences, the ease with which graduates can be hired discourages departments from taking on apprentices.

6. WORKFORCE DEVELOPMENT

6.1 ONGOING TRAINING

Having considered training for new, young staff, in the form of apprenticeships, we turn now to consider ongoing training for more established technical staff. We shall consider first the way in which the need for such training is identified, along with some of the impediments to the satisfaction of such needs. Finally, we shall consider the kind of ongoing training that is actually provided for technicians.

In a majority of cases, interviewees felt that departments are currently willing to fund ongoing training for established technicians, provided that it promotes the goals of the relevant department as well as those of the individuals requesting it. However, while the identification of training needs is gradually being formalised and systematised through the use of appraisals and personal development reviews, interviewees in a significant minority of departments indicated that it remains *ad hoc*, in the sense of being driven more by the short-term requirements of current or imminent research projects rather than by a systematic appraisal of the long-term needs of technicians themselves.[26] There remain a handful of departments, especially in engineering, where appraisals have only recently been introduced. In others, while an appraisal system is formally in place, it has not been greeted with great enthusiasm, especially by older technicians, and appraisals are sometimes not actually carried out in practice.

Even when the need for training has been established, a number of impediments to its satisfaction remain, of which interviewees mentioned three in particular. First, representatives from a number of biology and chemistry departments in particular said that they sometimes find it hard to release their technicians for off-the-job training, simply because – given the demands currently being placed on their technical staff – they find it hard to cover for their absence. Moreover, while some academics are said to be very good at supporting their technicians by giving them interesting work and opportunities to acquire new skills that will help them to develop their careers, others are less helpful. In particular, faced with considerable pressure to bring their research projects to a successful conclusion, some academics are said to be reluctant to allow the technicians who support their groups to spend time away from the laboratory, either for off-the-job training or for training on-the-job in other labs, so that the technicians in question may not have the opportunity to acquire as broad a range of skills as they – and, ultimately, their departments – might like. Academic staff want technicians to be 'in the lab,' one technical services manager observed, 'so getting day release can be a problem.'[27]

Second, technical services managers in a small minority of departments noted that the financial circumstances in their universities have begun to deteriorate and that, as a result, less money is available to support ongoing training than in the past. The danger here is that the provision of training, whether it be ongoing training for established technicians or indeed for apprentices, is all-too-tempting a target for hard-pressed finance managers seeking to save money. The reason is straightforward. The consequences of certain types of cuts – such as those involving

26 In total, 80% of respondents to a survey of technicians conducted in 2009 indicated that there is a systematic approach to identification of training needs in their department, but only around a third of respondents said that the process centred on staff appraisal. In addition, 30% of staff said that they identified their own training needs, while 40% felt that appraisal did not lead to useful training opportunities (HEaTED 2009: 11, 27).

27 A similar point was made by The Royal Society (1998: 6).

job losses – will be felt almost immediately, making it likely that such reductions will be vigorously opposed from the outset. However, the consequences of a failure to invest in training are likely to manifest themselves only after several years have passed, at which point departments will find either that the skills of established workers are no longer adequate (if it is funding for the training of current employees that is cut) or when retirees cannot be replaced (if it is the funding for apprentices that is reduced). But because the full impact of lower investment in training is likely to be felt, not immediately, but only after a number of years have passed, opposition to cuts in training budgets is more likely to be muted at the outset, making training a more attractive target for hard-pressed managers seeking to find straightforward ways of saving money. The problem, of course, is that in the medium- to long-term such an approach may well prove to be a false economy, as departments end up with inadequately trained technical staff.

Third, there are also cases where technicians neither seek opportunities for training nor enthusiastically embrace those that are made available to them. Interviewees in around a quarter of the departments suggested that there are occasions when technical service managers find it difficult to persuade some technicians to go on training courses in order to update their skills. This has been a source of frustration to technical services managers and academics alike, one of whom remarked that at times some technicians have 'devalued themselves' by neglecting to update their skills, as true professionalism – to which technicians ought to aspire – demands. Older technicians in particular may be reluctant to acquire new skills, having become comfortable in their current role and grade. That may be unproblematic if the technicians' current portfolio of skills enables them to complete their duties to the requisite standard. However, as a number of interviewees from engineering and especially from the biological sciences noted, problems can arise if, perhaps because of changes in the kind of support required, the skills possessed by those technicians have become peripheral to their department's current needs. For in that case it may become increasingly difficult for departments to find useful work for those technicians to do, increasing the burden that must be borne by other technical staff. The use of early retirement and voluntary severance schemes has helped to alleviate such problems, but it has not eliminated them completely and several departments continue to struggle with the challenge of finding useful work for older technicians whose skills have become increasingly irrelevant to the current requirements of their role. It is also important to note that older technicians' attitudes towards training are not always set in stone, and that a more enthusiastic response is likely to be forthcoming if the reasons why new skills are required is clearly explained to the technicians in question and if they are involved from the outset in the specification, sourcing, and installation of any new equipment on which they are to be trained. As one technical services manager from an engineering department put it, in words that were echoed by his counterparts in other departments, 'We need to get technicians to buy into training for themselves and, if you include technicians in thinking about the future, they'll respond more flexibly.'

Where ongoing technical training is provided, what form does it take?[28] We shall begin by considering uncertificated training, before moving on to training that yields formal qualifications.

28 University staff development units usually offer a wide range of training courses in non-technical skills, including both personal developments skills (e.g., CV writing, presentation skills), general IT skills, and managerial skills for those occupying, or seeking to occupy, laboratory and technical service manager positions.

Interviewees from all four disciplines made clear that one of the most important sources of uncertificated technical training for established technicians – as for new recruits – is the other technicians in their department, who will pass on their practical skills – for example, in welding, in particular experimental techniques, and in how to use specific pieces of equipment – to less experienced colleagues, usually via informal on-the-job training. On some occasions, such training may be formalised into short, one- or two-day internal training courses (e.g. in x-ray crystallography, NMR). Training on how to deal with the many health and safety issues that arise in science and engineering departments is also often provided internally, via uncertificated departmental or university-based courses.

Perhaps the most important external sources of uncertificated ongoing training in technical skills are equipment manufacturers, who are used as training providers by all of the departments visited for this study. Training of this kind usually accompanies the purchase of new items of equipment and/or associated software, although it can also be obtained independently of the latter. Examples include: training for mechanical and electronics workshop technicians in how to programme and use CNC machines and rapid prototypers (3-D printers); instruction in techniques for NMR spectroscopy, x-ray crystallography, and mass spectrometry for analytical services technicians working in chemistry and in the biological sciences; and training in high pressure and high vacuum technology for technicians working in chemistry and physics departments. Interviewees were keen to emphasise that, while such vendor-supplied training usually does not yield formal qualifications, it is often intense and of high quality.

Only around 20% of the departments visited for this study have sent their established technicians, as distinct from their apprentices, to local colleges for certificated vocational training (e.g. BTECs, HNCs, HNDs). In some cases this simply reflects the fact that external recruits often already possess such qualifications when they join departments. However, there are also cases where departments *would* like to make use of such courses but, because of the limited numbers of students in the local area wishing to take them, find it impossible to persuade local further education colleges willing to offer them. This is true both in the case of some physics and engineering departments, who have struggled to find colleges willing to offer HNCs in electronics, and also in the case of some biological science and chemistry departments, who would like to have some of their teaching and general support technicians take HNCs or BTECs in Applied Biology or Chemistry but have been unable to find a college that is willing to assist them.

In the case of academic qualifications, a majority of the chemistry, engineering and physics departments visited for this study indicated that they have sponsored small numbers of technicians – typically just one or two per department – to take an undergraduate degree. Typically, the technicians take their degrees part time, either at the local post-1992 university or via the Open University, with their home department granting them day release, or block release for OU residential summer courses, and paying some or all of their fees. Only one biological sciences department had supported a technician through an undergraduate degree, though three more had done so for technicians wishing to take an MSc. It should also be noted that it is quite common for those technicians and, in particular, technical officers who have PhDs to have acquired them in virtue of their work as a technician.

While technicians sometimes obtain training in other ways – by attending courses put on either by other universities, for example, or by the technicians organisation HEaTED – such sources are not widely used, and will therefore not be commented upon further here.

6.2 APPRAISALS AND CAREER PROGRESSION

A new pay and conditions framework for all staff working in higher education was introduced in 2005. The new framework brought all staff – whether previously classified as academic, academic-related, or non-academic – onto a single pay spine and provided for the assessment of all posts. Interviewees from the vast majority of the departments visited for this study reported that the process of job evaluation, role analysis, and grading through which the move to the common pay spine had been implemented had been viewed as fair by technical staff and, as a result, had not generated significant discontent amongst technicians. (Only around 10% of departments suggested that outcomes had been viewed as unfair because different people had received different grades for what they felt to be the same job.) Indeed, interviewees in some departments (just under around 10% of those visited) indicated that – in the words of one technical services manager – technical staff 'generally did very well' as a result of the move of the common spine. The reason is that the process of job evaluation through which the move to the single pay spine was accomplished led to the formal recognition of the additional responsibilities – for health and safety, for example, and for various aspects of laboratory management – that many technicians had accumulated over the years but which had not previously been acknowledged and remunerated. The upshot was that the job evaluation process led to those technicians receiving higher grades, and higher pay, than before.

However, while on the whole the transition to the common pay spine appears not to have caused great discontent amongst technical staff, other problems have emerged over time. The most oft-remarked difficulty stems from the fact that many technicians have now reached the top of the particular segment of the common spine associated with their current grade. Having done so, the scope for them to secure increases in pay beyond those agreed in national negotiations for university staff is severely circumscribed, being limited either to the award of a small number of discretionary points, which are increasingly difficult to gain given the current financial climate, or by augmenting their current role by taking on extra responsibilities so that it is placed at a higher point on the pay spine. However, given the finite set of duties that departments need their technicians to carry out, the scope for widespread re-grading of this kind is of course limited. One human resources manager elaborated on this point by noting that the common spine 'seems a bit inflexible now, because people can't get higher grades for volume of work or qualifications but only on the basis of the range and nature of tasks they undertake.' If neither the nature nor the range of tasks associated with their role changes, then people who remain in that role and have reached the top of the relevant spine segment 'have nowhere to go.' Interviewees from around one quarter of departments remarked that problems of this kind had led to unhappiness within the ranks of their technicians (cf. HEaTED 2009: 48).

The other way for technical staff to deal with this problem is, of course, to seek promotion. However, while – as already noted – some technicians have found their niche or comfort zone in middle-ranking roles, and so do not seek further advancement, many interviewees said that technicians sometimes express frustration at their lack of opportunities for promotion. The principal cause of the problem is to be found in the relatively small size and 'flat' organisational structure of most university science departments, which typically leaves room for a small handful of senior laboratory manager roles and just one technical services manager or laboratory superintendant position in any one department. The upshot, as one technician put it, is that the career structure for technicians is 'pretty truncated'. Moreover, the paucity of senior roles, coupled with the low turnover rate amongst technical staff, implies that once they are filled these more senior positions are likely to remain occupied for many years, severely circumscribing the scope for other technicians to be promoted into them. As another technical services manager succinctly put it, 'We can't just create another job so someone can get promoted.' A large number of interviewees used the same phrase to describe this problem, saying that people could enjoy career advancement only by filling 'dead men's shoes.' The limited opportunities for career progression that are open to technicians have long been lamented (The Royal Society 1998: 7, 10; Evidence Ltd 2004: 4-5, 19).

If the scope for promotion within the department is limited, then technicians might be expected to look outside their department in order to advance their career. Inter-departmental moves of the requisite kind certainly do happen, but they do not appear to be especially common. Both technical services managers and academics often described technicians as being 'rather parochial', in the sense of being reluctant to move to a new laboratory within their current department, let alone to a different department, in order to further their career. Moreover, as noted in Section 6.1 above, their ability to make such moves may be hindered by their having acquired only the relatively narrow range of skills required for their current role, rather than a broader range of skills that would prepare them more adequately for a wider range of positions. As one technical services manager from a physics department put it, if technicians do not continue to receive general training, then 'people who stay in one department might not be employable elsewhere.' Here we return to points mentioned earlier, namely that – according to several interviewees – departments need to be more willing to offer, and technicians themselves need to be more willing to avail themselves of, opportunities for training in a broader range of skills than is required for their current role. One vehicle for encouraging this might be some kind of technician registration scheme, to which we now turn.

6.3 TECHNICIAN REGISTRATION

Registration is a form of occupational regulation. It exists when an agency registers the names, addresses and other relevant details of some or all of the individuals who work in a particular occupation. A certain level of skill and/or possession of particular qualifications may be required for an individual to be able to join a register. There may also be requirements for ongoing training and continuing personal development. Registration may be voluntary or mandatory. Especially in cases where possession of certain competences or qualifications is a prerequisite for registration, individuals who join a register may also have the right to use a title of some kind. In order to retain the designation, individuals must pay the fees required for continued membership of the relevant governing body (Sandford Smith, Lewis, and Gospel 2011).

The recently-founded Technician Council is considering the possibility of establishing a voluntary registration scheme for technicians in engineering, science, ICT and health care (DBIS 2009b: 18, 2010). Under the auspices of the Council, the relevant professional bodies – such as the Science Council and the Engineering Council – are seeking to establish the standards by reference to which people's eligibility for registration might be judged, along with any requirements for ongoing training and professional development. If the scheme is indeed implemented, people who have the requisite skills, qualifications, and experience, and who are willing to pay the relevant fee, will be able to use a title after their name (perhaps something like, 'Registered Technician'). The immediate objective of the scheme would be to provide a clear and credible signal of the skills possessed by (registered) technicians, increasing their appeal to a broader range of employers and thereby enhancing their wages and career prospects.[29] Ultimately, the aim would be to improve the status and esteem in which technicians are held, thereby persuading greater numbers of talented young people to pursue a career as a technician than do so at present.

Of course, it will be financially viable for professional bodies to administer a registration scheme only if sufficient numbers of technicians are willing to register. Technicians will be eager to do so only if the prospects of using the achievement of registered status either as a vehicle for achieving promotion at their current employer, or as a passport for securing a move to a better job elsewhere, are good enough to persuade them that it is worthwhile paying the requisite fees. This will only be the case if registration standards reflect the needs of employers, so that registered technicians offer them the kinds of skills they need. What that means is that professional bodies, as the representatives of those employers who use technicians, will have an incentive to stay attuned to employers' requirements as the latter change over time, for the simple reason that if they do not do so the appeal of their registration schemes, and therefore their fee income, will decline.

Both academics and technicians displayed cautious support for a registration scheme along the lines noted above. Some of the most commonly made points were as follows. First, a number of interviewees pointed out that schemes akin to that being developed by the Technician Council already exist. For instance, both the Institute of Mechanical Engineers and the Institution of Engineering and Technology already offer technician grades of membership. However, in the experience of the interviewees, few technicians have availed themselves of such opportunities. If the proposed technician registration scheme is to be successful, therefore, interviewees were adamant that it must yield clear and tangible benefits in the form of better wages and career prospects. In the words of one technician, 'I personally would not join something like this until I had seen the benefits', and, as an academic noted, 'I suspect most [technicians] would join only if it would help career progression'. Higher wages and better career prospects are, of course, precisely the objectives that such a scheme would be intended to promote and, as noted earlier, there is a clear sense in which achieving those objectives – and thereby ensuring that the benefits of registration are sufficient to persuade technicians to sign up – is *the* key challenge that must be met in designing the proposed scheme.

29 There is some evidence that licensure – a stronger form of occupational licensing than registration or certification, whereby only individuals who are registered and certificated can practice a particular trade – does indeed increase the wages of the relevant workers. Similar, though smaller, effects would be expected in the case of registration and certification (Humphris *et al.* 2010).

Second, interviewees noted that, given the range of qualifications that technicians possess when they first join the sector – with some having no qualifications beyond GCSEs, some arriving with vocational qualifications, and others having degrees – it is important that there be a number of different routes through which people can access the scheme, so it is viewed as relevant by people with different initial levels of qualification. Given that not all technicians want to ascend to the highest ranks, there should also be various levels within the registration scheme at which technicians can settle, whilst still gaining credit and recognition for what they have achieved up to that point.

Third, interviewees indicated that the scheme would be most likely to appeal to younger technicians who as one interviewee put it: 'still have a career to forge', rather than older technicians who have found their niche and are no longer seeking career advancement. Interviewees argued that the requirements for achieving registered technician status might constitute a useful focus for young technicians' appraisals, providing them with a goal that could both inform their efforts to develop their career, and indeed to broaden their notion of a 'career' so that it encompasses not just their current department or even university but other universities and, indeed, employers outside of the university sector. In this way, it would be possible, as one department services manager put it, to 'sit down with a young technician and say, "Aim at this" [i.e. registered status] without being too prescriptive [about where precisely the technician would end up] ... It would help to provide a career structure independent of the university structure, in whatever institutions.' Thus, registration might also provide a way of addressing one of the common shortcomings of the ongoing training provided for technicians, namely that while research technicians may become expert in the specific set of techniques required to support the work of the group or laboratory to which they are attached at one particular moment in time, they may lack opportunities to acquire a more rounded technical education, especially if the academic leading their group is reluctant to allow them time away from the laboratory bench to attend training courses. Registration is of course likely to require that technicians possess a broader range of skills and experiences than will be acquired by working in just one laboratory or group, and might therefore provide technicians with a way of getting themselves out of the grasp of what one interviewee referred to as 'over-possessive academics' and thereby securing extra time away from the laboratory for training.

The issues surrounding registration are closely bound up with the question of career paths for technicians. It was argued above that the small number of senior technician posts in most departments leaves little scope for advancement for technicians in one department. If technicians are to have a wider range of career routes to more senior positions, they may have to be more willing to move to different departments, different universities, and different sectors than many have been thus far. One technical services manager expressed this point nicely when, in commenting on the limited scope for career progression within universities, she observed that technical support in universities 'is no longer a career for life – it's a stepping stone to another career [outside the university sector]'. Making such moves will be easier if technicians have a more rounded or general technical education, as evidenced by their being registered. In effect, some interviewees – academics from chemistry and the biological sciences in particular – mentioned something very like this possibility, arguing that departments should try to 'give technicians as broad an experience as possible so they acquire transferable skills' and in that way 'keep open their possibilities' for career advancement both within and outside their current department and university. In that way, gaining registered status might be a way for younger technicians in particular to forge more satisfying careers, not only within but also ultimately outside the higher education sector.

