

TECHNICIAN ROLES, SKILLS AND TRAINING IN THE UK CHEMICAL INDUSTRY: AN ANALYSIS

PAUL LEWIS
DEPARTMENT OF POLITICAL ECONOMY
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.

CONTENTS

	page
EXECUTIVE SUMMARY	1
SECTION 1 INTRODUCTION	6
SECTION 2 RESEARCH METHODOLOGY	9
SECTION 3 RESULTS I: THE CURRENT TECHNICIAN WORKFORCE: ROLES, QUALIFICATIONS, SIZE, ORIGINS, AND AGE PROFILE	11
3.1 Varieties of technician role and associated qualifications	11
3.1.1 Process operators	11
3.1.2 Maintenance technicians	13
3.1.3 Laboratory technicians	15
3.1.4 Mechanical testing technicians	18
3.2 Technician numbers	19
3.3 Qualifications	20
3.4 Source of the current technician workforce	20
3.5 Age profile	23
SECTION 4 RESULTS II: THE FUTURE TECHNICIAN WORKFORCE	24
4.1 Recruitment	24
4.2 Apprenticeship	26
4.2.1 Definition and involvement	26
4.2.2 Apprenticeship training for maintenance technician roles	26
4.2.3 The over-training of engineering apprentices	29
4.2.4 Apprenticeship training for process operator roles	30
4.2.5 Apprenticeship training for laboratory technician roles	31
4.2.6 Vocational training for degree-level engineers	34
4.3 Upgrade training	34
4.4 Careers: ongoing training and professionalism development	35
4.4.1 Ongoing training	35
4.4.2 Professional registration	36
SECTION 5 SUMMARY AND POLICY RECOMMENDATIONS	37
REFERENCES	41

TABLES

Table 1 Summaries of case study organisations, by type of organisation	9
Table 2 Involvement of the case study organisations in apprenticeship training, by type of organisation and role	26
Table 3 Attributes of apprenticeship training programmes, by employer and type of scheme	27

ACKNOWLEDGEMENTS

I am very grateful for advice and comments on an earlier draft from Daniel Sandford Smith and James Epps, neither of whom is in any way responsible for any remaining errors and infelicities.

Financial support from the Gatsby Charitable Foundation is gratefully acknowledged.

I am also extremely grateful to all the interviewees, who generously gave of their time and knowledge and were unfailingly helpful and patient in answering follow-up questions.

Paul Lewis
Department of Political Economy
King's College London
Paul.lewis@kcl.ac.uk

EXECUTIVE SUMMARY

- 1 The Coalition government has set itself the goal of creating 'a modern class of technicians.' Technicians are highly productive people who apply proven techniques and procedures to the solution of practical problems. They carry supervisory or technical responsibility and competently deliver their skills and creativity in the fields of science, engineering and technology. As the term 'technician' is currently used by policy-makers in the UK, it denotes people occupying technical roles that require either level 3 or level 4/5 skills. Consequently, the class of 'technicians' encompasses both 'skilled trades' and also 'associate professional/technical' roles.
- 2 There are currently concerns both about skills shortages at the technician level and also about the age of the technician workforce. The government is attempting to address these concerns through policies designed to increase both the status and also the numbers of technicians in the UK economy.
- 3 This report investigates the role played by technicians in an important industry in the British economy, namely chemicals. Chemical firms design and manufacture both consumer goods, such as soaps, detergents, cosmetics, personal care and household cleaning products, and also intermediate goods that other manufacturers use as raw materials in their production processes. The industry also contains specialist contract analysis laboratories which test, inspect and certify samples of chemicals for various kinds of customer. The UK chemical industry enjoys around an 8% share of the world market and has a turnover in the region of £43 billion, employing around 140,000 people and accounting for about 12% of the UK's (net) manufacturing output.
- 4 The goal of the research described in this report is to inform policy by examining how the UK chemical industry uses technicians and how it acquires and/or develops those it needs. The project forms part of a wider programme of research into technician duties, skills and training in various strategically important sectors of the economy, including – in addition to the chemical industry – aerospace, composites, and space.
- 5 The research project reported here examined six sets of questions.
 - First, in what roles are technicians employed in the chemical industry in the UK, and what are their main duties?
 - Second, what levels and kinds of skill and qualification do those technicians typically possess?
 - Third, how do employers in the chemicals industry acquire the technicians they need?
 - Fourth, do chemical companies suffer from any skill shortages at the technician level?
 - Fifth, what provision do employers in the chemical industry make for the ongoing training and career development of their technicians?
 - Sixth, what – if anything – should government do to help employers in the chemical industry in their efforts to acquire skilled technicians?

- 6 Data were collected via interviews with nine sector-level organisations, including government departments, learned societies, trade bodies, and sector skills councils, and through case studies of nineteen employers. The case study organisations included chemical manufacturers (twelve cases), contract analysis laboratories (four cases), and research and development laboratories (three cases).
- 7 The roles filled by the technicians who work in the chemical industry include, in the case of 'skilled trades' roles, those of process operator; leading technician, mechanical testing technician, mechanical maintenance technician, electrical maintenance technician, control and instrumentation technician, and laboratory technician; and in the case of 'associate professional/technical' roles those of assistant engineer, maintenance manager, project engineer, and laboratory supervisor/manager. The occupants of 'skilled trades' roles in engineering tend to possess a level 3 qualification in the relevant sub-discipline (such as chemical process engineering in the case of process operators, or mechanical, electrical or instrumentation engineering in the case of maintenance engineers). The occupations of engineering-related roles at the 'associate professional/technical' level tend to be qualified at least to level 4/5, possessing HNCs, HNDs or Foundation Degrees in engineering.
- 8 While the kind of work that is carried out by laboratory technicians typically requires no more than intermediate (level 3-5 skills), as certificated by level 3 qualifications in Applied Laboratory Science or Laboratory and Related Technical Activities, or by an HNC in chemistry, in practice many occupants of such roles are often qualified to degree level. Such workers are over-qualified in the sense that the highest level of formal qualifications they possess exceeds the level required actually to carry out their job effectively. This can lead to problems, both because the graduates in question often become dissatisfied, and also because while they possess considerable theoretical knowledge they sometimes lack the ability to apply their skills effectively in the workplace.
- 9 On average, technicians account for a little under 40% of the workforce in the manufacturers visited for this study. This overall average conceals a significant divergence between two kinds of manufacturer: those who, because of the type of manufacturing process they utilise, require their process operators to be qualified only to level 2 (in which group of firms technicians account for around 15% of the workforce as a whole); and those whose manufacturing processes demands that process operators be qualified to level 3 (where technicians account for just over 50% of the total workforce). The contract analysis laboratories estimated that just over 30% of their workforce occupied roles for which intermediate-level qualifications are appropriate (although, as noted above, many of those roles are occupied in practice by graduates). The specialist research and development laboratories visited for this study all reported that the kind of work carried out in their facilities requires that people filling STEM roles possess an understanding of chemistry and/or biological science to at least degree level. Consequently, those laboratories do not employ specialist technicians.

- 10 Of the seven manufacturers who provide estimates of the source of their technicians, three indicated that recruitment had made by far the biggest contribution to the process operator and maintenance technician workforce, with only a negligible contribution having been made by in-house training. The other four manufacturers indicated that in-house training had made a significant (25-70%) contribution to their current technician workforce. All of the contract analysis laboratories indicated that the vast majority of the current technician workforce had been recruited, often – as noted above - as graduates. It should also be noted that while none of the specialist research and development laboratories visited as part of this study employs specialist technicians, two of the three organisations acquired a small but significant minority (10-20%) of their research scientists through in-house training. The organisations in question take school-leavers after they have completed their 'A' levels and support them to take an HNC or Foundation Degree, followed by a full degree, on a part-time, day release basis.
- 11 There is some evidence that employers in the UK chemical industry are beginning to make a greater use of apprentice training as a means of filling technician roles. Two of the case study manufacturers that had not previously run an apprenticeship scheme have begun taking apprentice maintenance engineers within the past two years. Two of the contract analysis laboratories have very recently begun apprenticeship training programmes for their laboratory technicians, whilst a third is trying to do so.
- 12 The increased reliance on in-house training reflects a number of factors. First, in the case of the manufacturing firms, there is the difficulty of hiring high quality, experienced maintenance technicians – especially specialists in control and instrumentation engineering – from the external labour market. Second, in the case of the contract research laboratories, apprenticeship is seen primarily as a means of developing a cadre of specialist technicians to carry out relatively mundane laboratory work. This will, the employers believe, enable their graduate employees to focus on more demanding and interesting work, thereby – it is hoped – increasing efficiency and saving money, as well as helping to ameliorate discontent amongst over-qualified graduates.
- 13 In total, eight of the twelve chemical manufacturers visited for this study train apprentices to fill maintenance technician roles. In three cases, the apprenticeship training programme is three years in length and the goal is for the apprentices to achieve a level 3 award in either mechanical or electrical/instrumentation engineering. The other five manufacturers aim for their engineering apprentices to achieve a level 4 qualification (HNC) in engineering over a 4-5 year training programme. All the training programmes form part of the government's Advanced Apprenticeship scheme. In all but one case, the SFA contract is held either by a local group training association or a local college, indicating that the employers have delegated formal responsibility for organising the apprentices' training to a third party. At present, only one of the chemical manufacturers has had its engineering apprenticeship scheme accredited (in this case, by the IET).
- 14 Entry requirements are typically 3-5 GCSEs at grade 'C' or above, including English, maths and a science, although three of the level 4 programmes require apprentices to have a B grade in GCSE mathematics. In most cases, employers report that they receive enough good quality applicants. In two cases, however,

the employers have struggled to attract sufficient numbers of good applicants, reporting that local schools have had little interest in sending decent applicants to apply for apprenticeships, preferring instead to encourage them to apply to university. One large established chemical manufacturer also helps to train apprentices for other chemical firms in its local area ('over-training').