However, this potential solution to the problems of technician careers may pose other problems. Employers will only finance training if the increase in the value of what better-trained workers produce is greater than the increase in those workers' wages over that same period. That condition is more likely to be satisfied if the increase in the workers' skills is not readily apparent to other employers. The reason is that if the increase in the workers' skills is readily apparent, then other employers will be more willing to try to entice those workers away from the employer that trained them by offering them higher wages, forcing the employer who trained the workers either to raise their wages to retain them or to reconcile itself to losing them. Both of those alternatives will reduce the return the employer gets on its investment in training and, therefore, will weaken its incentive to pay for training. Because registration promises to increase the transparency of workers' skills – and also, in all probability, their generality and therefore their appeal to other employers – it seems likely to cause employers to become less willing to pay for training. Trainees will have to pay more for the training they receive, therefore, bringing us back to the issue of the importance of ensuring that the benefits of registration really are sufficient to persuade technicians to sign up to the scheme (Stevens 1999).

Finally, registration was welcomed by many interviewees as a means of enhancing the status and esteem in which university technicians are held. While many academics understand and appreciate the important contribution that technicians make to research and teaching within their department, and while many departments have over the past few years taken steps to improve the standing of technicians – such as including technicians on key departmental committees, giving them a higher profile in departmental newsletters and other publications, and making awards for teaching technicians whose contributions are highly rated by students – it remains the case that technicians often feel underappreciated, especially by those outside of their department. Perhaps because their main role is to support and facilitate the work of another, supposedly more eminent occupation that is widely thought to exercise authority over them, their contribution to research tends to remain invisible to those who are not intimately involved in science and engineering, with the result that their social standing is not commensurate with the true significance of their work (Shapin 1989; Barkley and Bechky 1994: 91). In particular, some interviewees reported that senior academics and administrators from their university sometimes betray a misunderstanding of the role played by technical staff by making comments to the effect that technicians do no more than set up equipment that is used by the academics, making no significant contribution to research in particular, and that therefore they need little training. As one technician put it, 'People don't know what we do.' Worse still, according to some interviewees, this failure to understand and appreciate what technicians do sometimes leads to a neglect of technical support by universities when strategic plans are being devised. To quote the phrases used by a number of technical services managers, technicians are 'a forgotten workforce' who are all-too-often 'taken for granted' and treated 'as a bit of an afterthought'. These interviewees felt that a registration scheme might be a way of 'improving our profile', that is of cultivating an image or a sense of identity that makes clear to people outside of science and engineering departments that technicians make a genuinely important contribution to research and that they need to be highly skilled in order to be able to do so (cf. Keefe and Potosky 1997: 77-81).

At root, the concern being expressed here reflects the fact that technical work of the kind carried out in university science and engineering departments stands at the interface of manual and mental labour, involving as it does the production of cognitive (symbolic) representations of material objects and processes. The danger to which the multi-dimensional nature of technical work gives rise is that, if its more cerebral dimension is ignored, as sometimes appears to be the case in universities, then it will end up associated only with physical effort, and will therefore be accorded low status (Shapin 1989; Barley and Bechky 1994: 116; Whalley and Barley 1997).[30] By helping to draw attention to the fact that technicians are often highly skilled workers, registration promises to help overcome some of the misconceptions about the nature both of technical work and also of the people who carry it out, thereby helping to raise the status and esteem in which both are held.

30 Status differentials were also sometimes apparent in the relationship between technicians and technical officers, with some interviewees cautioning against even casually referring to technical officers as 'technicians' because of the offence this would cause the (usually, more academically qualified) technical officers.

7. CONCLUSIONS

We return finally to the questions posed at the outset of this report. There are a variety of different kinds of laboratory and engineering workshop technicians in our universities: some, especially in post-1992 universities, focus on supporting teaching; others support research, whether it be through working in laboratories, operating various analytical facilities, or designing and building experimental equipment and apparatus; a third group help to sustain the general infrastructure that underpins teaching and research. In carrying out their duties, these technicians play an extremely important role in the life of their departments, with many making an indispensable contribution to the research projects they support in particular.

The provision of technical support is becoming increasingly centralised, as departments strive to exploit the benefits of economies of scale and reduce costs. This is especially true when it comes to very generic aspects of technical support, such as stores, glassware, sterilisation, and the like. There are, however, increasing calls for the centralisation of what are arguably more specialised forms of support, perhaps most notably that provided by mechanical workshops. Here, the case for centralisation seems less clear cut, with the benefits of cost savings potentially being offset by the difficulty of managing shared workshops in ways that ensure the continued provision of high quality technical support. However, given that university managers sometimes seem not to appreciate the vital contribution that workshop technicians make to research, it is important to highlight the scope for centralisation to generate problems, lest its advocates proceed in ignorance of the potential pitfalls.

Naturally, the precise skills of the technical workforce vary according to particular roles under consideration. To the extent that it is possible to generalise, the current situation is as follows: mechanical and electronics workshop technicians tend to have vocational qualifications such as HNCs and HNDs; most, though not all, general support technicians have vocational qualifications; research laboratory and analytical services technicians tend to have either vocational qualifications such as HNCs or – especially in the case of the younger occupants of these roles – undergraduate degrees; those teaching technicians whose formal duties are confined to preparing materials and equipment for teaching that is actually carried out by academics and PhD student demonstrators mostly have PhDs, while those whose formal duties extend to the actual teaching are more likely to have a BSc; finally, technical or experimental officers usually have advanced degrees, mostly PhDs. For the most part, this qualifications profile is thought to be a decent match to departments' needs. There are, however, signs that changes in the kind of research that is being done, and in the technology that is used to carry it out, are leading to changes in the skills that departments would like their technicians to have, as exemplified by the increasing demand for mechatronic skills (especially in the case of physics and engineering technicians) and for analytical and data-handling skills (in the case of chemistry and biological sciences, in particular).

The age profile of the technicians in chemistry, engineering and physics departments in the sample is giving rise to an emergent succession planning problem, with around half of the technicians in those departments due to retire within the next 15 years. The issue of succession planning is less pressing in the case of the biological sciences, where the average age of technicians is only in the low

40s. The departments' approach to succession planning varies primarily with the availability of skilled labour on the external labour market: where it is easy to hire suitably skilled workers, as is the case for departments of chemistry and biological science, departments rely primarily on recruitment as the primary succession planning tool; where skilled workers are in short supply, as is true of the case of the mechanical and electronics workshop technicians on which departments of engineering and physics in particular rely, then many departments have turned – or are seriously considering turning – to apprenticeship training as a means of succession planning. Recruitment, in the case of biological sciences and chemistry departments, and apprenticeship training, in the case of physics and engineering departments, is also viewed as a means of updating the skills of the technician workforce so that they are more in tune with the current requirements of research support in particular. At present, there is a need for better dissemination of information about apprenticeships to departments, and there may also be more scope than is currently being exploited for departments in different universities to work together on their apprenticeship programmes, possibly via some kind of group training arrangement, so that they have the critical mass required to persuade local further education colleges to respond to their needs. At present, there must be doubts about the sustainability of both strategies: the current financial climate may militate against the continued use of apprenticeships if universities prioritise short-term financial savings over long-term technical support; while the reliance on graduates may ultimately prove unsustainable if the increase in student fees leads to fewer people attending university, thereby reducing the supply of graduates.

Ongoing training for technicians still tends to be provided in a rather piecemeal fashion that often appears to be related more to the emergent requirements of teaching and research than to the long-term career development needs of individual technicians. One catalyst for remedying the lack of structured skill development of the kind that might help technicians to forge satisfying careers is the proposed technician registration scheme, satisfying the requirements which might help to provide both a focus and a catalyst for ongoing technician training. The 'flat' organisational structure of universities allows room for only a small number of senior technician positions, relative to the size of the technician workforce as a whole, and therefore seems likely to place an insuperable barrier to career advancement for more than a small number of technicians within any one department or university. A well-designed registration scheme would provide a means for technicians to signal their ability and skills to employers, with the achievement of registered status acting as a passport that might help technicians to secure a move to a better job at another employer, thereby helping them to forge a more satisfying career.

REFERENCES

Barley, S.R. (1996). 'Technicians in the Workplace: Ethnographic Studies Evidence for Bringing Work into Organization Studies.' *Administrative Science Quarterly*, 41: 404-41.

Barley, S.R and B.A. Bechky (1994). 'In the Backrooms of Science: The Work of Technicians in Science Labs.' *Work and Occupations,* 21: 85-126.

Barley, S.R and J. Orr (1997). 'Introduction: The Neglected Workforce.' In S. Barley and J. Orr (eds.) (1997), *Between Craft and Science: Technical Work in US Settings*. Ithaca and London: Cornell University Press.

DBIS (2009a). *Skills for Growth: The National Skills Strategy*. Cm 7641. London: TSO.

DBIS (2010). 'New Champion for Skilled Technicians.' Press release 6th April 2010. http://www.whitehallpages.net/news/archive/319441. Accessed 25th February 2011.

DIUS (2009). *The Demand for Science, Technology, Engineering and Mathematics (STEM) Skills*. London: Department for Innovation, Universities and Skills.

Evidence Ltd (2004). *Highly Skilled Technicians in Higher Education: A Report to HEFCE by Evidence Ltd*. Leeds: Evidence Ltd.

HEaTED (2009). *HEaTED Survey 2009: Full Report*. Available online at: http://www.heated.ac.uk/uploaded/survey_pages/HEaTEDSurveyFullReport.pdf. Accessed 25th February 2011.

HEFCE (2010). 'The Higher Education Workforce Framework 2010. Main Report.' Bristol: HEFCE. Available online at: http://www.hefce.ac.uk/pubs/hefce/2010/10_05a/10_05a.pdf . Accessed 3rd January 2011.

Humphris, A., M. Kleiner and M. Koumenta (2010). 'How does Government Regulate Occupations in the UK and USA? Issues and Policy Implications.' Unpublished paper, London School of Economics.

IoP and RSC (2010). *Follow-up Study of the Finances of Chemistry and Physics Departments in the UK*. London and Cambridge: Institute of Physics and Royal Society of Chemistry.

Keefe, J. and D. Potosky (1997). 'Technical Dissonance: Conflicting Portraits of Technicians.' In S. Barley and J. Orr (eds.) (1997), *Between Craft and Science: Technical Work in US Settings*. Ithaca and London: Cornell University Press.

Mason, G. (2001). 'The Mix of Graduate and Intermediate-level Skills in Britain: What should the Balance be?' *Journal of Education and Work*, 14: 5-27.

OECD (2002). *Frascati Manual: The Measurement of Scientific and Technological Activities: Proposed Standard for Surveys of Research and Experimental Development.* 6th edition. Paris: OECD.

PA Consulting (2010). *The Future Workforce for Higher Education: A Report to HEFCE by PA Consulting Group*. London: HEFCE. Available online at: http://www.hefce.ac.uk/pubs/rdreports/2010/rd03_10/rd03_10.pdf Accessed 23rd February 2011.

Royal Society (1998). *Technical and Research Support in the Modern Laboratory*. London: The Royal Society.

Ryan, P., H. Gospel and P. Lewis (2007). 'Large Employers and Apprenticeship Training in the UK.' *British Journal of Industrial Relations*, 45: 127-53.

Sainsbury of Turville, Lord (2007). *The Race to the Top: A Review of Government's Science and Innovation Policies*. London: HM Treasury.

Sandford Smith, D., P. Lewis and H. Gospel (2011). 'Technician Registration.' In *Technical Education for the 21st Century*. London: The Gatsby Foundation. Available online at: http://www.gatsby.org.uk/techedu.html Accessed 2nd April 2011.

Scarselletta, M. (1997). 'The Infamous "Lab Error": Education, Skill and Quality in Medical Technicians' Work'. In S. Barley and J. Orr (eds.) (1997), *Between Craft and Science: Technical Work in US Settings*. Ithaca and London: Cornell University Press.

Shapin, S. (1989). 'The Invisible Technician.' *American Scientist*, 77: 554-63.

Stevens, M. (1999). 'Human Capital Theory and UK Vocational Training Policy.' *Oxford Review of Economic Policy*, 15: 16-32.

Technician Council (2011). 'Presentation – The Technician Council.' London: The Technician Council.

THES (2008). 'Labs at Risk from Loss of Expertise.' *Times Higher Education Supplement*, 4th January.

THES (2009). 'Labs Face Crisis due to Shortage of Technicians.' *Times Higher Education Supplement*, 16th April.

Toner, P., T. Turpin, R. Woolley, and C. Lloyd (2010). 'The Role and Contribution of Tradespeople and Technicians in Australian Research & Development - An Initial Study.' University of Western Sydney: Centre for Industry and Innovation Studies.

Unwin, L. and A. Fuller (2004). *National Modern Apprenticeship Task Force Employers: Their Perspectives on Modern Apprenticeships*. University of Leicester: Centre for Labour Market Studies.

Whalley, P. and S. Barley (1997). 'Technical Work in the Division of Labour: Stalking the Wily Anomaly.' In S. Barley and J. Orr (eds.) (1997), *Between Craft and Science: Technical Work in US Settings*. Ithaca and London: Cornell University Press.

APPENDIX 1: SUMMARY OF FINDINGS IN THE CASE OF BIOSCIENCE DEPARTMENTS

1. DESCRIPTION OF THE CASES

The research project involved case studies of 13 Departments, Schools, and Faculties of biological science drawn from 9 different universities (6 pre-1992, 3 post-1992). The 9 pre-1992 cases were drawn from 6 different universities and encompassed a range of different types of department, including: very large multi-department faculties covering a range of sub-disciplines within biological science, broadly understood; large unified departments of biological science, again covering a range of sub-disciplines; smaller, relatively autonomous departments associated with a particular sub-discipline; and, in one case, a single department drawn from within a larger, multi-department faculty of biological science. The 4 post-1992 departments were all situated within larger Faculties, encompassing other disciplines related to biological science (e.g. health sciences, forensic science). The range of sub-disciplines covered by the cases includes anatomy, biochemistry, cell biology, pharmacy, plant science, and zoology. 28 interviews were carried out, involving 11 academics and 18 technicians/technical services managers. A summary of the key attributes of the departments in the sample can be found in Table A1:

Table A1: Summary of the attributes of the sample of biological science departments

	Academics	Postdocs	Undergraduates	PhD	Technicians	Technical/ Experimental Officers
Mean	52	67	552	92	37	3
Maximum	221	268	1888	377	174	17
Minimum	16	2	116	4	9	0

The ratio of academics to technicians and technical officers varies from a low of 0.81 academics per technician to a high of 2.2 academics per technician over the 9 pre-1992 departments in the sample, and from a low of 1.1 to a high of 2.3 in the case of the post-1992 universities. If departments are weighted according to their size, as indicated by the number of academics they employ, then average ratios are 1.3 and 1.9 academics per technician in the pre- and post-1992 departments respectively.

Almost every department had experienced a considerable decline in the number of technicians over the past 10-15 years, with the technical workforce declining by 50% or even 70% in some cases. While interviewees from 2 departments argued that they had previously been overstaffed, and that the reduction in technician numbers had posed no problems, representatives of other departments said that the changes had had a detrimental impact, either on the volume of practical work undertaken by students (4 cases), or on the ability of the department to deal with the absence of staff due to illness or off-the-job training (2 cases). As one interviewee said, 'We could do with 20% more technicians to give us breathing space.' Representatives from three of the post-1992 universities in particular indicated that the level of technical support they received was insufficient to enable them to meet the increasingly demanding targets they are being set for research and external consultancy work they are being set by their universities as well as supporting the teaching required for their burgeoning undergraduate and MSc programmes.

2. THE NATURE AND ORGANISATION OF TECHNICAL SUPPORT

The technical workforce employed in the pre-1992 departments of biological science visited for this study is characterised by a division of labour between a number of different technician roles. While the exact name given to each role, and the precise allocation of tasks between them, sometimes varies between departments, and while some departments do not contain examples of every role, the following list provides a reasonably accurate, broad-brush account of the different types of technician: infrastructure technicians; research laboratory technicians; facilities technicians; experimental officers; mechanical and electronics workshop technicians; and teaching technicians. We shall briefly consider each group in turn.

Infrastructure technicians – sometimes also called 'stores' or 'floor technicians' - support teaching and research by carrying out basic duties such as warehousing, waste disposal, washing glassware, decontamination, sterilisation, autoclaving, potting, and dealing with gas and liquid nitrogen cylinders. In some, larger departments they may also assist in the preparation of media and microbiological plates. A second category of technician, namely research technicians, supports the activities of the scientists in the specific laboratories to which they have been allocated. That support takes a number of different forms, ranging from generic laboratory support – including media preparation, decontamination, sterilisation/autoclaving, maintaining and repairing equipment, cell and tissue culture, and preparing microbiological plates – to carrying out more advanced experimental procedures and compiling and analysing the data that is generated by those experiments. Research laboratory technicians will also often instruct PhD and project students in how to perform experimental techniques and in the use of scientific instruments and equipment. More senior research and infrastructure technicians often take on managerial responsibility for one or more laboratories. Their duties will include budgeting, keeping basic accounts, sourcing and ordering supplies, maintaining equipment, ensuring compliance with health and safety regulations, carrying out risk assessments, helping with the induction of new PhD and postdoctoral researchers into their laboratory, and managing more junior technicians. In virtue of their long tenure and substantial experience, senior laboratory managers in particular are an important part of the 'institutional memory' in departments and, by assisting with the handover from one postdoctoral researcher to another, they provide an important source of continuity in laboratories and research groups.

Facilities technicians also primarily support research. Some specialise in particular instruments and experimental techniques/processes - such as DNA sequencing, electron and confocal microscopy, flow cytometry genomics, histology, HPLC, mass spectrometry, microarray, NMR, and proteomics – while others are expert in the kind of work that is done in animal houses and greenhouses (e.g. *in vivo*, horticulture). In three of the departments considered here, all of which are located in pre-1992 universities, the facilities technicians are supplemented by experimental officers. On average, there are 12 experimental officers in each of those three departments. Experimental officers, or scientific officers as they are also sometimes known, stand part way between academics and technicians in the academic hierarchy. They resemble technicians because they provide a *service* to researchers and students, based on their knowledge of and expertise in the use of particular instruments and/or experimental techniques (of the kind listed above).

But in other respects they are more like academics. As we shall discuss in more detail below, they are more likely to provide a significant intellectual contribution to research projects that will be recognised by their being named as authors on scientific papers. Relatedly, they are more likely than other kinds of technician to possess academic – as distinct from vocational – qualifications, in particular higher degrees. The ability to provide high-quality technical support for research projects demands a sound knowledge of underlying biological principles, of a kind usually acquired through an undergraduate degree, so that experimental officers in the biological sciences usually possess at least an undergraduate degree, with a majority of the experimental officers employed by the departments considered here also having a PhD (obtained either prior to them taking up their current position or whilst they were in post in virtue of their contribution to the research of the groups they support). In this respect also they resemble academics. Finally, in some of the departments visited here, experimental officers are like academics in being expected to apply for their own grants. In accordance with their position on the academic-technician boundary, experimental officers are usually situated on the academic-related segments of university pay scales.

A number of interviewees reported that research and facilities technicians and, in particular, experimental officers often make an intellectually significant contribution to the research undertaken in their departments. They often have many years of experience in using instruments and experimental techniques for the analysis of the specific subject-matter under investigation in their research group or department. Their expertise and know-how enables them to have a significant input into research projects, by advising researchers on how to prepare their samples, on how to use the relevant instruments or technique in order to gain the data they need, and also on how to analyse and interpret those data. In the words of one experimental officer who specialises in NMR:

Central to making the facility effective and productive is determining the core question the researcher is trying to answer and matching that to solutions that are achievable. Those discussions then [also] help to direct and inform future developments ... in both the technology to acquire and the applications to develop.'

In this way, technicians and, in particular, experimental officers provide a vital input into the generation of scientific knowledge. Five departments reported that technicians' and experimental officers' contributions to research were formally acknowledged through their appearing as named authors on scientific papers.[31]

Traditionally, all of the 9 pre-1992 departments of biological science considered here had its own mechanical and electronics workshop technicians, whose task it would be to design, build, modify and repair the experimental rigs, instruments, and other forms of apparatus used by researchers. The kind of work undertaken by such technicians includes the fabrication of plant and microbiological LED arrays, the construction of electroporator control units and of mounts for confocal

31 Similar remarks were occasionally made about mechanical and electronics workshop technicians. Interviewees from two of the biological sciences departments that had retained a significant number of workshop technicians described them as sometimes having a major input into the technical aspects of research projects. One academic, whose research relies heavily on the ability of workshop technicians to build novel instruments for the measurement of the atomic properties of certain kinds of molecule, expressed this point as follows: 'You're not trying to build a known device. You're trying to make this measurement and the question is, can you build an instrument that works? [The answer emerges through] professional collaboration between technicians and academics ... Such devices, requiring electronics skills and fine mechanics, are not commercially available and we could not do our research without them.' As was more often the case in physics and engineering departments, so in this instance do we also have a situation in which technicians play an indispensable role in solving the technical problems that arise in the course of scientific research. In this case, it should also be noted, the technicians were co-authors on the relevant academic papers.

microscopes, and the development of bespoke electro-mechanical devices that facilitate the measurement of physiological phenomena, as well as more routine maintenance work. Almost invariably, however, these workshop facilities are being either severely reduced in scale or shut down entirely. Four of the 9 pre-1992 departments that once had their own workshops – including one very large integrated department of biological science - have closed them, relying on outsourcing and/or the facilities available elsewhere in the university to satisfy their need for mechanical and electronics support. The remaining 5 departments have all seen considerable reductions in workshop technician numbers, up to the point at which 2 departments now have just one workshop technician. These changes have occurred partly because of a decline in the volume of research support that the workshops were being asked to carry out, which in turn reflected technological changes which made it easier and more economical to send equipment out for repair rather than fix it in-house, and partly because of a desire on the part of universities to exploit the benefits of economies of scale and thereby reduce costs by centralising workshop facilities.

The final role is that of the teaching technician. In most pre-1992 departments, such technicians' formal duties are limited to setting out the equipment and materials required for undergraduate laboratory classes. The teaching itself – the tuition in experimental techniques and the instruction in the use of scientific instruments – is usually provided by PhD student demonstrators. This does not, however, mean that technicians working in pre-1992 are never involved in teaching students. Two kinds of exception can be identified, one formal, one informal. So far as the 'formal' exception is concerned, in one pre-1992 departments of biological science, research technicians from particular laboratories will teach undergraduates on those occasions when practical classes focus on the experimental techniques commonly used by those technicians. Moreover, research and facilities technicians often contribute informally to teaching, for example by advising undergraduate project students on how to use particular pieces of equipment and carry out experimental procedures.

In practice, of course, the division of labour between the different categories of technicians is not always as sharp as the account presented above might suggest. Smaller departments in particular may not be able to support as many specialised technicians as their larger counterparts, and – as a result – often make more use of mixed roles. For example, it may be necessary for research support technicians to carry out some of the tasks that in larger departments are undertaken by specialist infrastructure technicians (e.g. autoclaving, media preparation). In a similar vein, as previewed in the previous paragraph, while the majority of a research technician's time may be devoted to supporting the activities of scientists in his/her laboratory, in smaller departments a fraction of his/her time may formally be allocated to providing teaching support during periods when undergraduate laboratory classes focus on the area of biological science that is the speciality of that technician's research group.

In some of the larger departments, however, the division of labour between different kinds of technician is quite pronounced, and is becoming sharper still as departments attempt to exploit the benefits of specialisation and economies of scale. In the case of a large integrated faculty of biological science, for example, there has been a concerted effort to maximise the amount of time that research technicians spend in the laboratory, providing the more specialised forms of technical support that are their forte, rather than on more generic activities such as glassware, stores, autoclaving, etc.. This has led to a very clear differentiation of tasks between research technicians, on the one hand, and a central, faculty-based pool of infrastructure technicians, on the other. A similar approach has been mooted in another multi-department faculty of biological science, whose administrators are considering moving towards the use of a central, faculty-level pool of specialised infrastructure technicians for those aspects of support that are common to a number of departments (e.g. basic teaching support, cleaning glassware, sterilisation), whilst leaving more specialised research technicians within their 'home' department. The aim of the proposed reform is of course to increase flexibility, exploit economies of scale, and therefore to increase efficiency.

The 4 post-1992 departments of biological science visited for this study have ostensibly moved towards a more centralised approach to technical support, with a view to increasing the flexibility and efficiency with which the technician workforce is used. In all 4 cases, the department is situated within a larger, multi-department Faculty and, formally, the locus of control for the technicians in each case lies at the Faculty rather than the department level. However, in 3 of the departments the technicians are divided into teams that support particular subject groups within their Faculty. Given that those subject groups are usually associated with particular departments, then a good deal of the day-to-day management of the technicians still takes place at the department level. In practice, therefore, the managerial systems in these past-1992 universities are perhaps not quite as centralised as they might appear at first glance.

The majority of the technicians' time in the post-1992 departments is spent supporting teaching. More specifically, two departments suggested that around 80% of their technicians' time is spent supporting teaching, with 20% being devoted to research and consultancy activities. Indeed, only one of the 4 departments visited for this study employed any specialist research technicians, with the people in question having been hired on fixed-term contracts to work on externally funded research projects. Within their broad pool of teaching technicians, all 4 post-1992 departments had a small number of technicians who specialise in the use of particular experimental techniques, procedures and instruments (e.g. HPLC, cell culture, microbiology, NMR, spectroscopy), although – as already noted – such technicians will typically spend considerably more time supporting teaching, and less time on research support, than their counterparts in pre-1992 universities. In all 4 post-1992 departments, the teaching technicians do not simply prepare the materials, apparatus and equipment used in practical classes. They also teach the students, by demonstrating how to carry out experimental procedures and how to use scientific instruments and other pieces of apparatus. More experienced technicians may also help to design some of the experiments.

3. TECHNICIAN WORKFORCE: ORIGINS, AGE, TENURE, CONTRACT TYPE AND QUALIFICATIONS

3.1 ORIGINS

Interviewees were asked to estimate the shares of their department's current technical workforce who were trained in-house via their own apprenticeship or traineeship scheme and recruited from various external sources. Their responses revealed that the predominant source of technicians in biological science departments was external recruitment: all 10 of departments that returned usable data indicated that at least 70% or more of their technicians were recruited externally. The 6 pre-1992 departments who provided data variously estimated that between 10% and 30% of their technicians had come to the department straight from school and had been trained internally, being rotated around a number of teaching and research laboratories and taking vocational qualifications like ONCs, HNCs and City and Guilds via day release at a local college.[32] None of the 4 post-1992 universities had made any use of apprenticeship training, hiring all their technicians from the external labour market.

So far as the source of the external recruits is concerned, while many technicians had previously worked in industry, two other sources of external recruits also figured prominently: 20-30% of the technicians in 3 departments had previously worked as technicians in other university departments; while 6 of the 10 departments indicated that a significant proportion (minimum 20%, on average around 30%) of their technicians were recent graduates, having been hired after recently completing a BSc (sometimes at the same universities, sometimes from other universities).

3.2 AGE PROFILE

The average age of the technicians in the bioscience departments visited for this study is around 41. Roughly 43% of the technicians in those university departments are due to retire within the next 15 years.

3.3 CONTRACT TYPE

Around 80% of the technicians in the 11 departments for which data are available are on open-ended contracts. Some of those 'permanent' positions will of course be partly financed via income obtained through external research grants, a trend that some departments are attempting to encourage as they attempt to reduce their reliance on diminishing HEFCE funding. That figure rises to around 85% if the 4 post-1992 departments are viewed in isolation, which is unsurprising given that they rely less on external research funding than the older universities.

3.4 QUALIFICATIONS

So far as the pre-1992 universities are concerned, research laboratory technicians tend to have either vocational qualifications (such as HNCs, HTEC, and City and Guilds) or, especially in the case of young technicians, undergraduate degrees.

32 Almost all such apprenticeship schemes closed down some 10-20 years ago (though, as we shall see below, one has recently been revived). Perhaps most notably, the pressure on departments to reduce technician numbers over the past two decades militated against taking on apprentices, as also – in some cases – did the propensity of trainees to leave once they had completed their apprenticeship. Another contributory factor was the difficulty of finding appropriate college courses. Until around 10 years ago, one medium sized department of biological science still used to send its trainee technicians to a local further education college for an HNC in applied biology. However, due to declining enrolments, local colleges ceased to offer either that course or a BTEC in Applied Science, so that the department's young technicians now have to receive all of their training in-house.

In around half of the pre-1992 biological science departments visited for this study, some research technicians also possessed a PhD. The picture is similar in the case of facilities technicians: older technicians, along with those working in animal or horticultural facilities, typically possess a vocational qualification; younger technicians may have a BSc; while some of the technicians who work on various kinds of instrument may have an MSc or PhD. As noted earlier, experimental officers typically have PhDs. Unsurprisingly, mechanical and electronics workshop technicians tend to be vocationally qualified. While some infrastructure technicians appear to have been vocationally trained, possessing BTECs or HNCs, many have no formal qualifications beyond those acquired at school. Finally, the greatest variety of qualifications in pre-1992 departments of biological science is to be found in the case of teaching technicians. The most commonly held qualifications appear to be vocational in nature (e.g. BTECs, HNCs). However, a substantial minority of teaching technicians appears not to have received any qualifications beyond those acquired at school, while a still smaller minority are qualified to degree level (or even – in one or two cases – possess higher degrees).

Matters are more straightforward in the post-1992 departments of biological science. All 4 departments had similar qualifications profiles, with a majority (65%+) of their technicians being qualified at least to BSc level, and with many having higher degrees. Indeed, in two departments, nearly half of the technicians had an MSc or PhD. A majority of interviewees felt that, although the technicians employed in these departments do carry out at least some of the actual teaching involved in practical classes, someone with a vocational qualification such as an HNC, along with substantial experience, would be quite capable of doing the job well. In practice, however, for reasons that will be considered below under the heading of 'recruitment', most of the technicians in these departments are qualified to at least first degree level.

A majority of the pre-1992 departments indicated that an undergraduate degree – but not an MSc or PhD - is now a prerequisite for someone wishing to fill a research technician position. Graduates are more likely to have a sound grasp of the scientific principles underlying the research they are supporting, interviewees averred, and are therefore less likely to make errors and more likely to be able to deal with any problems that arise. Many interviewees emphasised that both the nature and also the pace of change in biological science made it especially desirable to recruit graduates for research support roles. So far as the *nature* of change is concerned, the point here is that the development of high throughput sampling and other types of automated experimental procedure implies that the demand for research technicians who can do no more than carry out experimental procedures is likely to decline.[33] Conversely, the demand for technicians who have the scientific understanding and analytical skills required to analyse the data generated by those experiments is likely to increase. Given that the requisite data-handling and analytical skills are most likely to be acquired in the course of a university education, rather than via vocational training, it is unsurprising that universities are looking mainly to graduates to fill research technician roles. The rapid *pace* of change in the kind of experimental procedures used in biological science is also something that, according to interviewees, militates in favour of hiring research

33 The prime example of the nature and pace of technical change in biological science is DNA sequencing: twenty years ago it could not be done; between around 1992 and 2000 departments built up significant capacity in sequencing, relying heavily on manual techniques that required considerable input from technicians; by around 2006, however, automation had advanced to the point where there was significantly less need for technician support for sequencing.

technicians who have a (good) BSc. The reason is that, thanks both to their grasp of underlying scientific principles and also to the general intellectual skills developed during the course of their degree, (good) graduates are thought to be more able to familiarise themselves with new areas of research and to assimilate new techniques than people with only vocational qualifications.[34]

The consensus appears to be that nothing more than a vocational qualification such as a BTEC or ONC/HNC is required both for people providing infrastructure support and also - in those departments where teaching technicians' official duties were confined to preparing the equipment and materials for student practical classes - teaching support. Indeed, some interviewees argued that that the duties carried out by such technicians could quite adequately be carried out by people with no qualifications beyond those acquired at school, so long as the people in question were careful, methodical, and conscientious. In contrast, in those institutions where the teaching technicians were formally involved in demonstrating how to carry out experimental procedures and use instruments, it was thought that the minimum requirement for a teaching technician was either an HNC plus considerable experience or a BSc.

For the most part, interviewees indicated that the skills profile of their technical staff was a good fit for their department's needs. However, it is worth noting two caveats to this general view. First, interviewees from 3 post-1992 departments suggested that because many of their technicians have an MSc or PhD, they tend to be over-qualified for their role. Second, representatives of around half of the pre-1992 departments visited indicated that each of their departments contained some older staff who, partly because of the rapid pace of change in the technical requirements of biological research, and partly because of their own reluctance or inability to acquire new skills, have skills that are increasingly peripheral to their department's requirements. The existence of this problem was often said to be one of the drawbacks of the low labour turnover (well under 10%) that was said to characterise most of the biological science departments visited for this study. Several interviewees observed that, while long-standing staff often have substantial reserves of expertise and know-how, and provide an important source of continuity in research groups and laboratories, their presence can be a mixed blessing. For if the techniques and instruments in which those staff are expert are no longer central to the discipline, having been marginalised by changes either in the kind of science that is being done or in the technology that is used to do it, then low turnover may be problematic, as it can lead to there being technicians who – if they are reluctant to retrain – are less and less useful to the department. The difficulty of finding useful work for such technicians, and the strain that their presence places what is often an already over-stretched capacity to provide technical support, is a source of frustration for technical service managers and academics alike. Higher rates of turnover would help to prevent such situations from developing, with new recruits usually having up-to-date skills and a greater willingness to learn. We shall return to this issue in Section 6 below.

34 This is not to say that it is impossible for someone who is vocationally qualified to display the requisite flexibility, but rather that – as the interviewees saw things - people with degrees are better placed to do so. In practice, so far as new recruits are concerned, the point is moot, simply because most applicants for research technician posts now have a degree.

4. RECRUITMENT

All 13 bioscience departments reported that there was an abundant supply of skilled labour on the external labour market. Advertisements for almost every kind of biological science technician currently elicit large numbers of applicants. Many departments stated that they receive upwards of 40 applicants per post, with 2 reporting over 100 and one over 200 applications for technician jobs. Moreover, even relatively low grade teaching support posts, for which the minimum requirements are an HNC or ONC with some industrial experience, attract interest not only from very large numbers of graduates but also from people with PhDs and postdoctoral experience.

Not all of these applicants are appointable. Some graduates may lack the practical skills required for the job (e.g. they may not know how to carry out basic tasks, such as how to make up a molar solution). Departments typically set practicals tests to weed out such people. Other applicants, especially graduates and people with higher degrees, may fail to appreciate either that teaching technician posts involve a considerable amount of repetitive, mundane work – for example, putting out many sets of the same experimental apparatus for student practicals, and preparing buffers and enzyme solutions - or that research technicians are typically *supporting* scientists and providing them with a service rather than devising and prosecuting their *own* programme of research. Technical service managers involved in recruitment are determined to identify and reject applicants who labour under such misapprehensions, for two main reasons: first, because they want to avoid the discontent and disruption that might ensue when such people's expectations about their jobs are disappointed; and, second, because in the current financial climate they are keen for HEFCE-funded positions in particular to remain filled for a substantial length of time, lest the positions be frozen upon becoming vacant. In the words of one technical services manager, 'A key question is, "Will he stay?"', the reason being that, if the person leaves, 'finance may take the post away'. However, even when unsuitable candidates like those just mentioned are ruled out, departments are adamant that they are able to take their pick of large number of suitable candidates. As another technical service manager concluded, 'It's never a struggle appointing.'[35]

While the labour market for technicians used to be local, with applicants for technician posts mostly coming from the same area as the university that employs them, the past 5 years have seen the market – especially for research technician posts - expand until it has become national or even international in scope, with many departments also receiving numerous applications not only from all over the UK but also from overseas nationals. There is no one profile for recruits. To the extent that it is possible to generalise, recruits to research technician posts tend nowadays to be relatively young people who have recently graduated from university. Teaching support roles are perhaps more commonly taken by older individuals, some – especially in post-1992 universities - with degrees, others with vocational qualifications, and some with no qualifications beyond those they acquired at school. Older people tend to be preferred for teaching support roles because, especially if they have worked in industry, they are thought to be more used to routine work of the kind often undertaken by technicians than younger recruits and therefore more likely to be remain in post for a reasonable length of time, as well as being – in virtue of their age - more mature, more reliable, and better at dealing with young students.