- 15 The main reasons for taking engineering apprentices are: the difficulty of recruiting experienced, high-quality maintenance technicians, so that firms have to train them in-house if they are to acquire the ones they need; and the need to plan for the succession of an ageing technician workforce. Some employers also valued the way in which apprenticeship training can help to ensure that more and more engineering technicians are skilled at both mechanical and electrical work, thereby increasing the speed with which maintenance work can be carried out and raising the efficiency of the plant.
- 16 The four manufacturers who offer apprenticeships for their process operators aim for their apprentices to achieve either an Advanced Apprenticeship or an HNC in chemical process engineering. The principal reason for taking apprentices in this case is succession planning.
- 17 Three of the contract analysis laboratories currently take apprentices, while the fourth is trying to do so. Only in one of the three cases does the organisation have a long history of taking apprentices. Focusing on the two firms that have recently begun to take apprentices, and on the laboratory that wishes to do so, a similar pattern emerges. These organisations have tended to rely on recruiting graduates to fill laboratory technician roles, so that many straightforward tasks are being carried out by over-skilled graduates. The organisations have responded to this issue by beginning (or trying) to recruit apprentices, primarily because they believe that doing so will enable them to save money by reducing their wage bill and also because apprentices may well have better practical skills. Apprentices are working either towards level 3 qualifications in Laboratory and Associated Technical Activities and Applied Laboratory Science, under the auspices of the government's Advanced Apprenticeship programme, or towards a Foundation Degree in chemistry via day release. However, the employers have often found it difficult to persuade colleges and universities to offer the requisite training programmes; the two employers who have succeeded in taking on apprentices have had to adopt innovative approaches in order to do so, while one firm has thus far been unable to take on apprentices because of the lack of a provider.
- 18 Two of the specialist research and development laboratories visited for this study offer training programmes that allow school-leavers with 'A' levels to proceed to a degree via a part-time, work-based route, as does one of the chemical manufacturers that has its own research and development laboratory. A similar approach has also been adopted by one of the large chemical manufacturers visited for this study as a means of obtaining some of the graduate-level engineers it needs.
- 19 Informal in-house training, typically provided informally by more senior staff, was said to play an important role in the ongoing training of chemical manufacturers' established technicians. A majority of firms also offer opportunities for formal, certificated training for those technicians who were willing and able to

move up the firm's internal career ladder. For example, level 3 maintenance technicians might be supported to work towards an HNC, HND or Foundation Degree in engineering, with a view to their being promoted to more senior engineering positions, while able and ambitious level 3 process operators might be helped to take HNCs and Foundation Degrees in chemical process engineering, so that they were able to move up to more senior, supervisory roles such as production manager or process engineer. Such workers might also be supported to study for a full honours degree in electrical, mechanical or chemical engineering where appropriate.

- 20 A number of recommendations for policy emerge from the findings presented above, connected primarily with the need to help firms offer high-quality apprenticeship training and thereby deal with the problems posed by an ageing workforce and the increasing difficulty of recruiting experienced technicians.

While some contract services laboratories are attempting to establish apprenticeship schemes that will enable them to develop junior laboratory technicians in-house, these organisations have found it difficult to find colleges or universities to offer the relevant training and assessment services. The reason is that those colleges have found the number of apprentices too small to make it worth their while to offer the training. A number of possible courses of action are open to policy-makers.

- First, there needs to be better dissemination of information about the availability of the relevant modules in those cases where they are available, either locally or via distance learning/summer schools.
- Closer collaboration between employers, and between employers and educational institutions, might help to aggregate demand from employers, so that student numbers exceed the minimum required to make it worthwhile for universities/colleges to offer the relevant modules.
- Large, established providers of apprenticeships in the chemical industry might become involved in the 'over-training' of apprentices for other, smaller firms (as exemplified by one of the chemical manufacturers visited for this study in the case of engineering apprentices).
- Policy-makers need to consider changing the funding regime facing colleges so that they are confronted with sharper incentives to offer training for apprentices in STEM subjects.

More generally, the careers advice provided in schools requires improvement, so that young people are made aware that the vocational route can lead to high quality training, that taking it does not preclude going to university at some point, and that it offers the prospect of high-quality training and swift progress along a well-defined career path. The opportunities available are exemplified by the way in which the research and development facilities visited for this study have established work-based routes to degrees for aspiring research scientists, and also by the way in which one of the chemical manufacturers has created a work-based route to an engineering degree. While these possibilities are on offer, their existence is seemingly not well known to schoolchildren and teachers. Greater awareness of the opportunities available via the work-based route is essential.

SECTION I INTRODUCTION

Successive governments have argued that raising the number of skilled technicians in the UK workforce, especially in sectors such as manufacturing, is essential for improving the performance of the UK economy. Technicians are 'highly productive people who apply proven techniques and procedures to the solution of practical problems. They carry supervisory or technical responsibility and competently deliver their skills and creativity in the fields of science, engineering and technology' (Technician Council 2012). As it is currently used by policy-makers in the UK, the term 'technician' denotes people occupying technical roles that require 'intermediate' – that is, level 3 or level 4/5 – STEM (science, technology, engineering and mathematics) skills. Consequently, the category encompasses both 'skilled trades' and also 'associate professional/technical' roles (Jagger *et al.* 2010; Technician Council 2012).

Policy-makers' concerns about technicians are rooted in the perception that there are ongoing skills shortages at the technician level in the UK economy (BIS 2009, 2010; UKCES 2010a, 2010b; HM Treasury and Department of Business, Innovation and Skills 2011: 85; Spilsbury and Garrett 2011). The policy response to this problem has centred on the creation of a 'modern class of technicians,' a term that encompasses increases both in the status and also in the number of technicians in the UK economy, and ambitious targets have been set for the number of apprentice technicians (BIS 2009a: 18, 2010a: 7, 15, 18; HM Treasury and Department of Business, Innovation and Skills 2010: 18-19; House of Commons Library 2011: 4-6). A Technician Council has been established, its main goals being: to ensure that the contribution made by technicians to the organisations in which they work, and thence to society at large, is properly recognised, thereby raising the status and the esteem in which technicians are held; to increase (awareness of) the opportunities for career advancement open to technicians, in particular by helping to develop a common framework for professional registration for technicians working across science, technology, engineering and mathematics; and, ultimately, by increasing the attractiveness of the technician jobs and careers in the ways just described, to increase the number of technicians being trained in the UK (BIS 2009a, 2010a: 18; HM Treasury and Department of Business, Innovation and Skills 2011: 89; Technician Council 2012: 2, 5). In a similar vein, the government's acceptance of many of the recommendations of the recent Richard Review of Apprenticeships has been motivated by a desire to increase both the demand for, and supply of, high-quality apprenticeship training places with a view, ultimately, to increasing the number of qualified technicians in the UK economy. Perhaps most notably, Richard's recommendation that the criteria for what counts as an apprenticeship be tightened, in particular by requiring that (almost) all apprenticeships aim at general, transferable level 3 skills and involve mandatory off-the-job vocational education; his support for a new, more holistic assessment of apprentice's all-round competence; and his determination to sharpen the incentives for training providers to respond to the needs for employers by channelling government funding for apprenticeships via the latter, are all (admittedly fallible) attempts to increase the quality, attractiveness and (ultimately) the number of apprentices being trained (Richard 2012; BIS 2013; Lewis 2014a).

The policy goals of increased numbers of technicians and enhanced status will be achieved only if the nature of technician work, and the demand for and supply of technician skills, are well understood. The research reported in this paper helps to

achieve such an understanding by investigating the duties, skills, and training of the technicians employed in one of the most important industries in the UK economy, namely the chemical industry.

The UK chemical industry is one of the country's largest manufacturing industries. While chemical firms are found across the UK, they are most heavily concentrated in four main regions: the North-West; Yorkshire and Humberside; Teeside; and Scotland (in particular, around Grangemouth). Its constituent firms make three broad categories of product:

- consumer goods (including soaps, detergents, cosmetics and various personal care and household cleaning products);
- commodity chemicals (such as fertilisers, plastics, man-made fibres and industrial gases); and
- speciality chemicals (such as paints, adhesives, and explosives).

While the first type of product is, of course, used by final consumers, the latter two kinds of output are intermediate goods (that is, they are used as raw materials by other manufacturers both inside and outside the chemical industry). The industry has a turnover in the region of £43 billion, directly employs around 140,000 people, and accounts for about 12% of the UK's (net) manufacturing output. Recent years have seen the industry grow at around 5% per annum. It has an 8% share of the world market and its exports are worth £24 billion (UKTI 2009: 2, 28-35; COGENT 2010a).

Such a sector is naturally of interest to policy-makers such as the current government, who profess to want to rebalance the UK economy away from financial services and towards manufacturing, to increase the number of apprentices in training, and thereby promote the fortunes of UK manufacturing and catalyse export-led growth. In the words of a recent report on technicians, 'the level and type of skills that technicians have are vital to emerging markets in the UK, such as [the] advanced manufacturing and engineering industries. 'Becoming more production- and export-led means becoming more technician-led' (Skills Commission 2011: 16).

The goal of the research described in this report is to inform policy by examining how the UK chemical industry uses technicians and how it acquires and/or develops those it needs. More specifically, the paper seeks to answer six sets of questions:

- First, in what roles are technicians employed in the chemical industry in the UK?
- Second, what levels of skill and qualifications do the people occupying technician roles typically have?
- Third, how do employers in the chemical industry fill technician roles? Three sub-questions arise here. First, do employers use people with intermediate-level skills to fill those roles or do they fill them by hiring over-qualified graduates? Second, to the extent that technician roles in the chemical industry are occupied by people with intermediate-level skills and qualifications, do employers acquire those workers primarily by hiring experienced technicians from the external labour market or via some form of in-house training? Third, to the extent that employers rely on in-house training to fill technician roles, what form does such training take?
- Fourth, do chemical companies suffer from any skill shortages at the technician level?

- Fifth, what provision do employers make for the ongoing training and career development of their technicians?
- Sixth, and finally, what – if anything – should government do to help chemical firms in their efforts to acquire skilled technicians?

The structure of the report is as follows. Section 2 outlines the research methodology used in this study and describes the set of case study organisations. Section 3 starts the presentation of the study's findings, examining the current technician workforce with respect to five main sets of issues: the kind of roles that technicians fill; the skills – and, as a proxy for skills, the qualifications – they need to fill those roles successfully; whether employers in practice fill technician roles by using people with intermediate-level skills or by hiring (over-qualified) graduates; whether those technicians who actually do have intermediate-level qualifications were acquired by their current employer via the external labour market or through some form of in-house training; and the age profile of the current technician workforce. Section 4 continues with the presentation of the results, but shifts attention towards the workforce planning strategies that employers in the chemical industry are currently using to satisfy their need for technicians in the medium to long term. Accordingly, the section examines both the balance that employers seek to strike between recruitment and different forms of in-house training, and also to consider the ongoing training that employers provide for their more established technicians. Section 5 summarises the discussion and offers recommendations for policy.