35 The one possible exception to this finding concerns animal technicians, whom some departments find hard to attract.

5. APPRENTICESHIPS

There is little interest in apprenticeships amongst the biological sciences departments visited for this study, primarily because - as noted above - they are inundated with applications for technician positions and therefore perceive little if any need to grow their own technicians in-house. Moreover, according to a number of interviewees, the age profile of the technicians who work in biological science is such that succession planning is not yet a major issue, so there is correspondingly less need for an apprenticeship scheme.

Aside from these two main points, four other factors were adduced by interviewees as deterrents to taking on apprentices. First, the reduction in the number of technicians employed by departments has left them with insufficient spare capacity to countenance employing trainees who will not be fully productive employees almost from the outset. In the words of one technical services manager, 'We don't have sufficient skilled posts to be able to sacrifice one for an apprenticeship.' A second, oft-remarked impediment to participation in apprenticeships is the difficulty of finding a local college that is willing to offer a suitable off-the-job course. As noted earlier, it was the lack of a college willing to offer a relevant HNC that led one department to discontinue its apprenticeship scheme a few years ago. Third, interviewees from two departments were sceptical about whether they would be able to attract good applicants for trainee posts, because such people would most probably want to go to university rather than become apprentices. Finally, 2 departments expressed concerns about the health and safety issues arising from having people who are just 16-18 years of age in laboratories where carcinogenic and radioactive substances are commonly used.

The only case of an apprenticeship scheme for laboratory technicians amongst the 13 departments of biological science visited for this study is to be found in a medium sized department in a pre-1992 university. The department's technicians have what by the standards of biological science departments is a comparatively high average age (in the late 40s). In anticipation of forthcoming retirements, 2 apprentice teaching technicians have recently been recruited. The apprentices are being trained under the auspices of the government's Advanced Apprenticeship scheme, and are studying for a level 3 BTEC in Applied Science (Laboratory and Industrial Science). The formal training contract with the Skills Funding Agency is held by a local FE college, which provides both the off-the-job training for the BTEC and also the assessment for the NVQ component of the apprenticeship framework. Despite formal responsibility for organising the apprenticeship having been passed on to an external training provider, the department's technical service manager noted that there was a considerable administrative burden arising from the scheme. In selecting the apprentices, the department was looking for young people with a minimum of 5 GCSE passes, including maths and science, who did *not* want to go to university and who are likely, therefore, to remain in the department once their training is complete. In practice, the apprentices who were taken on are aged 18 and 19, one having AS levels and the other A levels, though neither harbours ambitions of going to university at this moment in time. While the apprentices have been given 3-year, fixed term contracts of employment, the expectation is that they will be retained once they have completed their training.

6. ONGOING TRAINING

Much of the training provided both for new recruits to technician posts, and also for more established members of the technical staff, is uncertificated and takes place informally, on-the-job. Depending on their level of experience, new recruits may either be sent to the teaching labs in order to acquire basic laboratory skills or, in the case of graduate recruits, given a brief induction and then sent to the research laboratory for which they have been recruited. Once there, they are typically receive on-the-job training in the relevant experimental techniques, and in the use of the relevant instruments, either from an academic or an experienced technician. Interviewees said that this reliance on informal, uncertificated training was to some extent inevitable, because some of the techniques used in research laboratories are relatively new and therefore have not been absorbed into standard training programmes. As one technician put it, 'By definition, because we do research the techniques are new and, therefore, aren't certified.' On occasions, such training becomes more formal, as in one large department where there is an ongoing technical seminar series covering both techniques and more general issues (e.g. career development). Departments also often send their technical staff on training courses provided by their own university in the health and safety procedures required for dealing with the carcinogens, biological agents, and radioactive materials often used in biological science departments, as well as technical training in the use of HV trans illuminators and laminar flow cabinets. University staff development units also provide technical staff with various forms of training, to develop their personal, IT, and managerial skills.

Equipment manufacturers are a significant source of external training for established technicians. The departments of biological science visited for this study have received vendor-supplied training in, for example, DNA sequencing, confocal and electron microscopes, NMR spectroscopy and x-ray crystallography. Typically, such training accompanies the purchase of new instruments or the development of new software for the equipment in question. Occasionally, technicians are sent on formal training courses offered by other universities (e.g. in NMR, bioinformatics). Interviewees from 2 departments said that they had sent some technicians on HEaTED training courses.

Few of the departments of biological science visited for this study appear to make much use of certificated vocational training for their established technicians. While 4 departments would like to send some of their infrastructure and teaching technicians for HNCs in Applied Biology, only one of them has been able to find a local college willing to offer the course. Only two of the 13 departments have used NVQs. In neither case has the experience been a happy one; the NVQs are thought to be overly bureaucratic and to involve little actual training, and are therefore unlikely to be used in the future. Some departments have sent their technicians to local colleges for formally certificated NEBOSH health and safety training.[36] Only one department reported having supported a technician to an undergraduate degree whilst (s)he was in post. It is more common for departments to sponsor technicians for advanced degrees, with 3 departments having sponsored some of their current technicians for MSc degrees and 5 having done so for PhDs.

36 An important exception to this general picture of relatively limited use of certificated vocational training concerns those departments of biological science that use animals in their research. Home Office regulations require research establishments that use animals to have suitably trained staff. Consequently, the animal technologists who work in departments that use animals will have received formally certificated vocational training (e.g. offered by the Institute of Animal Technology).

While interviewees indicated that the identification of the training needs of established technical staff is gradually being formalised through the implementation of personal development reviews, it is still often described as *ad hoc*, being driven more by the demands of current circumstances – for example, upcoming research projects – rather than by a systematic appraisal of the long term needs of the technicians themselves. Moreover, when training needs are identified, some interviewees highlighted various impediments to their satisfaction. First, interviewees in one post-1992 and 3 pre-1992 departments noted that, because of limited spare technical capacity and the increasing pressure to carry out research, some academics are reluctant to allow the technicians who support their groups to spend time away from the laboratory, either for off-the-job training or to broaden their skills by spending time in other laboratories. One consequence is that the technicians in question end up with a rather narrow range of skills, whereas they would be better served in the long term by having a greater range of expertise. As one academic said, departments should – but, all too often, do not – give technicians 'as broad an experience as they can so they can acquire [more] transferable skills'. The danger is that if technicians specialise too much, 'people who stay in one group for a long time might not be employable elsewhere.' We shall return to this issue below, when we discuss the scope for technicians to forge a satisfying career within university bioscience departments. Second, technical services managers in two universities remarked that 'funding is getting tight' and that it would be harder to support requests for training than in the past. Third, if finding the time and, perhaps increasingly, the money to provide training for established technicians is problematic, then it also has to be said that on occasions it is hard to persuade some technicians to avail themselves of opportunities to augment their skills. Interviewees from 7 pre-1992 departments remarked that some older technicians in particular may have found their niche in their current role and be reluctant to acquire new skills, even though doing so may be required not to further their chances of promotion to a higher grade role but simply to keep pace with the rapidly changing requirements of their discipline. One technical services manager described the situation as follows: 'People do get set in their ways; when they reach a certain age they [sometimes] become less willing and less able to learn new skills ... [so] they struggle with the new technology.' This reluctance to train can be problematic for technical services managers and heads of department, who – as noted earlier - may be confronted with technicians whose skills are increasingly out of date and irrelevant for the department's current needs, and for whom it is therefore increasingly difficult to find useful work. While the use of early retirement and voluntary severance schemes has helped to alleviate problems of this kind, it has not eliminated them completely and several departments continue to struggle with the challenge of finding useful work for older technicians whose skills have become increasingly irrelevant to the current requirements of their role.

7. BROADER HR ISSUES AND CAREER PROGRESSION

Interviewees at all but one department reported that the move to the common pay spine in 2005 had gone smoothly and had not generated major discontent amongst technicians. Of greater concern at present, in at least some departments, is the fact that many technical staff have reached the top of the segment of the common spine associated with their current grade. This implies that the scope for them to receive additional increases in pay beyond those agreed in national negotiations for academic staff is very limited. Managers in three biological sciences departments in particular said that this had led to some unhappiness within the ranks of their technicians.

One way for technical staff to deal with this problem is, of course, to seek promotion. However, while - as already noted - some technicians have found their niche or comfort zone in middle-ranking roles, and as a result do not seek further advancement, many interviewees said that other technicians had expressed frustration at the lack of opportunities for promotion. The main cause of the problem lies in the relatively small size and 'flat' organisational structure characteristic of university science departments, which means that there are typically only a very small number of senior laboratory and technical services manager positions in any one department. The low turnover rate amongst technical staff implies that, once filled, such roles are likely to remain occupied for many years, eliminating the scope for other technicians to be promoted into them. As one technician said, using a phrase that was often used to describe the limited opportunities for career advancement available to technicians, 'It's dead man's shoes.' A partial substitute, adopted in some departments, is for technicians to develop their existing role by assuming additional responsibilities until the role warrants re-grading. However, such an approach cannot come close to solving the problem of limited promotion opportunities, not least because the scope for using it is of course limited by the total set of tasks that the department needs to have carried out.

If the scope for promotion within one's department is limited, then one might have expected technicians to look outside their department when seeking to advance their career. While inter-departmental moves of this kind do happen, they are not especially common, reflecting what a number of interviewees described as the 'rather parochial' attitude of many technicians. Many older technicians in particular are said to be reluctant to move to a new laboratory within the current department, let alone to a different department. Moreover, according to a number of interviewees, to the extent that biological science technicians are willing to move between laboratories and departments, their efforts to do so may be hampered by their having acquired only the narrow range of skills required for their current role. Here we return to points mentioned earlier, namely that – according to several interviewees – departments/academics need to be more willing to offer, and technicians themselves need to be more willing to exploit, opportunities for training in a broader set of skills than is required for their current role. Doing so will enable technicians not only to move more freely to seek promotion but will also – as one interviewee put it – furnish them with an 'exit strategy' in case changes in science and technology eliminate the need for their current post.

APPENDIX 2: SUMMARY OF FINDINGS IN THE CASE OF CHEMISTRY DEPARTMENTS

1. DESCRIPTION OF THE CASES

The research project involved case studies of Departments and Schools of Chemistry in 11 universities, 10 of them of the pre-1992 variety and one being a post-1992 university. 17 interviews were carried out, involving 8 academics and 14 technicians/technical services managers. The key attributes of the departments in the sample are summarised in Table A2:

Table A2: Summary of the attributes of the sample of chemistry departments

	Academics	Postdocs	Undergraduates	PhD	Technicians	Technical/ Experimental Officers
Mean	42	60	470	145	20	5
Maximum	60	180	706	215	32	16
Minimum	20	14	304	15	8	0

The ratio of academics to technicians and technical officers ranges from a low of 1.1 academics per technician to a high of 2.9 academics per technician. Weighting departments according to their size, as measured by how many academics they contain, then the average ratio is about 1.8 academics per technician.[37]

Almost all of the departments said that there had been significant reductions in the number of technical staff over the past 15 years. Technician numbers have declined, relative to the number of academics and students requiring support, to such an extent in 5 departments that, while they can just about meet all the demands on their time when their full complement of technicians is present, they cannot do so when technical staff are absent, either due to illness or because they are away on a training course. In the words one technical services manager, 'When everyone's here, we're just about able to cope. During periods of illness, or if two people are on leave, we struggle.' What this means in practice is that, for example, academics or PhD students or research technicians have to be taken away from their main jobs in order to assist in undergraduate laboratory classes, and researchers have to wait longer for their technical needs to be met than was the case in the past.

37 An earlier study of the finances of 14 chemistry departments circa 2007-08 also reported a ratio of one permanent technician post for every 1.8 permanent academic posts (IoP and RSC 2010: 12-13).

2. THE NATURE AND ORGANISATION OF TECHNICAL SUPPORT

There is considerable similarity in the organisation of technical support across the 10 pre-1992 chemistry departments visited for this project. Typically, and with exceptions noted below, the technical workforce is divided into the following broad categories of worker:

- Research technicians
- Health and safety officers
- Scientific glass blower
- Analytical facilities technicians
- Mechanical and electronics workshop technicians
- Stores technicians
- Teaching technicians

Research laboratory technicians are typically involved in providing basic support for their research laboratory, including purifying and distilling solvents, preparing chemicals, cryogen refills, dealing with gas cylinders, making up thin liquid chromatography plates, ordering supplies, and carrying out minor repairs to equipment. They will help to set up equipment for researchers and will provide assistance in conducting experiments, as well as preparing and collating results for analysis. They may also carry out various forms of chemical analysis using spectrophotometers, mass spectrometers, NMR spectroscopy and gas chromatography, as well as liaising with other technical staff in the department – in analytical services, for example, and in the workshops – about meeting their research group's technical needs. They will also help to introduce PhD and project students to the laboratory and associated equipment, thereby helping to ensure continuity in laboratories, and ensure compliance with health and safety regulations. Senior research technicians will be more involved in helping to design experiments and in interpreting results. They will also be involved in the management of laboratories or even, in the case of larger departments, entire floors of departments (containing several laboratories). Their managerial duties will include budgeting and accounts, sourcing and ordering supplies and equipment, carrying out risk assessments, ensuring compliance with health and safety regulations, and managing junior technicians.

All but one of the pre-1992 departments visited for this study had research technicians. In the one department that did not, some of their duties – such as preparing solvents and dealing with glassware – had been taken on by stores technicians. 4 of the department visited have technicians as designated health and safety officers. 9 of the 11 departments also have their own scientific glassblower, who although based in the department of chemistry in many cases also provides services for other university departments.

As their names suggests, analytical facilities technicians support research by helping to provide various services pertaining to the analysis of the properties of chemical compounds and molecules. The analytical facilities in question include, to name but the most common, NMR spectroscopy, mass spectrometry, HPLC, microanalysis and X-ray diffraction. The technicians who work on such facilities sometimes work under the supervision of an academic or an experimental officer. Experimental, technical, or scientific officers – as they are variously known - occupy intermediate positions, part way between academic and technician roles, in the 'academic related' part of the university hierarchy. Every one of the 10 pre-1992 chemistry departments visited for this study contains experimental officers.[38] The precise number varies from 2 experimental officers in one medium-sized department to 16 in one of the larger departments, with an average of around 5 such positions across the sample as a whole. The experimental officers found in chemistry departments tend to specialise in the use of analytical facilities such as NMR spectroscopy, mass spectrometry, HPLC and x-ray crystallography. Experimental officers' and analytical services technicians' expertise in the experimental techniques associated with such facilities, often honed over many years of experience, enables them to advise scientists on how to design experiments and prepare samples for analysis, on how to optimise the instruments so that they are appropriately set up for the task at hand, and also on the analysis and interpretation of the data that are generated (e.g. by refining and interpreting x-ray diffraction data in order to infer the structure of the molecule or crystal being analysed). In the words of one technical services manager:

> *'You need their [analytical service technicians' and experimental officers'] expertise to properly validate and interpret results (for example, spectra) ... the technicians interact with the academics and help them to identify what the data is* [sic] *saying.'*

Indeed, interviewees at one department reported that an equipment manufacturer had sent its own technicians to the university in order to learn the new HPLC techniques that the department's technicians had devised. In all these ways, analytical services technicians and experimental officers often make an invaluable contribution to the research that takes places in their departments.[39]

The ability to contribute to research projects in this way usually requires not only considerable technical know-how but also a sound knowledge of the physical and chemical principles underlying both the instrument being used and domain of chemistry being investigated, which is why experimental officers are usually qualified to at least BSc level. A majority of those considered here also have a PhD, the latter sometimes having been acquired whilst its bearer was in post as an experimental officer. An indication of the importance of the contribution made by experimental officers to research projects in the chemistry departments visited is the fact that they are often named as authors on scientific papers, with many experimental officers having substantial numbers of publications.[40]

Seven departments, all situated in pre-1992 universities, have retained their own mechanical and electronics workshops, although in 5 of those cases the number of workshop technicians has declined considerably over the past few years. This reflects space and salary costs and also the reduced demand for workshop services, partly as a result of fewer repairs being done in house and also due to

38 There was no experimental officer in the one post-1992 chemistry department studied for this project.

39 Interviews in chemistry departments also suggested that the mechanical and electronics workshop technicians have a significant input into the technical aspects of research projects, along the lines described in more detail elsewhere in this report in the case of engineering and physics departments. As one technical services manager put it: 'It's a two-way conversation. The PIs [principal investigators] will have an idea but they won't [necessarily] have thought through its technical feasibility. The technicians will come up with suggestions and, via several rounds of conversation, come up with something that does the job the PI wants it to do.' Another interviewee thought that it would be more accurate if his department's mechanical workshop was referred to as a 'development and design workshop' in recognition of the fact that it did far more than simply produce standard items.

40 Interviewees in two departments also reported that experimental officers often also assume a managerial role, not just with regard to particular analytical facilities, but also within the associated research group, taking charge of the day-to-day running of the group on behalf of the academic group leader and training PhD students in the relevant experimental techniques.

a shift in the focus of research away from areas that require extensive workshop support and towards topics that demand less support. In 3 other pre-1992 universities, attempts to exploit economies of scale and reduce costs have led to a situation in which the department of chemistry now shares a mechanical workshop with other department (in one instance with a department of biology and in two cases with a department of physics). In at least one of these cases, the shared workshop still contains dedicated chemistry technicians who are the first port of call for the academics from the chemistry department who need technical support.

Technical support for the one post-1992 department of chemistry in the sample is provided by a broader faculty-level pool of technicians, who service a variety of departments in the biological sciences as well as chemistry, and from a shared, faculty-level workshop. The rationale for this approach is that, because technicians are line managed at the faculty level rather than within departments, there is greater flexibility to reallocate them between tasks and departments as circumstances demand, leading to a more responsive and economical service.

There are ongoing technical reviews at two of the pre-1992 universities visited as part of this study. In one case, the possibility of the centralisation of a chemistry department's mechanical workshop is under consideration. In the other, a move towards something akin to the 'shared services' approach adopted in the post-1992 university is being considered, whereby those elements of technical support that are generic in the sense of being common to a number of departments (e.g. basic teaching support, cleaning glassware, autoclaving) might be taken out of departments and provided by a central, faculty-based pool of technicians. The aim – as in the post-1992 university – is to exploit economies of scale and increase efficiency.

All of the departments considered here have a cadre of dedicated teaching technicians. In a majority (8 out of 11) of those departments, the teaching technicians do little formal *teaching*. Typically, the task of instructing undergraduates in the relevant experimental techniques is carried out by academics, PhD students, and postdoctoral researchers, with the teaching technicians *facilitating* that teaching by preparing the requisite materials, apparatus, and instruments but not actually carrying it out themselves. The three main exceptions to this general rule are all found in departments – two pre-1992, one post-1992 – where a majority of the teaching technicians have BScs and are formally involved in demonstrating how to use the instruments and in teaching experimental techniques. In two other departments, the technician who has taken on the role of laboratory manager has a graduate degree and assists academic staff in designing and running undergraduate practicals. In practice, of course, technicians' contribution to teaching often extends beyond the limits just described, with technicians of all kinds providing *informal* advice and assistance to students on how to use instruments and carry out experimental procedures both in laboratory classes and also – in the case of project students - in research laboratories.

While it is undoubtedly always the case that the division of labour within chemistry departments was never quite as sharp as the account presented above might suggest, as evidenced by the fact that teaching and analytical services technicians have typically provided informal instruction to undergraduate project students, the distinctions between different roles appear to be being eroded on the margins in at least some departments, as hard-pressed technical service managers struggle to find a way of dealing with declining technician rolls. In particular, 4 of the departments visited have in the relatively recent past begun to allocate their technicians not only a primary but also a secondary role, whereby they act as a backup to the person whose main job it is to, say, provide NMR or x-ray services, filling in for that individual when (s)he is absent. 'The substitutes may not have the same level of expertise as the primary role holder,' one technical services manger commented, 'but [they] can at least keep things ticking over.' And by adopting such a strategy, department managers hope to be able to increase their ability to respond flexibly to both unforeseen and planned staff absences (e.g. for training).

3. TECHNICIAN WORKFORCE: ORIGINS, AGE, TENURE, CONTRACT TYPE AND QUALIFICATIONS

3.1 ORIGINS

Departments were asked to estimate the shares of their current technical workforce who were trained in-house and recruited externally. All but one of the 10 departments that provided data suggested that at least half of their current technical workforce was recruited from the external labour market, with 7 of the departments in the sample indicating that recruitment accounted for over 60% of their workforce. The exception to this general pattern was a large department of chemistry in a pre-1992 university that had for many years run its own apprenticeship scheme through which many of its older technicians had been developed. As this example illustrates, the technical staff who are 'home grown' are usually older staff, who were trained in-house under old university technician apprenticeship schemes, most of which ceased operation well over a decade ago, or via Youth Training Scheme which existed in the 1980s. Some younger stores and teaching technicians may also have been trained internally, almost invariably by means of informal on-the-job training (rather than via an apprenticeship scheme).

The major sources of external recruits were industry and other university departments, each of which on average accounted for around 30% of the current technical workforce. In 4 cases, a small number of younger technical staff entered the technical workforce direct from a department's own undergraduate programme. In one exceptional case, where an unusually high percentage of the department's technical staff were experimental officers, and where a number of research technicians had followed an academic rather than a vocational route, 30-40% of the technical staff were estimated to have been recruited to the department directly from university, either as recent graduates or newly minted PhDs.

3.2 AGE PROFILE

Despite the fact that 6 of the 9 chemistry departments who were able to provide data on the age profile of their technician workforce have implemented early retirement and voluntary severance schemes in the recent past, the average age of the technicians in those 9 departments is about 47. Roughly 43% of the technicians in those university departments are due to retire within the next 15 years.

3.3 LABOUR TURNOVER AND TENURE

Turnover amongst the technician workforce is low, and large numbers of technicians - amounting to over 50% of the technician workforce in some cases - have been in post for over 20 years.

3.4 CONTRACT TYPE

Around 87% of the technicians in the 10 departments for which data are available are on open-ended contracts (though some of those positions will be financed at least in part via income obtained from external research grants rather than from core HEFCE funding). The vast majority of the technical staff who are on fixed-term contracts are concentrated in two pre-1992 departments, in each of which about 1/3 of the technical workforce is on a fixed-term contract. No other department in the sample has more than a couple of staff in fixed-term positions.

3.5 QUALIFICATIONS

Moving on to the qualifications possessed by members of the technical workforce, technical or experimental offers tend almost exclusively to be qualified to BSc or PhD level. In every department visited for this study, the analytical facilities technicians tended to have a mixture of BScs and vocational qualifications such as an HNC in chemistry, as did - in all but one case – the research laboratory technicians.[41] Almost without exception, interviewees viewed the fact that departments' research technicians typically have a mixture of HNCs and BScs as a good match to their departments' requirements. However, there were differing opinions about whether there would need to be a greater reliance on research technicians with academic qualifications in the future. Some interviewees argued in particular that changes in technology are increasing the extent to which tests and procedures that had to be done manually in the past can now be automated. The upshot, those interviewees maintained, is that in future there is likely to be less of a demand for technicians who can carry out practical procedures and more of a need for technicians who can design automated experiments and analyse the data produced by them. Given that the requisite computing, data-management and analytical skills are more likely to be acquired through degree programmes than through vocational education and training, this line of reasoning suggests that that the demand for research technicians with BScs is likely to increase relative to those with vocational qualifications. And, as we shall see below, it so happens that in practice departments *do* seem to be recruiting more people with BScs to research technician posts, though - as we shall also see - at least at present this may have more to do with the fact that departments advertising for technicians are inundated with applications from graduates.

Two findings common to all the departments in our sample are that the mechanical and electronics workshop technicians employed in chemistry departments tend to have vocational qualifications - such as City and Guilds, HNCs, and BTECs - with just one or two in each of 3 departments possessing a BSc, and that few stores technicians possess any qualifications beyond O-levels or GCSEs.

Matters were a little less clear cut when it came to the qualifications of teaching technicians. Here, practice appeared to differ quite markedly between departments, usually – but not invariably – according to how significant a role the technicians played in teaching students. In those departments where laboratory classes were taken primarily by PhD students and postdoctoral researchers, teaching technicians tended to be qualified to vocational level, typically possessing an HNC in chemistry, but with some possessing BScs. The experience of those departments lends some support to the view that an HNC is a suitable qualification for such technicians, for two main reasons. First, in one department whose teaching technicians were not qualified beyond GCSE/O-level, it was felt that their lack of training was a disadvantage and that the department would benefit if they took an HNC. Second, interviewees in 3 departments where teaching technicians' formal duties were confined to preparing the materials and equipment from practical classes that were actually taught by PhD students and postdoctoral researchers felt that those teaching technicians who had a BSc rather than an HNC were over-qualified, given the often rather mundane tasks they are required to carry out.

41 The two exceptions to this general pattern were a pre-1992 department where all three analytical services technicians had PhDs, and a pre-1992 department in which all of the research technicians possessed an HNC.

The situation was rather different in those departments where the teaching technicians either currently play a significant role in instructing students in experimental techniques, or where the department would like them to do more actual teaching in the future. In the three cases where technicians currently make a significant contribution to teaching, one half or more of the teaching technicians have BScs, with some possessing advanced degrees, so that they have a level of understanding that is deemed sufficient to enable them to instruct the students. In the other case, where the department would like its technicians to take a more prominent role in teaching in the future, it is thought that, if technicians are to assume more responsibility for designing experiments and teaching in practical classes, then it is important that more of them should have a BSc.

4. RECRUITMENT

There was considerable agreement amongst interviewees from all parts of the country about the state of the external labour market for technicians. All but two departments reported that they currently receive large numbers of high-quality applicants for research and teaching technician posts, often from people with higher degrees and postdoctoral experience. Ratios of over 50 applicants per place were quoted by some departments. As one head of a chemistry department in a southern university put it, 'We are awash with skills.' Similarly, the technical services managers of chemistry department in the midlands and the north of England remarked that they're 'snowed under' and 'swamped' with applicants for research and teaching technician posts. The existence of an abundant supply of skilled labour is usually attributed to the fact that chemical and pharmaceutical companies like Pfizer, GSK and Astra-Zeneca, as well as university departments, have been – and continue to be - making people redundant and thereby releasing them on to the labour market. The upshot is that, even allowing for the fact that departments have to take pains to ensure that applicants both possess the relevant practical skills, and also appreciate the sometimes mundane nature of technician work, it is relatively easy for departments to find good people to fill such posts.

The one exception to this general rule concerns mechanical and electronics workshop technicians, in which case skilled labour is said to be rather scarce. More specifically, 6 departments said that they had experienced difficulties in recruiting mechanical and electronics workshop technicians. In the words of the manger of the mechanical and electronics workshops in one midlands-based chemistry department, 'We are struggling to recruit engineers ... We have no chance of recruiting anyone.' This is, of course, quite consistent with the experience of many of the engineering and physics departments included in this study, who have found it hard to hire good workshop technicians. Moreover, just as some physics and engineering departments have responded to the paucity of workshop technicians on the external labour market by starting apprenticeship programmes, so too has one chemistry department just begun an apprenticeship scheme for its workshop technicians.

5. APPRENTICESHIPS

While departments are conscious of the need to engage in succession planning in order to deal with their ageing technician workforces, none of the 11 chemistry departments currently have an apprenticeship programme for their laboratory, teaching, or analytical services technicians. The main reason is the ease with which skilled laboratory technicians can be recruited from the external labour market, which implies that departments do not have to train their own technicians in-house. Four other factors were mentioned by interviewees as deterrents to taking on apprentices include the following. First, the very limited spare technical capacity possessed by departments means that when they get the chance to make a new appointment, they cannot afford to employ someone - like a trainee - who will initially work at less than full capacity, but must instead take on a more experienced person who can work productively straight away. As one technical services manager commented, 'We don't have the luxury of the time required to train them [apprentices]. We've got to get someone in who can hit the ground running.' Second, and relatedly, the considerable workload currently borne by established technicians deprives them of the time needed to provide the on-the-job train required by apprentices. A third, oft-mentioned barrier to involvement in apprenticeships is the difficulty of finding a local college that is willing to offer a suitable course, in particular an HNC in chemistry (5 departments). Finally, one department expressed concerns about the health and safety issues arising from having young (16-18 year old) people in laboratories.

The closest to an exception to the general pattern of non-participation in apprenticeship training for their research, analytical services, and teaching technicians arose in the case of a pre-1992 university chemistry department that in 2009 *almost* took on two apprentice laboratory technicians. Those technicians would have been part of a larger cohort of 10 apprentices, who were to have been trained under the auspices of a broader, faculty-wide apprenticeship scheme encompassing departments of physics and biological science as well as chemistry. The scheme was motivated by concerns about the age profile of the technician workforce, and also by dissatisfaction with the limited practical skills and commitment of potential recruits. Apprentices would have received training in the general skills required by a laboratory technician, taking a BTEC in Applied Science at a local college and being rotated around the participating departments in order to gain on-the-job training. They would have been on a fixed term contract, but the hope was that they would have been retained upon successful completion of the training programme. However, shortly before advertisements for apprentices were to run, the university's finances deteriorated, and approval for the scheme was withdrawn.

At present, two other pre-1992 departments are contemplating the possibility of taking on apprentice laboratory technicians. In one, frustration at the lack of practical skills possessed by applicants for one of its research technician posts has led the department to consider taking on an apprentice. The second department is undertaking a technical review that *may* lead to the creation of a faculty-level pool of technicians, who would provide certain basic kinds of technical support such as basic teaching support, glassware, and autoclaving for a number of different departments. An apprenticeship training scheme in basic laboratory skills is being considered for such technicians.

The only case in which a chemistry department has ongoing plans to take on apprentices is to be found in a pre-1992 department that has just sought approval to take on apprentices in its *mechanical workshop*. As is the case with the engineering and physics departments that have started apprenticeship schemes, the plan to take on apprentices is intended to address a succession planning problem in a context where the availability of skilled workshop technicians on the external labour market is very limited. The proposed scheme is similar to those adopted in the engineering and physics departments discussed elsewhere in this report: the scheme will run under the auspices of the government's Advanced Apprenticeship programme; the formal contract with the Skills Funding Agency will be held by an external training provide (in this case a local FE college); apprentices should have 5 GCSEs at grades A-C, with a B in mathematics; they will begin by studying for an ONC in engineering, with a view to moving on to an HNC; and they will be on a 3-year, fixed term contract of employment, with the hope being that they will be kept on once they have completed their apprenticeship.

6. ONGOING TRAINING

A good deal of ongoing training for technicians is provided in-house by more experienced members of staff, usually on-the-job (e.g. welding) but sometimes via short (one- or two-day) internal training courses on specific techniques and pieces of equipment (e.g. x-ray, NMR). University staff development units provide the usual gamut of personal training (e.g. presentation skills, IT skills), as well as training in management that might prove to be of use for those technicians who have moved into managerial roles. The university may also provide training in health and safety, some of it leading to formal certificates such as the NEBOSH health and safety qualification. Perhaps most notably, interviewees in three chemistry departments noted that such on-the-job instruction was being used in order to train a new scientific glassblower in preparation for the day when the current incumbent of that role retires. In at least two of those three cases, the aim is for the trainee's skills to be formally certificated and, to that end, the trainees in question will be entered for the examinations run by the British Society of Scientific Glassblowers.

Equipment manufacturers constitute the most significant external source of uncertificated ongoing training. Such vendor-supplied training is usually associated with the purchase of new equipment, though it can also be purchased on its own. Examples include the x-ray and 5-day NMR training courses provided by Brooker, training in high pressure and high vacuum technology offered by Swagelok, and courses in gas chromatography, mass spectrometry and infrared spectroscopy offered by Perkin Elmer. Equipment manufacturers also help to train workshop technicians in the use of CNC machines. Interviewees in 3 of the 11 chemistry departments said that they had sent some of their technicians on HEaTED courses. Local colleges may also sometimes be used for uncertificated training (e.g. in welding).

Few chemistry departments appear to make much use of certificated vocational training for their established technicians. Indeed, only one of the departments visited for this project is currently sending any of its established technicians for such training. (More specifically, it is supporting two of its older research technicians through BTEC level 3 qualifications in Applied Science and in Laboratory Science, and is also helping some of its stores technicians to gain NVQs in warehousing.) Two other departments had attempted to sponsor some of their established technical staff for an HNC in chemistry, but had been unable to find a local college willing to offer that qualification.

Moving on from vocational to academic qualifications, interviews revealed that all but two of the chemistry departments visited for this study contained one or two technicians who have taken, or are currently studying for, an undergraduate degree whilst working as a technician in the department. The degrees in question are usually in chemistry, although that is not invariably the case: in three departments the people in question worked in the mechanical workshop and took degrees in engineering or product design; while in another university an analytical services technician took a degree in physics. The technicians who take degrees typically do so part time, occasionally in their 'home' university but more often either at the local post-1992 university or via the Open University. Their home department gives day release and pays some or all of their fees. Two departments are currently sponsoring technicians for MSc degrees in chemistry. Finally, it is worth noting that many of the experimental officers and analytical facilities technicians who have PhDs acquired them in virtue of the work they have done as technicians.

Interviewees indicated that the identification of training needs for established technical staff is gradually being formalised and systematised through the implementation of personal development reviews/appraisals. Moreover, in most cases interviewees felt that well-made requests for training would be supported, so long as they helped to promote the interests of the department as well as those of the individual making the request. However, a minority of interviewees also sounded certain cautionary notes. First, representatives of two departments observed that a combination of declining technician numbers and increases in the demands made upon those who remain is making it harder to find the time for technicians to go on external training courses, with some academic staff in particular being reluctant to allow technicians to have long periods of absence from the laboratory. One head of department indicated that dealing with this problem might require departments formally to guarantee technical staff a certain number of days of off-the-job training each year. Second, technical services managers in two universities remarked that 'funding is getting tight' and that it would be harder to support requests for training than in the past.

7. BROADER HUMAN RESOURCE MANAGEMENT ISSUES

Most of the chemistry departments (10 out of the 11) included in this study of departments reported that the introduction of the common pay had been relatively unproblematic in the case of technical staff. Indeed, interviewees in one department in particular reported that technicians 'generally did very well' out of the move to the common spine, because the process of job evaluation that accompanied it had led to the recognition that they were carrying out hitherto unacknowledged duties and, therefore, to higher pay.

APPENDIX 3: SUMMARY OF FINDINGS IN THE CASE OF ENGINEERING DEPARTMENTS

1. DESCRIPTION OF CASES

The research project involved case studies of Faculties, Departments, and Schools of Engineering in 12 universities, 8 of which were pre-1992 and 4 of which were post-1992 universities. Of the 8 pre-1992 universities, 4 were large, multi-department faculties of engineering. In each of those cases interviews were conducted at the faculty level, with extensive supplementary interviews at the level of individual departments in one case. Three of the other pre-1992 case studies were general engineering departments that contained a number of different divisions within the same department. The final pre-1992 case study was formed by a free-standing department that concentrated on one sub-discipline of engineering only, namely electrical engineering. The 4 post-1992 departments were all situated within larger Schools, encompassing other disciplines related to engineering (e.g. computing, physics). A total of 26 interviews were conducted, involving 14 academics and 20 technicians/technical services managers. A summary of the key attributes of the departments in the sample can be found in Table A3:

Table A3: Summary of the attributes of the sample of engineering departments

	Academics	Postdocs	Undergraduates	PhD	Technicians	Technical/ Experimental Officers
Mean	133	121	1340	367	53	4
Maximum	382	475	3170	1500	147	12
Minimum	26	1	450	30	17	0

The ratio of academics to technicians and technical officers varies from a low of 1.2 academic per technician to a high of 4.7 academics per technician in the case of the pre-1992 universities, and from a low of 1.5 to a high of 2.2 in the case of the post-1992 universities.[42] Weighting departments according to their size, as measured by how many academics they contain, then the average ratio is 2.7 academics per technician and 2.0 academics per technician in the pre- and post-1992 universities in the sample respectively.

In every case, interviewees indicated that there had been significant reductions in the number of technical staff over the past 10-15 years, either in absolute terms or relative to the number of academics and students for whom support is required. Even so, none of the pre-1992 departments said that they currently had serious difficulties in providing adequate support for teaching and research. However, academics in two of the post-1992 universities *did* report a concern about the level of *research* support they received, reflecting the fact that, while technical support in those departments had until very recently been devoted almost exclusively to teaching, the academic staff now require additional technical support in order to meet the increasingly demanding targets they are being set for research and external consultancy.

42 It is worth noting, however, that it is unclear how meaningful comparisons between these ratios are, given that technicians in post-1992 universities tend to concentrate almost exclusively upon teaching support rather than research support.