SECTION 2 RESEARCH METHODOLOGY

In the absence of a large data set concerning the skills and training of technicians in the chemical industry, a case study method was adopted. This has the benefit of making it possible to explore employers' decisions how about to obtain and use technicians in considerable contextualised detail.

The process of data collection had two main stages. The first involved a series of nine interviews with various sector-level organisations, such as the Royal Society of Chemistry, national skills academies, trade associations, and sector skills councils (most notably Cogent, the sector skills council for the chemical, pharmaceutical, nuclear, life sciences, petroleum and polymer industries). These interviews, along with secondary sources such as reports and policy documents concerning the chemical industry in the UK, were used both to acquire information about key issues associated with the industry's use of technicians and also to inform the choice of case study organisations.

The second stage of the project involved the collection of data about technician duties, skills, recruitment, and training from a total of nineteen employers, drawn from the three main parts of the chemical industry, namely: chemical manufacturers (twelve cases); contract analysis laboratories (four cases); and research and development laboratories (three cases). Information was collected via nineteen semi-structured interviews with a total of twenty-three interviewees, whose ranks included HR managers, training, apprenticeship, engineering and production managers, operations managers, technical directors, and chief/lead scientists, using a schedule piloted in the early cases. The interviews were carried out between October 2011 and June 2012 and averaged a little over 60 minutes in length. Notes were written up and, where gaps were revealed, these were filled by email follow-ups. Primary and secondary documentation was also collected where available. The cases are summarised in Table 1.

Table 1: Summaries of case study organisations, by type of organisation

Type of organisation	Number of cases	Average number of employees	Average number of technicians	Average share of technicians in the total workforce
Chemical manufacturer				
Total	12	1020	290	38%
Process operators at level 2	5	1894	390	15%
Process operators at level 3	7	395	220	53%
Contract analysis laboratory	4	395 ^a	98 ^a	31% ^a
Research and development laboratory	3	250	0	0%

Notes:

a: based on data from three firms only

The first, and largest, category of organisations comprises twelve firms drawn from the three main categories of chemical manufacturer, and includes manufacturers of: plastics; agricultural products (e.g. pesticides); resins and polymers (such as adhesives and coatings); household and personal cleaning products (e.g., detergents, washing machine tablets, soaps and shampoos); foodstuffs (e.g. ice cream, sauces, dressings); and several kinds of intermediate chemical (that is, chemicals that are used by inputs by other manufacturers). Eight of the firms are located within the main geographical clusters of chemical industry activity in the UK, while four are situated elsewhere in the country. These manufacturers have an average workforce of 1020 workers, a figure that falls to 480 if one very large firm, which has 7000 employees, is excluded from the sample.

A second, smaller group of case study organisations consists of four 'contract analysis laboratories'. As their names suggests, these organisations provide analytical (laboratory) services, centring on the provision of testing, inspection and certification (e.g. for quality assurance purposes) services for several different kinds of sample and/or customer, including: environmental samples (e.g. ground water, drinking water, soil); commodities (e.g. oil and gas, petrochemical products); foodstuffs (e.g. both for manufacturers and also for retailers of food and drink); and various kinds of material used by construction and manufacturing firms (e.g. testing for corrosion in pipes, concrete, etc.). Three of these organisations are independent commercial entities, while one forms part of a larger construction/engineering company. On average, these organisations employ 395 workers.

The final, and smallest, set of case study organisations consists of three research and development facilities, where new products in the areas of coatings, composites and pharmaceuticals are devised, trialled and tested. All three laboratories form part of larger chemical firms. However, the fieldwork conducted for this study focused only on the research and development side of these organisations and did not cover the manufacturing side of the businesses. The average size of the workforce at the three laboratories is 250 people.¹

¹ Two of the chemical manufacturers visited for this study also provided information on the skills and training of the technicians who work in their R&D laboratories, and reference will be made to the data they supplied at appropriate points in the study.

SECTION 3 RESULTS I: THE CURRENT TECHNICIAN WORKFORCE: ROLES, QUALIFICATIONS, SIZE, ORIGINS, AND AGE PROFILE

This section reports findings of the research project concerning various aspects of the current technician workforce in the case study organisations. First, the technician roles most commonly found in the chemical industry, along with – second – the qualifications typically possessed by the occupants of those roles, will be outlined. Third, the size of the technician workforce in the different categories of case study firm will be considered. Fourth, an indication will be given of ‘origins’ of the current technician workforce (that is, of how the case study employers acquired the workers who currently fill technician roles in their organisation). Fifth, and finally, the age profile of the technician workforce will be considered.

3.1 VARIETIES OF TECHNICIAN ROLE AND ASSOCIATED QUALIFICATIONS

There follows an account of the most common types of technician role found in the chemical industry in the UK. The list is not, of course, fully comprehensive; only the most common roles have been included. Moreover, as will become apparent, in several organisations differences between certain roles becoming blurred or elided, as the occupants of some positions (most notably process operators) take on some of the duties hitherto more commonly associated with other roles (e.g. mechanical maintenance technicians and laboratory technicians). Third, as will also become clear, the members of one category of case study organisation – namely, the specialist research and development laboratories of major chemical firms – do not employ technicians.

3.1.1 *Process operators*

Chemical plants are typically operated via a distributed control system (DCS), whereby instructions about changes to the production process issued from a central control room are put into effect by people adjusting motors and other types of equipment, opening/closing valves, etc., out on the plant itself. The workers who implement such changes are known as process operators. As their job title suggests, people filling such roles operate the industrial plant in which chemicals are produced on a day-to-day basis, controlling the working of the plant in response to signals they receive from the DCS by: starting and shutting down pieces of equipment (e.g., pumps and compressors); opening and closing valves; changing pump speeds; offloading raw materials from tankers and loading finished products onto tankers; ‘pigging’ or maintaining pipes; measuring and adding chemicals to the vessels in which the chemical reactions involved in the production process take place; using the instruments out on the plant to monitor volumes, levels and rates of flow of chemicals to make sure that the chemical processes are taking place safely and efficiently; preparing equipment for maintenance; and doing routine safety checks around the plant.

All twelve of the manufacturers visited for this study have process operators. The firms in question can be divided into two broad categories, depending on how skilled their process operators need to be. In the first category, comprising five firms, most process operators are currently semi-skilled workers, possessing only level 2 skills. This conforms to the findings of past studies of the chemical industry, which suggested that most process operators in chemical plants tended to have

only level 2 skills (Marsden 1982). In such companies, only senior technicians with supervisory responsibilities – variously known as ‘lead technicians’, ‘lead hands’ or ‘boardmen’ – are qualified to level 3 or above. The higher level of skills possessed by these workers reflects the fact that they take responsibility for the development of working procedures, for coordinating different parts of the production process, and for solving operational problems, all of which are duties that require them to be more skilled than mere process operators.

So far as the skills of basic process operators are concerned, matters are rather different in the second category of manufacturers visited for this study. This second group comprises seven manufacturers whose process operators typically possess level 3 skills. The higher level of skills possessed by the process operators who work for firms in this second group is said to reflect two main factors. The first is the type of industrial process that takes place at those firms, whose complexity and hazardous nature – the plants in question are typically top-tier COMAH rated – are such that operators need level 3 skills if the plant is to be operated safely and efficiently.² The key point is that process operators need to exercise judgment in deciding how precisely to respond to the signals coming from the DCS. It follows that, in the words of a managing director of a company which manufactures special chemicals that was visited for this study, process operators ‘need to have a model of the process in their minds’ so that they can judge how to alter the working of the plant so as to ensure that it continues to work both efficiently and safely. The requisite level of skill, the interviewee argued, was level 3.

The second reason why firms in this category require their operators to be skilled to level 3 concerns the variety of tasks they are now required to carry out. Whereas in the past process operators would simply have operated the plant along the line described above, they are now increasingly required to perform duties that would in the past have been carried out by the occupants of other roles. There are two main examples of the expansion of the duties undertaken by process operators. The first concerns the routine maintenance of mechanical systems, along with the initial diagnosis and solution of simple mechanical problems. Seven of the manufacturers visited for this study now use their process operators to do basic (preventative) mechanical maintenance (e.g. oiling, greasing and lubricating machines, monitoring the noise made by pumps and taking pressure readings to check that they are working properly) so as to release specialist maintenance technicians for more difficult work. These employers also now use their process operators to diagnose and fix simple problems with the mechanical systems on the plant.

The reason is as follows. Chemical plants typically operate 24 hours a day, 7 days a week, and therefore require process operators to be present at all times. Process operators therefore work a shift pattern. In contrast, maintenance technicians typically do not work shifts, and so are not on site to deal immediately with breakdowns that occur outside normal working hours. Companies are, for obvious reasons, keen to ensure that their plants work continuously, with as few hours lost to stoppages as possible. Accordingly, it is highly advantageous if their process operators are able to diagnose and, if appropriate, deal with simple faults and

² The COMAH – or Control of Major Accident Hazards – regulations are designed to ensure that employers ‘take all necessary measures to prevent major accidents involving dangerous substances [and] [l]imit the consequences to people and the environment of any major accidents which do occur’ (HSE 2013). Having competent staff – whose skills are certified and whose attendance at (ongoing) training is well-documented – is, of course, essential for demonstrating compliance with the COMAH regulations.

breakdowns – in particular, those that occur at night, when dedicated maintenance technicians are not present – so that the plant can be kept running as near to continuously as possible. Process operators need, therefore, to have a good enough working knowledge of the mechanical systems within the plant to be able to identify whether a problem is relatively straightforward, in which case they can deal with it themselves (e.g. by replacing flanges in pipes, changing filters in pumps, switching motors over), or more difficult, in which case the plant needs to be shut down until a specialist maintenance technician can deal with the problem the next day. In this way, the length of stoppages can be minimised, increasing the efficiency with which the plant operates. And in order to ensure that their process operators are equipped to do this work, the employers in question now typically train them in basic mechanical maintenance, broadening their portfolio of skills and taking them to level 3 overall.

The second aspect to the multi-skilling and upskilling of process operators concerns the way in which they are increasingly now being asked to undertake duties that in the past would have been carried out by specialist laboratory technicians. In five of the manufacturers visited for this project, process operators will take samples, both of the final product and also from intermediate stages of the production process, and then test them in order to help ensure that the process is working as it should and the final product has the properties desired by the customer. The aim of such multi-skilling is, of course, to increase efficiency by having fewer people carry out more tasks. Again, assessments from external bodies such as COGENT and NSAPI indicate that such multi-skilling is associated with an increase in the skill level of workers from level 2 to level 3.

3.1.2 Maintenance technicians

Technicians of this kind are employed at all twelve of the chemical manufacturers visited for this study. Three broad categories of maintenance technician are normally distinguished: mechanical; electrical; and control and instrumentation. We shall briefly outline the principal duties of each.

Mechanical maintenance technicians are responsible for planning and carrying out routine, preventative maintenance on the mechanical equipment and systems found in chemical plants (e.g. by oiling and lubricating machines, changing screws and bearings, and ‘pigging’ or cleaning pipes). They also diagnose and solve mechanical faults and breakdowns. Chemical plants involve several kinds of mechanical systems and the work carried out by such technicians will involve them checking, maintaining and – where necessary – repairing a variety of mechanical equipment and parts, including pumps, valves, compressors, pipes, condensers, heat exchangers, fans, and various (other) kinds of hydraulic and pneumatic systems.

Electrical maintenance technicians will look after the electrical systems (power and lighting) and equipment (motors, pumps, agitators, compressors, etc.) on the plant. They will perform routine maintenance and testing and will also carry out first-line fault-finding and repair work on wiring and equipment in the event of breakdowns. In addition, they will also carry out electrical isolations to facilitate mechanical maintenance. Like both of the other kinds of technician described here, electrical technicians will also be involved in the installation and commissioning of new plant.

Control and instrumentation maintenance technicians maintain and, where necessary, repair the instruments that form part of DCS through which modern chemical plants are operated. The DCS consists at least in part of instruments that

(i) measure key variables – such as pressures, temperatures, flow rates, weights, and volumes, along with the chemical properties of various liquids and gases – in different parts of the plant and then (ii) convert those measurements into electrical signals that are transmitted to the plant's control room. The responses from the control room, which come in either electrical or pneumatic form, signal to the process operators out on the plant how the appropriate variable needs to be altered. Control and instrumentation technicians – or analyser technicians, as some types of control and instrumentation technician are also known – ensure that the DCS system performs these tasks well. For example, the technicians will calibrate the instruments in question, making sure that they are taking accurate measurements and transmitting that information correctly into the DCS. They will also check that the DCS sends response signals that are appropriate, given the information it is receiving from the instruments out on the plant (a testing procedure known as 'loop-checking'). In addition to calibrating the instruments, control and instrumentation technicians will also maintain and, in the event of a breakdown, repair or replace them as appropriate. They will also be responsible for testing and maintaining the plant's safety-instrumented trip system.

Maintenance technicians typically possess level 3 skills, with ten of the twelve firms who employ such technicians stating that they expect them to be qualified to that level in the relevant form of engineering (mechanical, electrical or control and instrumentation). In only two cases, both of which are top-tier COMA sites, were maintenance technicians expected to be qualified to level 4 (HNC). Electrical maintenance technicians will also possess the relevant electrical qualifications (e.g. 17th edition).

One potentially significant trend, emphasised by two employers and also by some of the sector-level bodies, concerns a desire on the part of employers to have more technicians who are skilled in electrical as well as mechanical maintenance (that is, who are multi-skilled or, to use an oft-heard phrase, are skilled in mechatronics). Such multi-skilling is exemplified by the case of mechanical maintenance technicians who has also been trained in electrical maintenance, so that they can carry out the electrical work associated with maintenance tasks in order to save time and money and thereby increase efficiency. For instance, if mechanical maintenance technicians are also skilled in electrical work, then they will be able to isolate electrically a pump that they need to repair or replace, before draining it down, rigging it and then repairing or replacing it as appropriate, without having to wait for the assistance of a specialist electrical maintenance technician. In this way, the flexibility and responsiveness of the workforce can be increased, thereby helping firms to maintain downward pressure on costs in competitive international markets.

Maintenance technicians who occupy more senior roles – variously known as 'Assistant engineers', 'Maintenance Managers' or 'Project Engineers' – will typically be more highly qualified, possessing HNCs or HNDs in engineering. They will be responsible for ensuring that the plant's systems are maintained in accordance with the relevant safety regulations and company policies and will organise the work of the more junior technicians in pursuit of that goal. In addition, they will also help junior colleagues with more difficult breakdowns. Moreover, as well as helping the junior technicians to deal with more complex problems, these more senior technicians will also carry out 'root cause' analysis by seeking not just to diagnose the immediate cause of a breakdown – as a standard craftsman would – but also

to identify the underlying ('root') causes of recurrent technical problems. The additional technical knowledge provided by an HNC or HND enables them to do this. The occupants of such roles may also work in project management, liaising with graduate-level chemical engineers in designing and implementing modifications and improvements to the plant. More specifically, if graduate-level chemical engineers design a modification to the plant, specifying the flows, volumes, etc., then it will be the assistant engineers who will liaise with the manufacturers of the relevant parts to determine what kinds of pipes, pumps, valves, etc., are required to put the modification in question into effect.

On occasions, technicians' participation in the redesign of plants may involve them reporting back to the graduate-level engineer that there exists scope for improving the proposed design. The technician may, for instance, point out to the designer that the proposed layout of the plant does not afford the access required to allow maintenance work and so needs to be amended. To take a second example, the technicians might know from their experience of maintaining the type of plant in question that because pipes in particular locations tend to get blocked, it would be worthwhile inserting more flanges or drain points than were specified in the original design. As one interviewee put it, 'The chemists will come up with a wish list and the assistant engineer will provide a "reality check" and feed back information about whether the changes will be possible.' What this goes to show is that there may be occasions when vocationally educated technicians are able to advise graduate-level engineers occupying more senior positions within their organisation about how best to design or modify certain features of a chemical plant. The technicians' practical experience of how the plant is operated and maintained, and of the problems that can arise in doing so, can enable them to provide advice and feedback to ostensibly better qualified, but in terms of hands-on experience often less knowledgeable, graduates about how to design the plant in ways that will make it as easy to maintain as possible.³

3.1.3 Laboratory technicians

Laboratory technician roles for which people with level 3-5 skills are a good fit are found in all of the chemical manufacturers and contract analysis laboratories visited for this study. However, such roles are not found in the three specialist research and development facilities run by chemical manufacturers, where people filling technician roles must be educated at least to degree level (albeit degrees that, as we will see, are sometimes achieved via a work-based route). Moreover, as we shall also see, despite the fact that laboratory technician roles in manufacturing plants and contract analysis laboratories often demand skills that lie below degree level, in practice such roles are often filled by graduates whose higher-level skills are under-utilised and whose practical skills are sometimes deficient.

The duties of the laboratory technicians who work in manufacturing plants and contract analysis laboratories almost invariably include the preparation of the equipment, reagents and samples used in various kinds of chemical testing. The tests in question will depend on the type of organisation employing the technician, and include: tests designed to assess the properties both of chemicals at intermediate stages of the production process and also of final products (in

³ Similar observations have been made in the case of technicians working in university engineering workshops and in the aerospace industry (see Lewis and Gospel 2011: 16-17) and Lewis (2013a: 9-10).

the case of technicians in manufacturing plants⁴); and tests designed to determine the composition of certain chemical products or the presence of certain kinds of microbes, DNA or pathogens (in the case of contract analysis laboratories). The preparatory activities will include calibrating balances and other pieces of equipment, maintaining centrifuges, cleaning glassware, preparing solutions and other chemicals for use in tests, homogenising samples, etc.. Technicians may play a role in collecting the substances that are to be tested, either by taking samples from industrial plants (in the case of technicians who work in manufacturing) or through fieldwork (in the case of some technicians who work in contract analysis laboratories). Technicians working in contract analysis laboratories may be responsible for receiving and tracking samples submitted by external bodies. Technicians in manufacturers' laboratories and contract analysis laboratories typically also carry out relatively simple tests themselves, in strict accordance with standardised procedures. The methods of testing will vary according to context, and may include: glass transition measurement tests, titrations, and gas chromatography (in the case of manufacturing firms); and gas, liquid and ion chromatography, simple mass spectrometry, and extracting, plating and counting bacteria (in the case of contract analysis laboratories). Laboratory technicians will typically document the results in accordance with established procedures so that they are available for interpretation and analysis by more senior colleagues. The latter are sometimes more senior, experienced technicians but more commonly are graduate-level chemists. In this way, laboratory technicians provide the raw data on which more highly educated scientists work.

More experienced laboratory technicians in all kinds of organisation may assume roles such as laboratory supervisor or manager. They will take responsibility for ensuring that the work undertaken in their laboratory is carried out and documented in accordance with the relevant health and safety and quality assurance procedures, for duties such as budgeting, ordering supplies, keeping accounts, and for organising the allocation of tasks between the junior technicians. They may also be involved in developing testing procedures and in the interpretation of the results of the experimental work carried out in their laboratory. The occupants of such roles tend to have HNCs, Foundation Degrees or – especially in contract services laboratories – full Honours Degrees in chemistry.

Interviewees from the eight manufacturers and four contract analysis laboratories who provided data reported that the kind of work carried out by their laboratory technicians who work in manufacturing plants and contract analysis laboratories typically requires no more than intermediate (level 3-5 skills), with standard technician roles usually requiring no more than level 3 skills, while laboratory manager/supervisor roles demand level 4/5 skills. Given this picture of the skills that are required to discharge the duties associated with laboratory technician roles, the question arises of whether there is a good fit between the skills required and those actually possessed by the people who work as laboratory technicians. As we are about to see, the evidence suggests that in many cases the fit is far from perfect, with the occupants of laboratory technician roles often being qualified to levels far surpassing what is required successfully to do the job.