2. THE NATURE AND ORGANISATION OF TECHNICAL SUPPORT

In the 4 multi-department faculties of engineering, it was traditionally the case that each of the constituent departments would have its own mechanical and electronics workshops, as well as its own specialised laboratories. Over time, however, the need to cut both wage and space costs has led all but one of these faculties to amalgamate at least some of their workshops. Typically, now, some of the departments in each faculty share a mechanical workshop, usually on the basis of similarities in the kind of work they require, so that there might perhaps be 3 or 4 mechanical workshops shared between (say) 7 or 8 different engineering departments. Such sharing of facilities may also reflect the imperatives of the increasing amount of research in engineering that crosses traditional disciplinary boundaries. Individual departments have usually been allowed to retain their own electronics technicians and, of course, they also continue to have their own more specialised laboratories and facilities, along with the associated technicians, such as clean rooms for electronics engineering and nano-technology, electron microscopy suites and X-ray diffraction facilities for materials engineering, wind tunnels for aeronautical engineering, structural testing facilities for civil and materials engineering, facilities for advanced manufacturing in automotive and aerospace engineering, chemistry laboratories and combustion facilities for departments of chemical engineering, and pilot plants tissue/cell culture labs for bio-engineering.

Each of the three general engineering departments has its own central mechanical and electronics workshops. In the larger two departments, some of the individual divisions or research groups also have their own, smaller and more specialised satellite workshops and laboratories, specialising along the lines mentioned in the previous paragraph. Two of these three departments are currently reviewing the way in which they provide technical support, examining the scope for avoiding duplication, exploiting economies of scale, and thereby cutting costs, by amalgamating workshops/laboratories and pooling technical staff.

As already noted, the 4 post-1992 departments are all situated within larger Schools, encompassing other disciplines related to engineering (e.g. computing, physics). Formally, the line management of the technicians in those departments lies at the School rather than the department level, as the universities in question attempt to exploit the benefits of economies of scale and create central pools of technicians that can be controlled more effectively, and therefore used more efficiently, than when control was decentralised to the departmental level. In practice, interviewees in most – but not all - of these universities said that departments still enjoyed a decent measure of control over their technicians, so the managerial systems are not perhaps as centralised as they might first seem.

The departments indicated that the vast majority of their full-time technician roles are mixed in the sense that their incumbents provide support both for research and teaching. Few of the pre-1992 departments have many teaching-only technician roles, though some technicians – especially those on fixed term contracts associated with an externally funded research project – tend formally to provide support only for research. Unsurprisingly, the pre-1992 and post-1992 departments in the sample exhibit considerable differences in the precise balance that is struck in allocating scarce technician time between teaching support and research support, with technicians in the post-1992 universities devoting considerably more of their time to teaching support than do their counterparts in the more research-intensive, post-1992 universities. For example, while a recent time allocation study carried out in one pre-1992 department revealed that around 75% of total technician time was devoted to supporting research, 3 of the post-1992 universities estimated that at least 70% of their technicians' time was currently spent supporting teaching (though two of those departments also indicated that they were being encouraged by their university to increase the proportion of technician time allocated to supporting research and external consultancy).

Departments typically have a variety of different types of research technician. These include both mechanical and electronics workshop technicians, and also laboratory technicians working in a variety of facilities, and on a range of tasks and pieces of equipment, including microfabrication, electron microscopy, MRI, lasers, high-speed photography, and tissue engineering, to name but a few. By operating – and, as we will see, in many cases designing and constructing – the experimental apparatus and equipment that the scientists need for the data generation and hypothesis testing part of their projects, such technicians play a key role in engineering research.

So far as the workshop technicians in particular are concerned, interviewees at a majority of departments emphasised that academics do not usually provide technicians with detailed technical drawings of the equipment or apparatus required to give practical effect to their ideas. Instead, academics typically involve technicians in the early stages of their projects, when they have framed the research problem they are trying to address but before they have a clear idea about the kind of rig or experimental apparatus required to help solve it. It is here that the technicians' input - and, in particular, their knowledge and understanding of engineering and electronics, their practical expertise and understanding of what particular tools and instruments can be used to achieve, their knowledge of the properties of different materials, their skills in using computer-aided design packages, and their general problem-solving skills – comes into its own. For it is on the basis of that knowledge and expertise, much of it accumulated over many years of work in industrial and university labs and workshops, that the technicians will help to correct and develop the academic's initial rough outline in order to come up with a design for the requisite experimental rig, piece of apparatus, or electronic component that will be get the job done in practice. In the words of one mechanical workshop superintendent, 'People come in with half formed ideas and we try to make them work.' Indeed, such is the importance of this part of the technicians' work that one interviewee argued that his department's mechanical workshop should be renamed as the 'Design and Fabrication Service.'

The account given by many interviewees, therefore, is one in which research is portrayed as a dialogue or iterative process, whereby academics and technicians work as a team in order to design the experimental apparatus required to give practical effect to researchers' ideas. In doing so, technicians make an indispensable contribution to the research that takes places in engineering. Moreover, representatives of 5 of the 8 pre-1992 departments visited for this project stated that this contribution is sometimes recognised by technicians being included on the list of authors of the academic papers that derive from the projects they support.

Teaching support technicians typically assist academics and PhD/postdoctoral student demonstrators in running laboratory classes by preparing the requisite materials and equipment and by remaining in the laboratories whilst the classes are under way in order to ensure adherence to health and safety regulations. Moreover, in most of the engineering departments visited at least some technical staff are actively involved in *teaching* students, most notably by providing instruction in how to use various pieces of equipment and by supervising final year projects. For example, one large, multi-department faculty of engineering has a number of 'technical tutors' who help to teach practical skills to undergraduates, while departments in three other universities have technical officers who are involved in devising new experiments for laboratory classes, in demonstrating equipment and experimental techniques, and in providing expert design support for student projects. Furthermore, interviewees suggested that even in those departments where technicians do not *formally* provide tuition, they may still do so *informally*, most notably by providing both undergraduate and postgraduate students with advice about the design of the objects required for their research projects (in the case of engineering and electronics workshop technicians) or providing guidance in particular experimental techniques and associated equipment (in the case of technicians who are embedded within research laboratories that accept undergraduate project students).

Finally, three other kinds of contribution that technicians make to research and teaching should briefly be noted. First, senior technicians usually take responsibility, in conjunction with an academic colleague, for carrying out risk assessments of the instruments, facilities and experimental rigs used in engineering departments. Second, and relatedly, electrical and electronics technicians often carried out safety tests for various kinds of electrical appliances found in departments (PAT testing). Third, and finally, lower grade technicians usually provide basic support for research and teaching, by working in stores, preparing basic materials, disposing of waste, and so forth.

3. TECHNICIAN WORKFORCE: ORIGINS, AGE, TENURE, CONTRACT TYPE AND QUALIFICATIONS

3.1 ORIGINS

Interviewees in all 12 departments indicated that a majority of their current technician workforce was recruited from the external labour market, rather than developed internally via an in-house apprenticeship or traineeship scheme. More specifically, 6 of the departments visited estimated that over 90% of their current technician workforce had been acquired externally, usually from industry. Another 6 departments estimated that over 70% of their technicians were recruited, with the remainder typically being either graduates or – most often - older workers who had been obtained via old departmental apprenticeship training programmes, most of which had by the 1990s been discontinued due to cuts in the size of the technician workforce, the poaching of newly qualified apprentices by other employers, and the ready availability of workers on the external labour market. However, as will be discussed below, more recently a shortage of skilled workers on the external market – coupled with concerns about an ageing workforce, has led to a resurgence of interest in apprenticeship training amongst engineering departments, with many of the departments considered here either recently taking on apprentices or seriously contemplating doing so.

3.2 AGE PROFILE

The average age of the technicians in the departments is around 51, a figure that would have been a little higher were it not for the early retirement and voluntary severance schemes operated by some of the departments in the past few years. To put this point slightly differently, around 48% of the technicians in the university departments considered here are over 50 years of age. The age profile of the technician workforce is currently the cause of considerable concern within engineering departments and, as we shall see below, has been one of the major reasons why a majority of departments in the sample have either recently begun, or are very seriously considering, taking on apprentice technicians.

3.3 LABOUR TURNOVER AND TENURE

Turnover is usually said to be 'very low' or 'effectively zero', and with all but two of those departments who provided numerical data reporting turnover rates of under 5% per annum amongst their technicians. Tenures of 10-30 years – and in many cases considerably longer - are common amongst technicians, though the data obtained also reveal that a substantial fraction (35-45%) of the technician workforce in three of the larger departments in the sample has been employed within the past five years.

3.4 CONTRACT TYPE

All of the technicians in the post-1992 universities considered here were on open-ended contracts. Around 83% of the engineering technicians in the 7 pre-1992 universities for which data are available are on open-ended contracts, with no department having more than about 30% of its technical staff on fixed-term contracts.[43]

43 These figures exclude apprentices, who are usually on fixed-term contracts until they have completed their apprenticeship.

3.5 QUALIFICATIONS

All but one of the departments reported that the vast majority (85%+) of their technical staff are vocationally qualified, possessing HNCs, HNDs, and City and Guilds awards in mechanical engineering and electronics.[44] Interviewees reported that, on the whole, the skills possessed by the technicians in their departments correspond well to the departments' requirements. However, interviewees also observed that there remains some scope for improvement. Perhaps most notably, interviewees in 6 of the 12 departments stated that they would like to have more technicians who possess mechatronic skills and who, as a result, are able to work at the interface of mechanical and electronic systems (e.g., by setting up data acquisition and control systems). Three other departments also stated that they need more technicians who are well versed in 3-D design and CAM-CAD packages. More generally, departments reported that they would like to have more technicians who are multi-skilled, and who as a result are able to respond flexibly to the varying demands made by the researchers they support.

To the extent that it is possible to generalise, the small numbers of technical staff who possess BSc or higher qualifications usually fall into one of two main categories. First, and most often, they occupy what are variously described as technical, experimental or scientific officer roles. The data collected for this study suggest that such positions are found only in pre-1992 universities (where there is an average of 6.5 scientific or technical officers across the 8 departments visited). Technical officers are like technicians in that they possess technical expertise but they differ in being more likely to specialise in the use of particular instruments or techniques. For example, in three of the pre-1992 universities considered here, people occupying scientific or experimental officer roles are BSc-qualified design engineers who specialise in providing technical support for the design of the experimental rigs, components and pieces of apparatus required for research projects. Other experimental officers specialise in electronic circuit design, in electron microscopy, in the use of lasers, and in clean-room techniques - such as molecular beam epitaxy - used for research in semi-conductor materials and electronics. Experimental officers are more likely than technicians both to manage laboratories or other experimental facilities (e.g. combustion facilities, electron microscopes, mass spectrometers, X-ray diffraction, etc.), and also to design and conduct experiments and to analyse and interpret the results of those experiments themselves. Consistent with this, as noted above, technical and experimental officers are more likely than technicians to have a BSc or PhD, and are more likely than technicians to be named as authors on academic papers.

Second, the evidence gathered here suggests that technical staff with degrees tend also to support research that involves the application of traditional engineering principles to particular kinds of subject-matter that are usually studied by one of the other scientific disciplines (e.g., bioengineering and chemical engineering). In such cases, technicians who have at least a BSc, and sometimes a higher degree, in the relevant science are employed to help run the research laboratories in question and to provide subject-specific scientific input into the design of experiments and the analysis of data. Degree-level knowledge or better is said to be essential for research technicians working in such fields.

44 The one exception was a department of engineering in a post-1992 university, where all but two of 17 technical staff have at least an undergraduate degree.

4. RECRUITMENT

When seeking to recruit to technician posts, engineering departments are typically looking for people who are vocationally qualified to HNC or HND level (or equivalent) and who have considerable industrial experience. Such recruits are valued primarily as a source of up-to-date practical skills in machining and electronics. Consistent with this profile, recruits tend to be middle-aged men, who have acquired vocational qualifications and many years of experience, usually in industry but sometimes as technicians in other university departments. Typically, recruits come from the same area as the university itself, so the relevant labour market is local or regional.

Interviewees expressed mixed opinions about the state of the external labour market. While representatives of 3 departments suggested that they had experienced no difficulty in recruiting skilled labour in the recent past, 6 reported that there had been occasions in the last few years when they had struggled to find acceptable candidates for technician posts, sometimes to the extent that they had failed to make an appointment.[45] Such problems were not confined to one particular geographical area, with universities from all of the regions covered in this study reporting no more than a low-to-moderate availability of skilled labour on the external market. While some interviewees attributed such difficulties to the low wages paid by universities relative to what is available in industry, the limited availability of skilled labour was most commonly said to reflect the decline of the traditional industries from which technicians had been recruited in the past.

If it is the case that actions speak louder than words, then it is noteworthy that there has been sufficient concern about the scope for recruiting skilled technicians – even amongst those departments who suggested that there was a reasonable availability of workers on the external market - for there to have been a revival of interest in apprenticeship training schemes, with all but two of the engineering departments visited as part of this project either restarting, or giving serious thought to restarting, an apprenticeship in the past few years.[46]

45 Two of the post-1992 universities disclaimed any knowledge of the external labour market, having not tried to recruit anyone for several years.

46 The two universities that have not seriously considered becoming involved in apprenticeships are both post-1992 universities, one of which has recently begun to recruit some of its own undergraduates to technician posts. While not taking on apprentices, there is a sense in which – like the departments that have revived their apprenticeship schemes – that university too is beginning to rely more heavily than it did in the past on in-house training to acquire the technicians it needs.

5. APPRENTICESHIPS

The evidence gathered for this project suggests that the last few years have seen renewed interest in apprenticeship training amongst university engineering departments. Of the 12 departments visited for this project, 6 have either recently started – or are just about to begin - an apprenticeship scheme for their technicians. Apprenticeship programmes are also under formal consideration in 2 of the other departments.[47] Such developments are motivated primarily by a belief that apprenticeship training is central to sustaining high quality technical support in the face of the twin problems posed by an ageing technician workforce, with a significant number of technicians due to retire in the next 10-15 years, and the limited availability of suitable workers on the external labour market. An apprenticeship programme, one interviewee said, provides a way of dealing with the problem of 'where the next generation of technicians is coming from.' In some departments, apprenticeships are also viewed as a means of bringing in fresh young people whose skills can be tailored so that they are more closely attuned to the current requirements of the department than are those of some of the older workers they are replacing (by having, for example, more mechatronic and CAD skills).[48]

The 6 departments that have decided to take on apprentices have adopted very similar strategies to managing the programme. In each case, the apprentices are taken on under the auspices of the government's Advanced Apprenticeship scheme. All 6 departments have devolved formal responsibility for organising the apprenticeship to an external training provider (in 4 cases, a local further education college, in one a private training provider, and in one a group training association). It is those external training providers that hold the apprenticeship training contract with the Skills Funding Agency and are in direct receipt of the government training subsidy. The government funding covers the fees for the college courses required for the apprentices' off-the-job training and also pays for the assessment of their practical on-the-job skills (i.e., the NVQ).[49] The universities have to pay the apprentices' wages, typically £12,000-£13,000 per annum, and also cover the costs of overseeing the scheme and providing the on-the-job training.[50] In some cases, those costs are split between the relevant department and the central university. In others, the department covers the entire salary cost. Given the relatively low apprentice wage, given that departments expect the apprentices to do a fair amount of useful work after their first year, and given finally the scope for apprenticeship training to yield highly skilled and adaptable technicians of a kind that appear to be increasingly hard to come by on the external labour market, these departments believed that apprenticeship training was a worthwhile investment.[51]

47 All but one of the 8 departments just mentioned are in pre-1992 universities.

48 While a stable workforce with a high average tenure brings benefits, most notably the accumulation of a considerable stock of practical knowledge, it also gives rise to problems. In particular, according to interviewees in 2 departments, the stability of the technician workforce sometimes makes it more difficult for departments to update the skills of their technicians. Both apprenticeship training, and also - where possible - recruitment, are viewed as ways of updating the skills of the technician workforce.

49 In the case of one department where an established technician is a trained NVQ-assessor, the assessment of the apprentices' practical skills is undertaken in-house, being subject to periodic verification by the local college.

50 In three cases, interviewees from departments that have embarked upon an apprenticeship scheme expressed reservations about the quality of support they received from the external provider that was ostensibly organising the training. Concerns encompassed both the quality of teaching on the college courses taken by the apprentices and also the effectiveness with which the provider notified the department of any problems (e.g. apprentices who were struggling with, or failing to attend, the college courses).

51 While representatives of the departments that had taken on apprentices were clearly conscious of the amount of time that experienced technicians had to spend training apprentices on-the-job, some interviewees also observed that providing such training raised the morale of the established technicians, who enjoyed passing on their skills. As one senior technician put it, 'We want to leave a legacy of young, well-trained people to the department.'

So far as the content of the training programme is concerned, apprentices are typically studying for qualifications in mechanical and electrical/electronic engineering. Apprentices typically start at level 2, working towards an ONC and an NVQ2, before progressing to a level 3 NVQ and an HNC.[52] The departments provide the apprentices with the requisite on-the-job training and work experience by rotating them through different workshops and laboratories, thereby exposing them to a wide variety of tasks, materials, and equipment and also developing their flexibility. The off-the-job training required for the ONC and HNC comes from a local further education college, which apprentices attend either via day release (in the case of 5 departments) or via block release for the first year of the apprenticeship followed by day release thereafter (in one case).

The number of apprentices taken on by each department is low, averaging just one or two year each. The rate or intensity of apprentice training, as measured by the ratio of the number of apprentices currently in training to the total number of technicians employed, averages about 5% across the departments that offer apprenticeships. That figure will rise over time if departments, most of whom have only recently started taking on apprentices again, continue to do so and ultimately have apprentices in all three years of their training programmes.

In selecting their apprentices, engineering departments are typically looking for young people aged between 16 and 20 who have passed 4-5 GCSEs at grades A-C, with English and a science at grade C and mathematics at grade B. Some departments set practical tests for shortlisted candidates. The quality of the pool of applicants for apprenticeships appears to be mixed, with 4 departments receiving enough good applicants to fill all the places on offer but two struggling to do so. Apprentices have a fixed term contract of employment, coterminous with their apprenticeship, but departments hope and expect that they will be kept on at the end of the training programme, subject to satisfactory performance.