Of the nine manufacturing plants that were able to provide data on the skills possessed by their laboratory technicians, four reported that all or almost all of the people who filled such roles were qualified to no more than level 3 (possessing

4 As noted in Section 3.1.1 above, there appears to be a tendency for chemical manufacturers to reduce the number of laboratory technicians they employ, with process operators taking over the collecting and analysing of samples from the plant.

qualifications such as a BTEC level 3 Diplomas in Applied Laboratory Science or an NVQ3 in Laboratory and Associated Technical Activities, or an NVQ3 in chemical process operations). Three of the other five manufacturers reported that their laboratory technicians consisted of a mix of people with vocational qualifications such as those just described and graduates. The two remaining manufacturers stated that, notwithstanding the fact that the role in question demands sub-degree level skills, their laboratory technicians were almost all graduates. A similar pattern emerges in the four contract analysis laboratories visited for this study. In addition to employing people with vocational qualifications – such as HNCs and Foundation Degrees in chemistry, as well as the level 3 qualifications listed above – all four organisations also reported that many relatively low-level technician posts are filled by graduates.

The picture that emerges from the interviews, therefore, is of a situation where, although many laboratory technician roles in manufacturing plants and contract analysis laboratories demand no more than intermediate-level skills, the positions in question are filled by graduates. This is an example of what is known as over-qualification; the highest level of formal qualifications possessed by the workers in question exceeds the level required actually to carry out their job effectively (Wolf 2011: 29). In the words of an interviewee from a contract analysis laboratory, 'We have kids with degrees who're little more than glorified auto-sample-loaders.' Or as one interviewee from a manufacturer said of its technicians, 'We have too many graduates at the wrong level'.

This arguably reflects the way that over the past 15 or so years employers across a variety of sectors of the UK economy have been tempted to take on graduates to fill positions that would previously have occupied by people whose highest qualification was below degree level, not because the skills required to discharge the duties associated with such roles have increased, but rather because employers were not required to incur the costs of training the graduates in question (whereas the costs borne by those employers who trained technicians to fill such positions were substantial). In the words of Alison Wolf:

Higher education subsidies mean that employers are often able to displace a sizeable part of the training they used to do on to higher education institutions. Even if the training is less specific to their needs, and even without the work the apprentice does, they are often at least as well off as under apprenticeship, if not better off ... [so] employers will inevitably recruit as far as possible from graduates' (2009: 96; also see Mason 2012: 15-19, 27; Keep and James 2011: 59-60).⁵

Moreover, the abundant supply of graduates implies that they can be hired at relatively low wages. As one employer put it, 'You can get chemistry graduates cheap, they're ten a penny.' Hence, the relatively cheap supply of graduate labour has encouraged firms to rely on graduates rather than vocationally-educated technicians to fill skilled trades and associate professional roles.⁶

However, the over-skilling to which this reliance on graduates has often given rise can create problems, both because the graduates in question often become dissatisfied with their lot, and also because while they possess considerable theoretical knowledge some lack the ability to apply their skills effectively in the workplace. More

⁵ Evidence indicates that the problem of over-qualification is widespread, with somewhere in the region of one quarter and one third of UK employees falling into that category (Chevalier and Lindley 2009; Green and Zhou 2010).

⁶ SEMTA (2009: 42) notes, consistent with this, that 25% of the (level 6) graduates employed in the chemical industry are initially employed in occupations below Level 4.

specifically, graduates who're occupying technician roles 'soon become bored and unhappy', partly because they're not being stretched intellectually – 'they often do menial and repetitive tasks' – and also because of the relatively low wages they earn in entry-level roles.⁷ This is especially problematic where promotion prospects from entry-level positions to more senior and demanding roles is limited, as is the case at several – though not all – of the organisations in question.⁸ Second, while graduates are often over-qualified for technician roles in terms of the theoretical knowledge they possess, they may also be under-skilled because while they have high-level academic qualifications they lack the (lower-level) practical skills with which a more vocational route would have equipped them.⁹

The prospect of cost savings, coupled with a desire to avoid the problems caused by unhappy, over-skilled graduates, has prompted three contract analysis laboratories to try to begin apprenticeship schemes so that they can have people with level 3 qualifications – rather than graduates – fill junior laboratory technician posts.¹⁰ (One manufacturer is considering doing so, but has not yet done anything concrete.) The aim is to have a more elaborate division of labour, with simpler tasks being done more cheaply by lower-level, vocationally educated technicians while more complex tasks only are undertaken by graduates. This promises both to save money and also to increase graduate satisfaction. As an interviewee put it, 'The challenge [to save money] is to get [graduates] to focus only on high-value added activities' rather than on the simpler tasks that could be done just as well, and more cheaply, by technicians qualified only to level 3 or 4. We shall discuss these schemes in more detail in Section 4.2.5 below. Moreover, as we shall also see (in Section 3.3), while people filling STEM roles in the three specialist research and development facilities run by chemical manufacturers must be educated at least to degree level, in two cases at least some such workers have achieved their degrees via a part-time, work-based route, precisely because doing so gives them the practical skills and experience that people who have gone straight to university sometimes lack.

3.1.4 Mechanical testing technicians

Two employers – one chemical manufacturer and one contract analysis laboratory – also employ a small number of mechanical testing technicians (amounting in neither case to more than 5% of the total workforce). As their job title suggests, the occupants of these roles are involved in building and operating experimental rigs and pieces of apparatus in order to carry out tests of various kinds of material. They may, for example, build experimental rigs in order to test the properties of various kinds of composite material. Alternatively, they may develop an experimental set-up that simulates the conditions found in a chemical or power plant in order to analyse the impact of corrosion of the plant's pipework. As well as constructing and running experiments on pieces of apparatus, such technicians may prepare samples for testing (e.g. polishing samples of steel from a pipe so they can be viewed under a scanning electron microscope). They may also be involved in

7 Such findings are consistent with the work of Green and Zhou (2010) who, using evidence drawn from national skills surveys, find that where over-qualification is associated with a genuine under-utilisation of the skills of graduates, as is the case with the laboratory technicians described in the main text, substantial job dissatisfaction results on the part of the employees.

8 Two manufacturers argue that while their degree-educated laboratory technicians may be over-qualified for the entry-level position they fill when they first join the firm, they tend to be promoted rapidly into more demanding roles in which their higher-level skills are more fully utilised.

9 Similar problems arise in the case of many of the teaching laboratory technicians who work in university chemistry and biological science departments. Teaching technician roles require only no more than level 3 or 4 skills, yet they are often filled by people qualified to first degree level or above, whose expectations may not be satisfied by such posts and who may also lack some of the requisite practical skills (Lewis and Gospel 2011: 29, 65-66).

10 One other analytical services company and one manufacturer already offer apprenticeships for laboratory technicians at some of their sites.

collecting – but not in analysing – the data generated by the experiment or test in question. Mechanical testing technicians typically have level 3 qualifications in some form of mechanical engineering.¹¹

3.2 TECHNICIAN NUMBERS

Eighteen of the case study organisations provided usable data on the overall size of their technician workforce (the exception being one of the contract analysis laboratories, which operates with a very decentralised structure and where the interviewee was unable to access data for the various sites). (See Table 1.)

Consider first the chemical manufacturers. For the purposes of analysing the size of the technician workforce, the manufacturers are best divided into two sub-categories, according to whether their process operators are primarily semi-skilled (level 2) or skilled (level 3) workers. In the former case, the process operators do not count as technicians while in the latter case they do. This has a significant impact on the share of the organisation's total workforce that is composed of technicians. In the case of the five manufacturers whose process operators are semi-skilled, technicians account on average for only about 15% of the workforce as a whole. In contrast, in the seven manufacturers whose process operators have level 3 skills, technicians on average account for just over 50% of the total workforce.

One noteworthy trend concerns a growing tendency for manufacturers to contract out maintenance work that would have been carried out in-house in the past. More specifically, seven of the twelve manufacturers visited for this study reported that such outsourcing has led to them employing a smaller maintenance technician workforce than they would have done in the past. Pipefitting and the maintenance of specialist pieces of equipment were two of the most frequently mentioned examples of such outsourcing.

The three contract analysis laboratories that were able to provide data estimated that just over 30% of their workforce occupied roles for which intermediate-level qualifications are appropriate. However, as noted above, in practice many of those technician-level roles are occupied by graduates whose skills are under-utilised. Put slightly differently, the graduates who fill those roles are over-qualified in the sense that the highest level of formal qualifications they possess exceeds that required actually to carry out their job effectively.

The three specialist research and development laboratories visited for this study all reported that the kind of work carried out in their facilities requires that people filling STEM roles possess an understanding of chemistry and/or biological science to at least degree level. The upshot is that the three specialist research and development facilities employ no technicians. In this respect, the private-sector research and development laboratories resemble the research laboratories found in university chemistry and biological science departments, according to whom the nature of academic research in chemistry and the biological sciences now typically requires research support 'technicians' to possess a degree in the relevant discipline (Lewis and Gospel 2011: 28-29).

¹¹ Technicians filling similar roles are also found in the engineering workshops that form part of university physics, engineering, and chemistry departments (Lewis and Gospel 2011: 16-17).

3.3 QUALIFICATIONS

This section of the report draws out and summarises the findings of the research project concerning the qualifications possessed by the different kinds of technician employed in the chemical industry.

So far as the process operators who work on chemical manufacturing plants are concerned, there is – as we have seen – something of a divergence between two sets of companies. In one case, process operators tend to be semi-skilled workers, qualified to no more than level 2, as was typically the case in the past. Such workers do not qualify as technicians. A second category of firm, however, requires process operators to possess level 3 skills (that is, to be genuine ‘technicians’). This reflects two broad considerations: first, the complex and hazardous nature of the work carried out in those plants, the safe conduct of which requires operators to possess intermediate-level skills; and second, the broader variety of tasks that the workers in question are now required to carry out, which extends beyond simply operating the plant to include basic mechanical maintenance and sampling/testing. In both categories of firm, workers who assume supervisory responsibilities for the operation of the plant are qualified at least to level 3 and therefore count as technicians.