Four departments are currently neither involved in, nor formally considering, an apprenticeship scheme. Two of them *had* seriously contemplated taking on apprentices in the recent past. In one case, the department came close to participating in an apprenticeship scheme similar to those described above. However, the scheme was shelved before any apprentices were taken on due to concerns about the financial implications of the rather high grade that newly qualified apprentices would be assigned. The department may well revisit the possibility of taking on apprentices in the next couple of years, possibly in conjunction with a neighbouring department of physics. In the second case, an engineering department in a post-92 university attempted to establish an apprenticeship scheme about 5 years ago, primarily in order to introduce 'new blood' – and, more specifically, new skills, especially in digital media and product design – into its ageing technician workforce. However, the university refused to countenance the scheme, on the grounds that the department in question already had enough technicians.

Only 2 engineering departments, both in post-1992 universities, have not seriously contemplated taking on apprentices within the past few years. One appeared to have had little difficulty in recruiting workers from the external labour market, and therefore has little need of apprentices. The extent to which it has attempted

52 An exception to this general pattern is to be found in the one post-1992 university in the sample that has started an apprenticeship scheme, whose apprentices are studying under a Laboratory Technicians Apprenticeship Framework rather than an Engineering one, and are aiming at a level 2 rather than a level 3 qualification.

to develop its own technicians internally has been limited to academic, rather vocational, education and training and has involved the department recruiting recent graduates from its own BSc programme to technician posts. In the second case, interviewees said that the department has found it less easy to recruit high quality workers, but remains sceptical about apprenticeships, for three main reasons: first, because they feel that the job requires people with more industrial experience than the apprentices would possess; second, because they are concerned that young apprentices will lack the maturity required to do a do a good job;[53] and third because in a small department like the one in question, where the technical staff are already working at full capacity, experienced technicians simply do not have the time to provide the on-the-job training required by the apprentices.[54]

53 It is interesting to note in this regard that one of the departments that *has* taken on apprentices has had concerns about the attitude of some of its young trainees, ultimately dismissing two of them for lack of commitment. The conclusion that the department has drawn from that experience is not, however, to cease its involvement in apprenticeship training but rather to refine its selection procedures, and in particular to consider taking 18-19 year old apprentices rather than 16-17 year olds.

54 This problem was also noted by one of the departments that had taken on apprentices.

6. ONGOING TRAINING

We move on now from the training of new staff to consider the provision of training for established technical staff. While most engineering departments expressed a willingness to fund ongoing training for established technicians in cases where it promotes the department's goals, personal development appraisals appear to have had only a limited impact in terms of systematising the identification of training needs. In some cases, appraisals have only recently been introduced. In others, while appraisals have formally been introduced, they have not been received enthusiastically by technical staff, or indeed carried out at all in practice. As one interviewee put it, only 'lip service' has been paid to appraisals and in practice they have 'fallen into abeyance.' The evidence gathered here suggests, therefore, that despite recent efforts to formalise and systematise the identification of the training needs of established technicians through personal development reviews and appraisals, in practice many departments continue to provide such ongoing training in a rather *ad hoc*, unstructured fashion, simply as the requirements of research and teaching support dictate. There was, as a result, concern expressed by interviewees in a small minority of departments that ongoing training for technicians was 'sometimes a bit forgotten'.

Interviewees suggested that one of the most important sources of training for established technicians is the other technical staff within their department and/or university. Such training usually involves more skilled technicians passing on their practical skills – in, say, welding, milling or microscopy - to more junior colleagues informally, on-the-job. Occasionally, such training may be formalised into short, in-house training courses. A second variety of in-house training that deals with technical issues focuses on the many health and safety issues that arise in engineering departments and involves training in to how to deal with hazardous materials and/or situations training (e.g. lasers, radiation, lifting, etc.). Third, university staff development units usually offer a range of training courses in non-technical skills centring on personal development and managerial skills, some of which may be used by technicians who are moving into laboratory and departmental services manager roles.

The second major source of uncertificated training for established staff is equipment manufacturers, who typically provide training for a small number of technicians from departments that buy a new piece of kit from them as part of the purchase price (e.g. CNC machines). Having received that training, the individuals in question pass it on to their colleagues as necessary via informal, in-house training, so that the requisite skills are disseminated more widely through their home department. Such vendor-supplied training can also be purchased independently of the equipment itself. The departments in the sample considered here have used external providers to develop their technicians' skills in a variety of different areas, including computer-aided design, microwaves, welding, CATIA software for digital product design, and the use of data acquisition devices and associated software like Lab View. Local colleges may sometimes be used for uncertificated training (e.g. in welding).

Some limited use is made of training that is certificated in the sense of leading to formal qualifications. 3 departments said that they had sent small number of established technicians – as distinct from apprentices - to local further education colleges for certificated vocational training (leading to NVQs, HNCs, and HNDs). 8 departments reported that they have supported small numbers of technicians – typically just one or two per department – to take a degree. More often than not, the degree in question is a BSc, though sometimes it is a Foundation degree (one department), sometimes an MSc or PhD (2 departments in each case). Typically, the technicians take their degrees part time, either at the local post-1992 university or via the Open University, with their home department granting them day release, or block release for OU residential summer courses, as appropriate and paying some or all of their fees.

Interviewees also reported that little if any use is made of joint technician training either with engineering departments in other universities or with industry. Only 3 departments had made any use of the training offered by the technicians organisation, HEaTED.

7. BROADER HUMAN RESOURCE MANAGEMENT ISSUES

Interviewees at three engineering departments indicated that the introduction of the common pay spine in 2005, and the associated job evaluation and grading process, had generated some discontent amongst technical staff, some of whom felt that the outcome involved highly dissimilar jobs being given the same grade. While discontent with such outcomes appears to have dissipated over time, it has been replaced in the same departments by a new source of dissatisfaction, namely the frustration – referred to by interviewees from 4 departments - that some technicians feel about having reached the top of the spine segment associated with their grade and the limited scope they enjoy to take on new responsibilities in the way required to develop their role so that re-grading is warranted. In the words of one technician, 'you cannot get re-graded and the whole process grinds to a half ... It's dead men's shoes.'

APPENDIX 4: SUMMARY OF FINDINGS IN THE CASE OF PHYSICS DEPARTMENTS

1. DESCRIPTION OF CASES

The research on technical support in physics is based on case studies of 9 university departments, including 8 pre-1992 and 1 post-1992 universities, and 2 non-university research laboratories. 15 interviews were conducted, involving 8 academics and 18 technicians/technical services managers. A summary of the key attributes of the departments in the sample can be found in Table A4:

Table A4: Summary of the attributes of the sample of physics departments

	Academics	Postdocs	Undergraduates	PGR	Technicians	Technical/ Experimental Officers
Mean	57	87	364	150	32	2
Maximum	132	200	812	345	80	11
Minimum	15	18	0	12	9	0

The two non-university physics laboratories employ around 650 and 1200 people, including scientists, engineers and administrators as well as technicians. The total number of technicians is around 250 and 350 respectively.

The ratio of academics to technicians and technical officers varies from a low of 0.63 academics per technician in one pre-1992 department to highs of 3.3 in the case of one pre-1992 university and 14.0 in the sole post-1992 university in the sample. If departments are weighted according to their size, as measured by the number of academics they contain, then the average ratio is 2.8 academics per technician across all 9 departments (falling to 2.1 academics per technician if the sole post-1992 university in the sample is excluded from the calculation).[55]

A majority (7 out of 9) of the departments said that there had been significant reductions in the number of technical staff over the past 10-15 years, either in absolute terms or relative to the number of academics and students for whom support is required. These reductions were attributed to cuts in funding. Despite falling number of technicians, none of the departments said that they currently faced serious problems with providing adequate support for teaching and research. More specifically, none of the departments indicated that a lack of technical resources had impacted detrimentally on the amount of practical work undertaken by undergraduates. Nor, except perhaps on the margin, did most interviewees indicate that a lack of technical support had led to a significant reduction in their department's capacity to conduct research.[56] However, 4 departments did suggest that their technical staff were working at full capacity, and that they struggled to provide adequate support when people were off sick or absent from the department for other reasons. As one Head of Department put it, 'We are at the limit of our technical resource.'[57]

55 This does not appear to be substantially different from the a ratio of one permanent technician post for every 2.4 permanent academic posts reported in a recently published overview of the finances of 14 university physics departments circa 2007-08 (IoP and RSC 2010: p. 12-13).

56 For similar findings, see IoP and RSC (2010: iii).

57 The paucity of spare technical capacity may have consequences for the kind of technician training that departments provide, for reasons that will be discussed in Section 5 below.

2. THE NATURE AND ORGANISATION OF TECHNICAL SUPPORT

The support of laboratory and engineering workshop technicians is essential for many branches of physics research. While the amount, and the nature, of technical support required varies according to the precise fields of research in which a department specialises - with space research and solid-state physics, for instance, requiring considerably more technical support than theoretical physics - it is undoubtedly true that academic physics as a whole is heavily dependent on the support provided by technicians. In particular, many physicists use bespoke instrumentation, so that the ability of departments and non-university research laboratories to develop high-quality, custom-built instruments is of paramount importance for their success. Senior technicians also tend to take responsibility, along with an academic colleague, for undertaking risk assessment and for ensuring that academics, PhD students and postdocs comply with health and safety regulations when carrying out their research. Technicians on lower grades will also tend to provide basic support for research and teaching, by working in stores, preparing basic materials, disposing of waste, etc..

Departments typically have a variety of different types of research technician. These include both mechanical and electronics workshop technicians, and also laboratory technicians working in a variety of facilities, and on a range of tasks, such as technical drawing, lasers, microfabrication, cryogenics, high field magnets, and MRI. In all but one of the cases considered here, technical support is organised primarily at the department level, with some devolvement of control and responsibility for the provision of highly specialised technical support to individual research groups. More specifically, 7 of the 9 university physics departments considered in this project have their own centralised departmental mechanical and electronics workshops, manned by dedicated technicians.[58] In some of the larger departments, these central workshops may be supplemented by smaller, satellite workshops attached to specific research groups and catering to the specific technical requirements of those groups, though on the whole the use of such smaller workshops is diminishing as departments attempt to exploit the benefits of economies of scale and cut costs. Those laboratory technicians who are allocated to particular facilities or pieces of equipment that are used by a number of research groups - such as lasers, clean rooms, helium liquification, and MRI - also tend to be managed at the departmental level. In contrast, day-to-day control of the technicians who provide other, more specialised forms of technical support is often devolved to the relevant research groups, which have often raised the funding for those technicians via external grants.

Research support in some departments is also provided by technical or experimental officers. Technical officers in physics resemble technicians in possessing technical expertise but who are more likely than technicians to *specialise* in the use of particular instruments or experimental techniques. They also differ from technicians, and more closely resemble academics, in often playing a significant role in the design of the experiments on which they work, in analysis of the empirical data produced by those experiments, and also in the more

58 The two exceptions are as follows: one pre-1992 university shares its mechanical workshop with its university's department of chemistry; while the sole physics department in our sample that is situated in a post-1992 university has a small number of teaching technicians who operate as part of a faculty-level pool, on which a variety of departments can draw, and who work in a shared, faculty-level workshop.

general management of long-term research projects (in particular those funded by rolling grants). Finally, technical and experimental officers are more likely than experienced technicians to have a BSc or PhD. In some universities, the use of the terms 'technical officer' and 'experimental officer' appears to have ceased since the move to common pay spine in 2005. In others cases, the use of those titles persists but only for those employees who already bore the relevant job title in 2005. In such cases, the expectation is that no new appointments will be made to experimental/technical officer positions and the use of those titles is expected to die out as the remaining technical/experimental officers retire or move to other jobs. This diversity of practice helps to explain the fact that, while there is a mean of 2 technical or experimental officers per department in the sample considered for this study, this average conceals significant variation in the number of people bearing those titles across the different departments: only 4 of the 9 university physics departments visited contained people bearing the title of Experimental or Technical Officers; while no fewer than 11 technical officers were found in just one large, research intensive department.

In carrying out their duties, research technicians and technical officers typically work closely with their academic colleagues, drawing on their knowledge and understanding of engineering, electronics, and physics in order to design, build, modify, test and operate the instruments and equipment that the scientists need for the empirical part of their research. Such knowledge enables technicians not only to operate standard equipment so that it satisfies the performance standards required by the scientists, but also to modify existing equipment in order to perform new functions, and even to devise and construct new instruments and experimental set-ups in order to meet novel technical challenges posed by researchers.

In discussing those cases where scientists require bespoke instruments and new experimental apparatus in order to generate the data required for the empirical side of their research, interviewees at a majority of the physics departments in our sample were keen to point out that scientists do not usually provide technicians with detailed descriptions, let alone complete technical drawings, of the relevant equipment or apparatus. On the contrary, scientists typically involve their technicians in the early stages of their research, when they have defined the scientific problem they are trying to address, established the goals of their project, and identified the scientific principles that underpin it, but when they have only a rough idea about the kind of equipment or apparatus required to achieve their research objectives. Equipped with a broad sense of the objectives of the research, the technicians will draw on their knowledge and practical expertise of engineering – and, more specifically, their understanding of what particular tools and instruments can be used to achieve, their knowledge of the properties and performance characteristics of materials, their skills in using computer-aided design packages, and their general problem-solving skills - in order to develop an initial design for the requisite instrument, electronic component, or experimental rig. The technicians will then discuss their suggestions with the researchers, who may suggest changes, leading to a modified design. After a number of such discussions, and possibly the production of a rough working model (e.g., using a rapid prototyping machine or 3D printer), something that appears to be a workable design will emerge, at which point a prototype of the relevant instrument, component, or piece of apparatus can be built.

What this account suggests is that the development of the instruments and other types of equipment used in physics research is best viewed as an iterative process in which from the very early stages of research projects technicians and academics engage in a dialogue about the best way to build the objects required to give practical effect to the researchers' ideas. As one technical services manager in a physics department described it, the design of new instruments and experiments is 'best done by iteration', whereby academics can involve the technical services from the start in a dialogue about what they are trying to achieve and how to achieve it.[59] In this way, technicians make an invaluable contribution to solving the technical problems that arise in the course of research projects.

Indeed, not only is it the case that scientists typically do not present technicians with detailed technical drawings of the equipment they need, a number of interviewees also suggested that it is counterproductive when they try to do so, because the technicians' superior knowledge of the practical, engineering side of research means that they are better able than the scientists to design feasible, cost-effective apparatus of the kind required to achieve the scientists' goals. It is for this reason that, according to another interviewee, 'Technicians are [often] involved in projects right from the start, in the [development of] the proposal', participating in research team meetings when funding bids are being developed and attending meetings with funding bodies to discuss the practical side of proposed, as well as ongoing, projects.

The informal, iterative interaction between academics and technicians, as it might be termed, is – according to one academic physicist - 'priceless' and is recognised in a number of ways. Perhaps most notably, technicians' contributions' to research projects are often formally acknowledged by the authors of the ensuing academic papers. Moreover, interviewees at 7 of the 9 physics departments in our sample also said that technicians who made a substantial contribution to a research project, above and beyond that normally expected of them, would sometimes be included as a named author on academic publications. Inclusion as a named author was said to be most common in the case of papers focusing on the design and operation of new scientific instruments, where – as noted above – technicians' contribution is most likely to be significant.

Another important aspect of technical support concerns support, not for research, but for teaching. Teaching support technicians assist academics in putting on laboratory classes, primarily by preparing the requisite materials and equipment and by remaining in the laboratories whilst the practicals are under way in order to ensure that there are no breaches of health and safety regulations and to provide assistance with equipment that malfunctions. Technicians may also help to design and test new practicals over the vacation. In most (6 out of the 8) departments visited for this project, the technicians formally leave the actual *teaching* – the demonstration of the experiments, the provision of instruction about how to use equipment, and the discussion of the underlying physical principles – to PhD students and postdoctoral researchers. In the words of one academic, teaching technicians 'support the delivery of the core teaching programme, [but] they don't actually *deliver* it.' In two cases, however, some of the teaching technicians *are* formally involved in teaching, both in laboratory classes and also - in the case of one university - by supervising final year projects. Moreover, interviewees

59 As we shall see below, this has important implications both for the kind of person who is suitable for a technician role and also for the organisation of work within science and engineering departments and faculties.

suggested that even in those departments where technicians do not provide formal tuition they may nevertheless do so informally, most notably by teaching both undergraduate and postgraduate students how to use particular instruments and by providing them with advice about how to design the objects and experiments required for their research projects.

In most of the departments under consideration, there is a fairly sharp formal division of labour between the technicians who provide research support and those who support teaching. About 20% of the technicians in the departments in our sample have some formal involvement in teaching support, with 80% devoting themselves formally to research support alone. One concrete manifestation of this formal division of labour is the fact that all of the university departments in our sample that take undergraduates have technicians who specialise in supporting teaching. There is a mean of 4 such teaching-only technicians per department in our sample. In 3 of the 8 departments, the division of labour between research support and teaching support roles is stark, with there being no mixed roles whose occupants formally provide both teaching support and research support. The other 5 departments supplement their specialist teaching technicians with some mixed roles. There is an average of 3 such mixed posts across those 5 departments. Overall, only around 8% of the technicians in our sample occupy such mixed roles, underlining the sharp formal division between teaching and research support.

In practice, however, this division is less pronounced than formal job descriptions suggest. In particular, interviewees indicated that some of the technicians whose official duties centre exclusively on the provision of research support also offer *informal* teaching support, perhaps most notably by assisting undergraduates who are carrying out final year projects. This assistance may take a variety of forms, depending on the nature of the project and technician in question. It may, for example, involve technicians assisting with the design and fabrication of prototypes (in the case of engineering and electronics workshop technicians), providing guidance in the use of particular pieces of equipment (in the case of those technicians who specialise in the use thereof), or offering instruction in particular experimental techniques (in the case of technicians who are embedded within research groups that host undergraduate projects).

3. TECHNICIAN WORKFORCE: ORIGINS, AGE, TENURE, CONTRACT TYPE AND QUALIFICATIONS

3.1. ORIGINS

Most departments were able to offer rough estimates of the proportions of their current technical workforce who were trained in-house and recruited externally. The principal source from which most of the departments have obtained their technicians is the external labour market. More specifically, 7 of the 9 physics departments visited estimated that well over half (on average, 60-70%) of their current technician workforce had been acquired externally (mostly from industry, but with a small contribution being made by recruits from other university departments). The remaining 20-30% of the technical workforce in these departments is composed of older workers who were trained in-house under old university traineeship programmes, most of which ceased operation some 15-20 years ago.