By far the most common qualification possessed by maintenance technicians is a level 3 certificate in mechanical, electrical or control and instrumentation engineering, the precise qualification varying according to the particular kind of engineering in which they have chosen to specialise. The occupants of more senior maintenance roles usually have HNCs or HNDs in the relevant kind of engineering, the higher level of qualification reflecting the greater demands and responsibilities of their role. All such workers count as technicians as that term is currently defined. The same is true of mechanical testing technicians, who are typically qualified to level 3 in mechanical engineering.

Laboratory technician roles requiring intermediate (level 3-5) skills are found in all of the chemical manufacturers and contract analysis laboratories visited for this study. However, as noted above, in practice such roles are often filled by people with degrees (i.e. level 6 skills). In contrast to the process operator and maintenance technician roles, where employers report that the skills possessed by workers are typically pitched at a level appropriate for the role in question, the case of laboratory technicians is one where the level of skills possessed by the workers in question exceeds that required to do the job. Such over-skilling is not, however, found in the three specialist research and development facilities, where people filling STEM roles must be – and are – educated at least to degree level.

3.4 SOURCE OF THE CURRENT TECHNICIAN WORKFORCE

This section of the report explores the question of how the chemical companies visited for this project acquired the technicians they currently employ. Three broad sources of technicians may be distinguished.

The first, namely external recruitment, sees employers hire experienced technicians ‘ready-made’ from the external labour market. In such cases, the technicians are sufficiently familiar with the kind of work they will be required to do that little if any additional training, beyond induction training, is required before they can work productively in their new role. Second, at the opposite end of the spectrum, comes apprenticeship training, whereby employers acquire technicians by training people without any relevant industrial experience from scratch,

via their own apprenticeship schemes. An apprenticeship can be defined as a contract between an employer and a (traditionally, young) person that: combines a structured programme of on-the-job training and productive work with part-time, formal technical education; normally takes at least two years to complete, after compulsory general education; is usually formally certificated; and equips people with intermediate-level skills of the kind required to fill roles often described as 'Skilled Trades' and 'Technicians/Associate Professionals and Technical Occupations' (Wolter and Ryan 2010: 523; Lewis 2013a). A third possibility also involves the employer playing a role in training workers, but in a rather different way to what is involved in apprenticeship. This third approach involves what is known as 'upgrade training'. The latter tends to be: provided on-the-job, with little or no off-the-job vocational education; closely tailored to the specific requirements of the particular job role for which the person is being trained by the employer in question; is often uncertificated; and prepares workers – who may be recent recruits or more established employees, and who may have a broad range of ages, prior levels of skill and qualifications – for (in this case) technician-level roles. Compared with apprenticeship, therefore, upgrade training is limited in breadth, depth, generality, duration, and (therefore) cost (Ryan 1995: 30-32; Ryan *et al.* 2007: 130, 137).

What balance was struck by the firms visited for this study between these three different ways of obtaining technicians? Data on this issue proved hard to obtain, so the findings expressed in the remainder of this paragraph need to be treated with caution. Only seven of the twelve manufacturers ventured an estimate of the source of their technician workforce. In-house training was thought to have made a significant (25-70%) contribution to the current technician workforces in four cases, two of which involved the use of upgrade training to develop level 3 process operators, one of which involved the use of apprenticeship to develop maintenance technicians, and one of which saw apprentices being used to develop both process operators and maintenance technicians. The other three manufacturers indicated that recruitment had made by far the biggest contribution to the process operator and maintenance technician workforce, with only a negligible contribution having been made by in-house training. In case of the laboratory technicians who work in the manufacturing plants, the five manufacturers who offered a view indicated that they relied primarily on recruitment – in particular, of graduates – to acquire the technicians they need. A similar pattern was described by representatives of the three contract analysis laboratories which commented on the source of the workers who occupy technician roles in their organisations. In all three cases, the vast majority of the current technician workforce was said to have been recruited, often – as noted above – as graduates.¹²

It is worthwhile commenting on the way in which the research and laboratory laboratories visited for this study acquire some of their research scientists. At first glance, this may seem surprising, because – as noted above – none of these organisations employs specialist technicians, for the simple reason that the kind of work carried out in their facilities requires the occupants of STEM roles to have a degree. However, in two of the three cases, a small but significant minority (10-20%) of their research scientists have been trained in-house via a work-based route. The two organisations in question adopt broadly similar approaches.

¹² In the light of this reliance on graduates – rather than people with intermediate skills acquired via a work-based route – to fill laboratory technician roles, it is perhaps unsurprising that science apprenticeships account for less than 1% of all apprenticeships in the UK (BIS 2012).

They take school-leavers who have done 2-3 'A' levels, including chemistry. In the first instance, the apprentices typically study for a part-time HNC or Foundation Degree in chemistry, usually on day release. Typically, they can take an HNC/FD after 2 years, before proceeding to a full BSc in 5-6 years in total. The advantages of training people up to degree-standard in this way, rather than recruiting them direct from university, are the mirror-image of some of the shortcomings of graduates mentioned earlier: people who have come up via the work-based route have greater practical experience and therefore are better able than many graduates to apply their skills; and they often have more reasonable expectations of what their job involves, leading to greater loyalty.

A similar approach has also recently been adopted, for similar reasons, by one of the manufacturers visited for this study. The manufacturer has its own research and development facility and in 2010 began a scheme to train in-house some of the research scientists who work there. As in the other two cases, students are recruited after 'A' levels, which must include chemistry or physics, and study for a Foundation degree on day release, after which they will proceed to a full BSc in chemistry. Nine students were recruited in the first two years of the programme and, while the employer has experienced a degree of reluctance on the part of local schools to encourage good candidates to apply for this scheme (as opposed to going straight to university), the employer in question is expecting the programme to become more popular given the recent rise in university tuition fees.

This case study evidence may be brought to bear on the question of the balance that Science, Engineering and Technology employers strike between employing university-educated graduates and vocationally educated workers to fill roles in their organisations (Mason 2012: 25-27). Mason notes that over the past 10-15 years employers have been motivated to employ university graduates – and, more specifically, graduates who went straight from school to university – to fill such roles, primarily because they do not incur the cost of training them, whereas they do pay for at least part of the cost of training those workers who have been developed via a work-based route. However, Mason also cites recent case study evidence showing that employers' frustration with the limited practical skills and experience possessed by graduates is now prompting some employers to rethink their strategy for acquiring skilled workers, leading in particular to a greater reliance on work-based training. While Mason's discussion focuses on education and training for technician roles, the example of the research laboratory scientists discussed here suggests, perhaps unsurprisingly, that similar issues also arise in the case of at least some roles requiring degree-level qualifications, with graduates who have come up via the work-based route being more likely to have the practical skills and commercial understanding needed by businesses than those who followed a more narrowly academic path.¹³

¹³ For similar points in the case of the aerospace industry, see Lewis (2013a: 29-33).

3.5 AGE PROFILE

It proved difficult to obtain clear, systematic data on the average age of the technicians at many of the companies. The rather vague answers that often emerged – such as that the average age of the technicians ‘is in the 50s’, that ‘most are over 50’, or that ‘60% of technicians are over 45’ – did however suggest (without conclusively establishing) that there is an emerging succession planning issues in the chemical industry, due to the fact that a sizeable share of the technician workforce are in their late 40s or older. This conclusion is supported by two other pieces of evidence. The first is that, as we shall see below, one of the central reasons why chemical manufacturers are involved in apprenticeship training is because they view it as a means of succession planning, which enables them to develop a workforce with a more balanced age distribution. Second, sector-level data indicate that nearly 50% of the total chemical industry workforce is over 45 years of age, while the proportion of the workforce in the 16-24 range is below the national average. The age profile for the occupants of skilled trades and process operator roles is skewed even further to the right than that for the workforce as a whole, implying an especially pressing need for succession planning for those roles (COGENT 2010c: 11; IER 2010).¹⁴

This age profile was attributed by several interviewees, both employers and representatives of sector-level bodies, to the way that in the 1990s many chemical manufacturers responded to the considerable pressure they were then under to cut costs by scaling back, or closing entirely, their apprenticeship training schemes, relying instead on recruiting experienced middle-aged technicians from other firms that were closing down. As a report by the sector skills council, COGENT, put it:

A generation ago, the ICI conglomerate was the bellwether of the UK economy. In the same era, energy production was a nationalised industry while much of petrochemicals was the domain of a handful of oil companies. In that era, these all-encompassing organisations could manage the whole ‘skills pipeline’ for their workforce. Today, break-up and privatisation within these industries has brought sector renewal and an expansion of enterprises. ... Overall, a downside of the sector’s recent history has generally been a reduced ‘skills horizon’ for a given employer. This risks a gradual decline in skills investment and a skills macro-management void. (COGENT 2010c: 6)

The upshot, as one interviewee put it, has been ‘a lost generation in the chemical industry’, whose absence has led to the present situation where ‘the age distribution is skewed to the right and has no middle’.¹⁵

¹⁴ It is also noteworthy in this context that one analysis of Labour Force Survey data indicates that around a third of all Science, Engineering and Technology technicians – defined so as to include both Skilled Trades and Associate Professionals – are 50 years of age or older (Mason 2012: 19-20).

¹⁵ Also see Steedman (2011: 2), where data showing a decline in the number of level 3 apprentices trained each year in Britain between 1996 and 2010 can be found.

SECTION 4 RESULTS II: THE FUTURE TECHNICIAN WORKFORCE

Having considered the chemical industry's current workforce, we move on now to consider how employers propose to satisfy their future need for technicians, focusing in particular on the balance they expect to strike between recruitment and training and, within the latter category, between apprenticeship and upgrade training.

As we shall see, apprenticeship training is most commonly used for maintenance engineering roles, reflecting the difficulty that many firms have in hiring experienced maintenance technicians. Apprenticeships are less commonly used for process operator roles, for which recruitment is relatively straightforward. Where process operator apprenticeships are in place, they are viewed primarily as a means of succession planning rather than as a response to recruitment difficulties.

There is some evidence that the use of apprenticeship is becoming more widespread. Two manufacturers have begun apprenticeship training schemes for engineers within the past two years. Moreover, two of the contract analysis laboratories have very recently begun apprenticeship training programmes for their laboratory technicians, whilst a third is trying to do so. The rationale for such schemes is that, by relying on technicians to carry out relatively mundane laboratory work, it should be possible to release graduates to focus on more demanding work, thereby saving money/increasing efficiency and also dealing with the problems sometimes posed by over-skilled graduates.

4.1 RECRUITMENT

We explore first how easily the various kinds of chemical employer can hire experienced, work-ready technicians of the kind they need.

Ten of the twelve chemical manufacturers offered views on this issue. Of the six whose process operators are typically qualified to level 3, only two – one which is expanding and the other of which is located away from the areas where chemical firms, and pools of experienced workers, are normally situated – found it hard to recruit experienced operators of acceptable quality. The other four found recruitment straightforward, especially in those two cases where the employers in question were located in the same area as other manufacturers who had recently closed down and had therefore laid off their staff.

Matters proved rather different in the case of maintenance technicians, however, with six employers indicating that they found it hard to recruit good quality, experienced maintenance technicians. In the words of the training and development manager for the engineers at one large manufacturer, 'It's really difficult to recruit ... [T]he people coming for jobs aren't of the calibre we want to work in our company in the twenty-first century.'¹⁶ This problem has two aspects: the first is that the sheer number of applicants is too low ('You just don't get the volume of applicants you'd like'); and, second, the quality is deficient, as for example when applicants for electrical maintenance jobs include people who are qualified electricians but who only have experience of working with household electrical systems, rather than the larger, high-

¹⁶ COGENT (2010b) reports that 55% of chemical employers describe vacancies for craft and technician level positions as being 'hard to fill'. The highest proportion of skills shortage vacancies (38%) is accounted for by Associate Professional/Technical and Skilled Trades roles (i.e. by technicians) (IER 2010).

voltage systems characteristic of industrial plants ('They don't know what a three-phase [electrical system used to power large motors] is'). Two employers reported that it was especially difficult to recruit experienced control and instrumentation technicians. As one interviewee put it, 'Lots of firms in the area are advertising for instrument technicians ... All we're doing is stealing from each other.'¹⁷

It is worth noting some of the remarks made by interviewees when describing the efforts of, and the problems created by, firms in efforts to recruit experienced maintenance technicians. 'All we're doing is stealing from each other,' one HR manager averred. His thoughts were echoed almost word-for-word by his counterpart at another firm, who commented that 'firms are just stealing from each other' before pointing out that this is ultimately counter-productive for the industry as a whole because 'all that ultimately happens is that the average level of wages increases, making all businesses less competitive.' Similar views were expressed by another HR manager, who argued that 'the industry is being a bit short-termist' in trying to rely too much on recruitment rather than in-house training.

The views expressed by these, and other, interviewees, concerning at least some firms' reluctance to train enough apprentices and their attempts to rely instead on external recruitment, are redolent of the well-known problems that the prospect of poaching causes for employers' incentives to train for transferable skills. Briefly, the key points are as follows: an industry as a whole will be better off if its member firms all, or almost all, engage in training, because by doing so they will ensure that there exists an adequate pool of skilled workers from which all firms can benefit; but each individual firm will do best if all the other firms train but it does not, choosing instead to 'free-ride' on the other firms' efforts to develop skilled workers by luring them away once they've been trained with offers of higher wages that their current firms cannot afford to match if they are to recoup the cost of training them; however, if every firm thinks along these lines, and attempts to rely principally on recruiting workers, then too few workers will be trained overall, leading to the kinds of problems – poaching, rising wages and costs, shortages of skilled labour on the external labour market – described by interviewees.¹⁸

In stark contrast to the case of maintenance technicians, none of the chemical manufacturers reported difficulties in filling their laboratory technician posts, principally because – as noted in Section 3.1.3 above – job advertisements for such roles typically precipitate a large number of applications from (over-qualified) graduates. Unsurprisingly, the same is true of the four contract analysis laboratories visited for this study, all of whom reported that they found it very easy to fill technician roles via external recruitment. Interviewees spoke of very high ratios of applicants to places, with one even reporting a case where two hundred people applied for a laboratory cleaner post in the hope of doing that job for six months and then moving into a technician role. As one manager from a contract analysis laboratory put it, 'Firms advertise for a basic technician and are swamped with people up to PhD level.'¹⁹

¹⁷ Far from being confined to the chemical industry, difficulties in hiring experienced engineering technicians are widespread in advanced manufacturing, being found for example both in the aerospace and space industries (see, for example, Lewis 2012a: 21-22, 2012b: 25-26). On the pressing need for additional technician skills more generally, see UKCES (2010a: 6, 30-34, 2010b: 182).

¹⁸ In the language of economics, the situation faced by the firms is an example of a prisoners' dilemma (that is, a situation in which the rational course of action for each individual to take leads to an outcome that is sub-optimal for the group as a whole). For a more detailed on such problems in the case of training, see Chapman (1993: 95-99) and Lewis (2014).

¹⁹ For similar views from employers in other sectors, see Lewis and Gospel (2011: 31-32).

4.2 APPRENTICESHIP

4.2.1 Definition and involvement

As noted in section 3.4 above, an apprenticeship is a programme of learning that combines on-the-job training and experience at a workplace with part-time, formal technical education. Apprenticeships normally take at least two years to complete after compulsory general education, are usually – though not invariably – formally certificated, and equip people with intermediate (level 3-5) skills of the kind required to fill roles ‘Skilled Trades’ and ‘Associate Professionals and Technical Occupations’ roles.

Table 2: Involvement of the case study organisations in apprenticeship training, by type of organisation and role

Type of organisation	Number of cases	Number of employers currently offering apprenticeship training for various technician roles		
		Process operators	Maintenance technicians	Laboratory technicians
Chemical manufacturer				
Total	12	4	8	3
Process operators at level 2	5	0	4	0
Process operators at level 3	7	4	4	0
Contract analysis laboratory	4	0	0	3
Research and development laboratory	3	N/a	N/a	N/a ^a

Notes:

a: None of the research and development laboratories employ specialist technicians. However, two of the three do train research and development laboratory scientists to degree-level via a work-based route, as does one of the chemical manufacturers that has its own research and development laboratory (see Section 3.4 for details).

4.2.2 Apprenticeship training for maintenance technician roles

Eight of the twelve chemical manufacturers visited for this study train apprentices to fill maintenance technician roles. Most of the schemes are long-standing, with one having run continuously since just after World War Two, although two have been established – for reasons that will be discussed below – only within the past six years. For the purposes of describing the training on offer, the eight manufacturers that offer engineering apprenticeships will be divided into two groups, depending on whether the initial goal of the apprenticeship programme is to train apprentices to level 3 or level 4 (see Table 3).

Table 3: Attributes of apprenticeship training programmes, by employer and type of scheme

Type of organisation	Number of cases	Target qualification	Average number of apprentices in training	Apprenticeship intensity
Chemical manufacturers' engineering maintenance apprenticeships				
Total	8		18	19%
Goal is a level 3 qualification	3	Advanced Apprenticeship in Engineering	5	20%
Goal is a level 4 qualification	5	HNC in Engineering	25	14%
Chemical manufacturers' apprenticeships for process operators	4	Advanced Apprenticeship or HNC in Chemical Process Engineering	13	7%

In three cases, all of which are numbered amongst the smallest firms – measured by total employment – in the sample, the apprenticeship training programme is three years in length and the goal is for the apprentices to achieve a level 3 award in either mechanical or electrical/instrumentation engineering. Entry requirements are 3-5 GCSEs at grade 'C' or above, including English, maths and a science. None of the firms report any difficulties in attracting applicants of the requisite calibre. The apprentices spend the first year of their training on block release at a further education college in two cases and on day release in the third. All three training programmes form part of the government's Advanced Apprenticeship scheme. In every case, the SFA contract is held by a local group training association, indicating that the employers have delegated formal responsibility for organising the apprentices' training to a third party.

In this first set of firms, apprentice numbers tend to be very low in absolute terms, ranging from one every other year to three per year. It is worth noting, however, that assessments of the importance of apprenticeship training for an employer that focuses simply on the absolute number of apprentices in training can be misleading. In particular, comparisons of apprenticeship activity between different employers and at different times are potentially clouded by differences in skilled employment, with smaller employers taking on fewer apprentices than their larger counterparts simply because they have to sustain a smaller technician workforce. An allowance can be made for this by calculating the apprenticeship intensity, defined as the total number of apprentices in training for technician roles divided by the total stock of technicians currently employed in such roles. This averages around 20% in this first group of organisations, indicating in fact that these firms are taking on a relatively large

number of engineering apprentices given the size of their maintenance technician workforce. This reflects the fact that one employer in particular is expanding rapidly and, given the difficulty of recruiting experienced maintenance technicians, is training a large number of apprentices relative to its current maintenance technician workforce. (It has an apprenticeship intensity of no less than 50%.) The other two firms have an average apprenticeship intensity of 12%.

The remaining five employers, which are the five largest manufacturers by total employment in the set of case study organisations, all aim for their apprentices to achieve a level 4 qualification (HNC) in engineering. Entry requirements for these level 4 apprenticeship programmes tend to be a little higher than for the level 3 programmes considered above, with three of the firms in this second group demanding that apprentices have a B grade in GCSE mathematics in particular on the grounds that, where apprentices struggle, it tends to be with the mathematical component of the off-the-job component of the apprenticeship. In three cases, the ratio of applicants to places tends to be high, with two relatively large and well-known employers quoting applications to places ratios of 20:1 and even 60:1. In two other cases, however, the employers have struggled to attract sufficient numbers of good applicants and have argued in particular that local schools have had little interest in sending decent students to apply for apprenticeships, preferring instead to encourage them to apply to university.

The training programmes in question tend to be 4-5 years in length, with apprentices spending their first year on block release either at a local college of further education or – in one case – in the company's own engineering training school. The apprentices are employed by the chemical manufacturer from the outset of their training in three of the five cases, while in the other two cases apprentices are initially only sponsored by the manufacturer, becoming its employees only after the period of college-based training is successfully completed. Only one of the five employers holds the SFA contract for the apprentices; in the other four cases, the contract is held by a further education college or group training association. Apprentices typically study both mechanical and electrical/instrumentation engineering for the first three years of their training, before specialising in either mechanical, electrical, or control and instrumentation engineering for their HNC. Amongst this group is the one firm in the sample whose apprenticeship scheme is accredited by a professional body. Apprentices who complete their training at that organisation achieve EngTech status.