There are exceptions to this general pattern. One university estimated that 75% of its physics technicians came through an old in-house training scheme, while another indicated that around 40% of its current technical workforce was home-grown. In the smaller of the two non-university research laboratories, around 80% of the mechanical workshop technicians were home-grown via apprenticeships. The larger of the two non-university research laboratories has continued to run a relatively large apprenticeship programmes through the last decade and, as a result, around 50% of its current technicians were trained in-house. In contrast, whilst it was the case that most of the physics departments considered here used to have their own traineeship schemes for school leavers, almost all of them were shut down in the late 1980s or 1990s, due to a combination of factors including: shortages of funding; a decline in departments' need for new technicians during a period when their technician workforces were being cut; the poaching of newly qualified trainees by external employers; and the (then) high availability of workers on the external labour market. The smaller of the two non-university research laboratories also closed in traineeship scheme during that period, for similar reasons. Hence the fact that, in most of the departments considered, a majority of the technical workforce has been recruited rather than grown in-house.

However, as a later section will document, the availability of skilled recruits of the kind sought by physics departments currently appears to be significantly lower than in the 1990s and early 2000s. And, as we shall also see below, this change in the state of the external labour market has led to a revival of interest in apprenticeship schemes for technicians.

3.2. AGE

The average age of the technicians in the departments and research laboratories visited for this project is about 48, a figure which would be higher were it not for the fact that two of the larger university departments, and one of the non-university laboratories, have implemented early retirement and voluntary severance schemes within the past few years that have reduced the average age of their technicians. To put this point slightly differently, around 55% of the technicians in the university departments considered here are over 50 years of age. The relatively high average age of the technicians employed in physics departments has led to concern about succession planning and, as we shall see below, has been one of the catalysts for a revival of interest in apprenticeship training programmes in some departments.

3.3. LABOUR TURNOVER AND TENURE

Turnover amongst established technicians is variously described as 'low', 'very low', and 'effectively zero', with those departments and research laboratories who provided data reporting turnover rates of under 5% per annum amongst their technicians. Consistent with this, the average length of service tends to be high, with many technical staff having been in post for over 20 years. Indeed, the principal reason why physics technicians leave universities is said to be retirement.

3.4. CONTRACT TYPE

Around 90% of the technicians in the 7 university departments for which data are available are on open-ended contracts. The greatest proportion of technical staff on fixed term contracts in any one of the university departments visited for this study was around 37%.[60]

3.5. QUALIFICATIONS

The majority of the technical staff who work in physics departments, and in the two non-university physics research laboratories visited, have vocational qualifications in mechanical engineering and electronics (e.g., HNCs, HNDs, City and Guilds, and Advanced Apprenticeships). Only a minority of technical support staff - usually estimated at under 10% of the total technician workforce, though amounting to 25% in the case of 2 university departments and 30% in a third - have BScs in physics or engineering. Those people who have BScs are usually either technical/experimental officers, whose role tends to demand the analytical skills and understanding of theoretical principles provided by a degree, or – in 3 departments in particular – electronics technicians. In the latter case, the departments in question indicated that a combination of the demands of the job and a paucity of people with relevant vocational qualifications has led to a tendency to employee people with degrees to provide technical support in electronics. The skills profiles of the departments in the sample are invariably said to be a good match to the departments' needs, though some departments and research laboratories said that they ideally they would like to have more technicians with multiple or mechatronic skills.

60 These figures exclude any apprentices, all of whom are on fixed-term contracts for the duration of their apprenticeship.

4. RECRUITMENT

In seeking to recruit technicians, physics departments are typically looking for people with vocational qualifications, usually acquired via an apprenticeship, and considerable industrial experience. Such recruits are valued not only for their practical skills in machining and electronics but also for what a number of interviewees referred to as their design or 'problem-solving' skills (that is, their ability, developed during their time in industry, to modify and develop equipment in order to solve technical problems). As one technical services manager who was involved in recruitment put it, alluding to the informal interaction between technicians and researchers described above, 'You need people who can take an idea and develop it ... [who have] design skills.' Or, in the words of an engineering workshops manager from one of the non-university research laboratories, technicians 'need breadth and versatility, with problem-solving skills, so that they can work with little supervision.'

Consistent with this profile, recruits tend to be middle-aged men, usually with vocational qualifications and considerable experience in industry. The relevant labour market is usually local or regional rather than national, with recruits tending to come from the area in which the university is located. Typically, recruits are attracted by the fact that working in a university offers more varied work, greater autonomy, and superior job security and pensions, than do private sector technician jobs. These intrinsic benefits of working in academia help to compensate for the fact that the wages offered by universities are typically lower than those available in industry. Interviewees also observed that because recruits tend to be older men who have paid off their mortgage and whose children have left home, they are more able to afford to take the pay cut that is often involved in moving from industry to a university. For the most part, and with the possible exception of electronics technicians, physics departments tend not to recruit people with BScs to technician – as distinct from technical/experimental officer - posts, simply because graduates tend not to have the practical skills and experience for which departments are looking.

Three of the university departments emphasised that even those recruits who have had a good industrial apprenticeship and several years of experience may require additional 'upgrade' training in order to be able to carry out some of their duties (e.g. making conical joints for ultra-high vacuum work, precision welding and high-quality soldering of unusual materials, and using cryogenic equipment). The need for such training - which is usually provided informally, on-the-job by more experienced colleagues - arises because technical work of the kind just mentioned is so specialised that even experienced recruits are unlikely to have had a chance to carry it out and acquire the relevant skills before arriving at the university. It is in recognition of this point that interviewees from some of physics departments said that, when recruiting for technician positions, they attempt to evaluate not only the *existing* skills of potential recruits, but also their aptitude and attitude, in order to ascertain their ability and willingness to master the new techniques – and also to engage in the problem-solving - required to support physics research. The specialist nature of the skills required by departments also implies that it is important to try to retain skilled workers once they have been trained in house. As one Head of Department put it, 'You don't want a revolving door policy in technical support [because] once you lose those skills it's very hard to rebuild them'.

Having outlined the kind of person that physics departments would *like* to appoint to technician roles, we shall consider the extent to which they are *able* to do so. Here, a majority of our interviewees suggested that, in contrast to the 1990s and early 2000s, the picture is far from rosy. A majority of the university departments (6 out of 9), and one of the two non-university research laboratories, reported a low-to-moderate – and deteriorating - availability of skilled labour on the external market, as evidenced principally by the fact that there had been occasions in the last few years when the field of applicants for vacant technician posts was too poor to enable them to make an appointment, sometimes even after re-advertising the job in question. Most, though not all, interviewees attributed such difficulties to the relatively low wages paid by universities compared to those available in industry. The uncompetitive salaries, coupled with the limited career prospects, were thought likely to deter young people in particular from entering the university sector from private firms. Significantly, even in the case of those departments where the supply of skilled labour is viewed as moderate – rather than low – there is sufficient concern about the scope for acquiring skilled technicians externally for there to have been a revival of interest in apprenticeship training schemes.

5. APPRENTICESHIPS

The past 5 years have seen a resurgence of interest in apprenticeship training schemes amongst university physics departments, as technical services managers strive to find a way of continuing to provide high quality technical support in the face of (i) an ageing workforce, with a significant number of technicians due to retire in the next 5-10 years, and (ii) the limited availability of the right kind of workers on the external labour market, given the wages that departments are able to pay. More specifically, of the 9 university departments visited for this project, 3 have either begun in the past three years – or are just about to commence - an apprenticeship scheme for their physics technicians, while a fourth is currently considering doing so. In addition, one of the two non-university research laboratories has a large, well-established apprenticeship programme.

The 3 university departments that have chosen to take on apprentices and the non-university research laboratory have all adopted similar, though not identical, approaches to running their apprenticeship programmes. In each case, the apprentices have been taken on under the auspices of the government's Advanced Apprenticeship scheme, and are studying for qualifications in engineering (usually mechanical engineering, sometimes electronics engineering). Apprentices start at level 2, studying for an ONC and an NVQ2, before moving on to work for a level 3 NVQ and an HNC.[61] The off-the-job training required for the technical certificates is provided by a local further education college, either via day release (in the case of two departments) or via block release for the first year of the apprenticeship followed by day release thereafter (in the case of one department and the non-university laboratory). The departments and laboratory provide the apprentices with the requisite on-the-job training and work experience by rotating them through various laboratories and workshops.

In the case of the university departments, the number of apprentices taken on tends to be small, usually just one or two per annum. The non-university research laboratory that continues to offer apprenticeships has a larger programme, normally recruiting 6 trainees each year. Comparisons of apprenticeship activity across employers and time are of course potentially clouded by differences in skilled employment, with larger employers taking on more apprentices simply because they have a bigger technician workforce to maintain. A simple way of allowing for such differences is to calculate the ratio of the number of apprentices currently in training to the number of skilled employees within the relevant occupation (in this case, technicians). This indicator, known traditionally as the apprentice–journeyman ratio, can be used to compare the rate or intensity of training across employers. The intensity of training averages about 3% across the three university departments that offer apprenticeships, and is about 6% in the case of the non-university research laboratory.[62]

In selecting their apprentices, the university departments are looking for young people aged between 16 and 18, who have GCSEs in English and, in particular, maths. Some departments set written and practical tests for shortlisted candidates.

61 Two departments suggested that level 4 skills are required for some technician work, especially the construction of precision instruments. Their hope is that at least some apprentices will ultimately progress beyond an Advanced Apprenticeship to do an HND in order to acquire the requisite skills.

62 One would expect the figure for the intensity of the apprenticeship training undertaken by university department to rise over time if those departments, most of whom have only recently started taking on apprentices again, continue to do so and therefore ultimately have apprentices in every year of their training programmes.

Departments report that they receive enough good applicants to be able fill all the places they are offering. In all three cases, although the young people have a fixed term contract of employment, coterminous with their apprenticeship, the departments hope and expect that they will be kept on at the end of the training programme, subject to satisfactory performance. New apprentices at the non-university research laboratory are usually aged between 18 and 20. Entrance requirements are 4 GCSEs at grade C or above and maths at grade B. On the whole, the programme attracts good applicants and, at under 10%, the drop-out rate is low.

All four organisations have passed on formal responsibility for organising the apprenticeship to an external training provider (in three cases, a local further education college, in one a group training association), though in some cases departments have had to work hard to ensure that the colleges deliver the quality of support required for the apprenticeship programme to be a success. It is the external training providers, rather than the departments and research laboratory, that hold the apprenticeship training contract with the Skills Funding Agency and are in direct receipt of the government funding for the apprentices. The government subsidy covers both the fees for the college courses required for the technical certificate and key skills elements of the apprenticeship, and also the cost of the assessment of the on-the-job training (NVQ). The departments and research laboratory are left, therefore, to cover the (explicit) cost of the apprentices' wages and the (implicit) costs of overseeing the scheme and providing the on-the-job training. In the two cases for which data is available, salary costs are split between the relevant department and the central university. Moreover, interviewees at two of the university departments intimated that it was not long before apprentices were doing useful work around the department, and that the time required for more experienced technicians to provide the on-the-job training was not prohibitive, so that overall – while cost is undoubtedly a consideration - apprentices constitute 'quite good value for money'. A similar view was expressed by representatives of the non-university research laboratory, who noted that while apprenticeship training is not cheap, it is cost effective nevertheless, because it delivers high quality technicians who are able to do the job required of them.

It is worth remarking that the three university physics departments that have taken on apprentices are the biggest three in the sample, measured in terms of total technician numbers, and the first, second and fourth biggest departments measured in terms of numbers of academics. The non-university research laboratory is large indeed, with over 300 technicians in total. The scale of operations in these four cases is undoubtedly one of the factors that drives and facilitates their involvement in apprentice training, because it means that there is a sufficient demand for apprentices to make bearing the fixed costs of overseeing the scheme worthwhile.

Three other university departments have seriously considered taking on apprentices, for the same reasons as were noted above. In one department, a similar scheme to those described above was developed that was supported by the department in principle but was not implemented in practice due to financial concerns about the (rather generous) wages the newly qualified apprentices would receive. The department may well revisit the possibility of taking on apprentices in the next couple of years, possibly in conjunction with the department of engineering in the same university. In the second case, while apprenticeship was viewed as 'attractive in theory' as a tool for dealing with the succession planning problem, it was rejected, primarily for two reasons: (i) first, because of concerns about whether newly qualified Advanced Apprentices would really have the skills required to do a job that proves taxing even for technicians with many years of industrial experience; and (ii) second, because in a small department like the one in question, where the technical staff are already working at full capacity, experienced technicians simply do not have enough time to provide the on-the-job training required by the apprentices. The third department that considered the possibility of starting an apprenticeship scheme, only to reject it, is situated in an area where a number of large manufacturing firms have shut down in the recent past, yielding a relatively abundant supply of skilled workers whose availability significantly reduces the department's need to grow its own technicians. The department was also deterred from taking on apprentices by the amount of time required for existing staff to administer the scheme and provide the on-the-job training and by the fear that newly qualified apprentices would be poached by local firms, as was said to have happened all-too-often under the university's old training scheme.

Only two physics departments had not seriously entertained the possibility of starting an apprentice training programme. Significantly, neither had experienced the combination of an ageing workforce and scarcity of suitable recruits that had prompted other departments to consider taking on apprentices. In one, the average age of the technician workforce was estimated to be just 38, the lowest of any of the physics departments considered here, so succession planning was not yet thought to be a major issue. Nor had the department had much difficulty in finding suitable recruits from the external labour market. In the other department, which is situated a post-1992 university where technicians are used primarily to support teaching, it was thought that older recruits would be better than recent school-leavers in dealing with students. This second department was also reasonably confident that it would be able to pay enough to recruit suitable technicians when required to do so.

6. ONGOING TRAINING

Having considered apprenticeships, we move on now to explore the provision of ongoing training for established technical staff. Although much of this training still appears to be provided in a rather *ad hoc* fashion, as the requirements of research and teaching support dictate, the identification of training needs is becoming increasingly systematic as more and more technical staff undertake personal development reviews and appraisals. We start by considering uncertificated training, before moving on to training that gives rise to formal qualifications.

A large amount of uncertificated, ongoing technician training is provided in-house by more experienced members of staff, usually on-the-job but occasionally via short internal training courses in specific techniques and in using certain pieces of equipment (e.g. lasers). Interviewees in both the university departments and the research laboratories indicated that this is one of – if not *the* – most important sources of training for established staff. Moreover, as noted earlier, given the practical and highly specialised nature of some of the skills that technicians in physics are required to possess, such on-the-job training is probably the only cost effective way for technicians to acquire them. A second type of uncertificated training is mandatory training designed to deal with the health and safety issues that arise in physics departments (e.g. gas cylinder handling, lasers, radiation, etc.). Again, this kind of training is usually provided in-house. Third, moving away from technical skills, university staff development units offer the usual range of personal development and managerial training, some of which is used by technicians, in particular those moving into laboratory manager and departmental services manager roles.

Equipment manufacturers constitute the major external source of uncertificated ongoing training. Such training usually accompanies the purchase of new equipment and/or associated software, though it can also be purchased independently of the latter. Perhaps most notably, 3 of the physics departments visited for this study had recently refurbished their workshops and / or laboratories, and had introduced several new pieces of equipment such as CNC machines and rapid prototypers (3D printers). The technicians in those departments had all received extensive training from the manufacturers of those machines on how to programme and use them. Other examples of vendor-supplied training mentioned by interviewees include training in vacuum technology from Edwards Vacuum Limited and Swagelok, and in Labview graphical programming software from National Instruments. Interviewees were keen to emphasise that, even though this training does not lead to a formal qualification, it is often intense and high quality. Interviewees in two physics departments where a significant amounts of space research is undertaken also reported that funding bodies such as the European Space Agency require technicians to have taken certain external training courses (e.g. in 'planetary protection'). Interviewees reported that little use is made of joint training with departments in other universities - one exception is York University's annual 2-day training course in vacuum technology - and only two departments had made any use of the training offered by the technicians organisation, HEaTED.

Departments also make some, albeit limited use of training that is certificated in the sense of leading to formal qualifications. In a majority of the university departments (6 out of 9), there are one or two technicians or technical/ experimental officers who either have taken or are currently studying for a BSc, usually either in physics, electronics, or engineering, whilst working as a technician. Typically, they do so part time, either at the local post-1992 university or via the Open University, are given day release, and have some or all of their fees paid by their home department. In a similar vein, both of the non-university research laboratories have supported technicians who wish to do a degree. Indeed, in the larger of the two, there are currently 3 technicians doing degrees and 4 doing foundation degrees. Little use appears to be made of local further education colleges to provide certificated vocational training for established – as opposed to apprentice - technicians (e.g. HNCs, HNDs). Of the university departments visited, only two reported sending established on external, certificated vocational training courses. There are some problems with the availability of college courses, with few colleges being willing to offer courses (e.g. HNC electronics) given the relatively small numbers of people wanting to take them.

7. BROADER HUMAN RESOURCE MANAGEMENT ISSUES

2005 saw the introduction of a new pay and conditions framework for all staff working in higher education. Amongst other things, the new framework brought all staff – whether previously classified as academic, academic-related, or non-academic staff – onto a single pay spine and provided for the assessment of all posts. A majority (8 out of the 9) of the university departments indicated that the introduction of the common pay spine, and the associated system of job evaluation, role analysis, and grading had been viewed as fair by technical staff. Two departments in particular indicated that their technical staff 'came out very well' at the end of the job evaluation process, the reason being that as the number of technicians in those departments had declined over time the remaining technicians had taken on extra responsibilities that were formally recognised only during the move to the common spine. As a result, the job evaluation process led to them ending up with higher grades, and therefore higher pay, than before.

However, as time has passed some problems appear to have emerged. The most oft-remarked difficulty, noted by 4 departments, stems from the fact that the segments of the pay spine associated with each grade are now shorter than they were prior to the introduction of the common spine. What that implies, interviewees noted, is that people on a particular grade reach a pay ceiling earlier than they did in the past. Having done so, they can secure pay increases only by taking on extra responsibilities. However, especially given the relatively flat organisational structure in universities (with relatively few laboratory manager, workshop superintendant and departmental services manager posts), the scope for taking on additional duties is quite limited, making it hard for people to 'grow their roles' in the way required for upgrading. The consequent tendency for technicians' pay to stagnate has led to some dissatisfaction amongst technical staff.

The Gatsby Charitable Foundation
The Peak, 5 Wilton Road, London SW1V 1AP
T +44 (0)20 7410 0330 www.gatsby.org.uk
Registered Charity number 251988

May 2013