Reckoned in absolute terms, four of the five organisations have quite large engineering apprenticeship training programmes, each having somewhere between 20 and 45 engineering apprentices currently in training. (The fifth organisation currently has five engineering apprentices, and decided not to take on a new apprentice in 2012, due to financial pressure from the recession.²⁰) In large part, though, this reflects the fact that these firms have a larger maintenance technician workforce than the first set of manufacturers; at 14%, apprenticeship intensity is around in the same as that in the first set of firms, provided that the rapidly expanding manufacturer is excluded from the first group.

The main reasons for taking engineering apprentices are the same across both groups of firm, and are twofold. The first, highlighted by six of the employers, lies

²⁰ Another manufacturer, which does not have apprentices, attributes that at least in part to headcount restrictions imposed by senior management. Sector-level interviewees indicated that similar headcount restrictions had deterred several other firms from taking on apprentices.

in the difficulty of recruiting experienced, high-quality maintenance technicians and the consequent need for firms to train them in-house if they are to acquire the technicians they need. As one employer put it, the limited availability of good engineering technicians in the external labour market implies that 'you have to grow your own.' The second reason, mentioned as a major reason for taking apprentices by seven of the eight employers, lies in firms' desire to plan for the succession of an ageing technician workforce. As one employer colourfully put it, the technician workforce will 'fall off a cliff in 10 years' if young people are not trained and recruitment difficulties continue.²¹ It is for these reasons that the two manufacturers who have started an apprenticeship programme within the past six years chose to do so.

It is also worth noting that two employers also mentioned that a significant benefit of apprenticeship is to be found in the way that it enables them to shape the skills of their workers so as to increase the flexibility and efficiency of their maintenance technician workforce. In particular, apprenticeship training helps to ensure that more and more engineering technicians are skilled at both mechanical and electrical work, thereby increasing the speed with which maintenance work can be carried out, helping to ensure that problems on the plant are dealt with more rapidly and the efficiency of the plant increases.

4.2.3 The over-training of engineering apprentices

While none of the chemical manufacturers who taking engineering apprentices has reported serious difficulties in finding a further education college to offer the requisite training to a decent standard, some of them say that other (especially smaller) firms do have problems.²² It is particularly noteworthy in this context that one of the larger manufacturers visited for this study reports that some of its smaller neighbours in the chemical industry have had difficulty in finding a further education college that is willing and able to offer high-quality hands-skills training for their engineering apprentices. The large chemical company in question has not had this problem, because it has in-house training workshops in which its own apprentices spend the first year of their training, learning hand-skills and workplace health and safety. Having learned of the problems faced by these smaller firms, and having some spare capacity in its training workshops, the larger chemical manufacturer offered to play role in the training of the apprentices who were being recruited by its smaller neighbours, a phenomenon known as 'over-training' (see Lewis 2013b).

Loosely speaking, 'over-training' involves large employers that currently offer high-quality apprenticeships playing a role in the training of more apprentices than they themselves require to meet their own anticipated business needs, with the extra apprentices being employed by other firms in their sector and/or supply chain (often, though not always, SMEs). However, as the vagueness of the phrase 'playing a role' indicates, the precise meaning of the term 'over-training' is unclear, with

21 Concerns about the age profile of the STEM workforce in the chemical industry are documented in SEMTA (2009: 40-42; also see COGENT 2010a and 2011: 5-7). More generally, Mason (2012) notes that the SET technician workforce as a whole is an ageing one, with around 30% of skilled trades and 23% of associate professional/technical workers being 50 years of age or older in 2010.

22 In this respect, the chemical firms' experience is rather different from that 'enjoyed' by firms taking engineering apprentices in the space and aerospace industries, many of whom report problems with finding a college willing to offer courses ('technical certificates') in the relevant underpinning knowledge and/or with the quality of the practical training offered to first-year apprentices in the colleges' training workshops (Lewis 2012a: 31-33; 2012b: 31). Similar problems have been documented by two recent reviews of various aspects of vocational education and training in the UK, namely Wolf (2011: 126) and Richard (2012: 107-08).

different organisations using it to denote rather different degrees of involvement on the part of large employers in the training of apprentices for other firms. In the specific case considered here, the over-training scheme works as follows.

The apprentices who are being 'over-trained' are employed and paid from the outset of their training by the smaller chemical firm who recruited them (their 'home' firms, as they will be described hereafter). In each case the apprentices spend the first year of their training programme alongside the large chemical manufacturer's own apprentices in its dedicated training facilities, where they acquire basic practical skills, certificated via an NVQ2 in Performing Engineering Operations (PEO2), and an awareness of the requirements of workplace health and safety. While the apprentices who are being over-trained typically return to their 'home' employer for the second and third years of their apprenticeship, the large chemical manufacturer – which has its own instructors and NVQ assessors – continues to manage and oversee their training, both by advising the home firms about what their apprentices need to do in order to satisfy the requirements of the competence-based part of the apprenticeship framework and also by assessing their practical skills (as required for the award of an NVQ3). The large firm is also willing to continue to host other firms' apprenticeship at its own facilities for the second and even the third year of their apprenticeship if the apprentices' home employers wish them to do so. In those cases where apprentices' home employers have taken up this offer, the large firm provides the on-the-job training as well as the assessment required for some or all of the NVQ3 part of the apprenticeship framework. In this way, high-quality opportunities for high-quality training can be provided to apprentices employed by firms who might otherwise struggle to procure such training. Around 12 apprentices are being 'over-trained' in this way, alongside the 40 or so apprentices that the large firm is in the process of training for its own needs.²³

The large chemical manufacturer assists the other firms, not out of a sense of charity, but rather because doing so helps it to sustain the financial viability of its in-house apprenticeship programmes, in particular by helping it to cover some of the overheads associated with running that scheme. As noted above, the manufacturer has its own dedicated training workshops and employs its own specialist instructors and NVQ assessors to manage and deliver training for its apprentices. Since it must incur the costs of running those facilities, and of employing those instructors and assessors, in order to train its own apprentices, and given also that – after taking into account the need to train apprentices for their own organisation – it has scope to take on additional apprentices, it can benefit from over-training because doing so: (i) adds little if anything to its costs (most of which will have been incurred anyway); and (ii) enables it to access the SFA funding for delivering and assessing the NVQ2, which they can use to offset some of the fixed costs of running their training school. Overall, therefore, the manufacturer believes that its involvement in over-training promotes its own interests as well as those of the 'home' firms.

4.2.4 Apprenticeship training for process operator roles

It was noted above that the process operator workforce tends to possess level 3 skills in seven of the twelve manufacturers visited for this study. In such cases,

²³ This kind of over-training contrasts with approaches that have borne that title in the past. Examples of the older approach to over-training were mentioned in particular by some interviewees from sector-level bodies, who referred to the practice, apparently common in the past, of larger firms such as ICI deliberately taking on more apprentices than they needed, employing and paying the apprentices themselves, and then simply letting those who were surplus to its own requirements leave at the end of their training programme to work for another employer. In contrast, all of the contemporary examples of over-training documented in a recent study involve apprentices being employed from the outset, not by the organisation that is carrying out the over-training, but by the firm for which they are ultimately going to work (Lewis 2013b).

apprenticeships, with their orientation to intermediate (level 3-5) skills, provide a potential source of skilled labour. In practice, four of the seven manufacturers – three of which also take engineering apprentices – participate in the training of apprentices in chemical process operations (see Table 3).

In all four cases, the apprenticeship is a four-year programme, the goal of which is an Advanced Apprenticeship and, for those with the requisite ability, an HNC (both in chemical process engineering).

Three firms, all of which are located in the same region, take their process apprentices via the same training programme, run by a local not-for-profit training provider. Apprentices are required to have As and Bs at GCSE in mathematics, English and a science. The training provider not only holds the SFA contract for the apprenticeships but also employs the apprentices throughout their training. The apprentices are, however, 'sponsored' by the employers in the sense that the latter both finance the payment of the apprentices' wages and also provide the apprentices with the on-the-job component of their training. The latter comes in the final two years of the apprenticeship, during which the apprentices undertake practical work and on-the-job training at the sponsor's workplace, their first two years having been spent at the training provider's facilities. While the sponsoring employer is not committed to employing the apprentices at the end of their training, interviewees indicated that in practice most are taken on. The fourth manufacturer adopts a slight variation on this theme, the major difference being that the SFA contract is held by a local further education college and that the apprentices do become employees of the manufacturer after the first year of their training (which they spend on block release at the college).

Apprentice numbers tend to be relatively low, with an average apprenticeship intensity of just 7% across the four employers (see Table 3). The principal reason for taking apprentices is succession planning. While all but one of these firms finds it relatively easy to hire experienced technicians from the external labour market, interviewees report that those technicians tend to be relatively close to retirement, implying that hiring them does little if anything to reduce the average age of their technician workforce. Notwithstanding the abundance of process technicians on the labour market, therefore, these firms tend to view their involvement in process apprenticeships principally as a means of dealing with the looming succession-planning problem posed by their increasingly elderly process technician workforce. Only in one case, of a rapidly expanding firm that has struggled to recruit experienced operators and has therefore had several unfilled vacancies for a year, is the use of process apprenticeship viewed primarily as a means of solving recruitment difficulties.

4.2.5 Apprenticeship training for laboratory technician roles

Three of the four contract analysis laboratories currently take apprentices, while the fourth is trying to do so. Only in one of the cases is there a long history of taking apprentices. The organisation in question is a decentralised contract analysis company with several laboratories around the country, some of which occasionally train an apprentice for a laboratory technician role. (There is no fixed number of apprentices taken each year.) At the time when the research for this study was carried out, one of the organisation's facilities had just advertised for an apprentice laboratory technician. The apprentice was going to be trained under the auspices

of the government's Advanced Apprenticeship Scheme and would be studying for an NVQ3 in Laboratory and Associated Technical Activities and also – via day release – for a BTEC level 3 Diploma in Applied Laboratory Science. The impetus for taking an apprentice lay in an age and skills profile that was 'a bit top heavy' and in the hope that, by training a (relatively inexpensive) specialist technician to carry out relatively simple tasks, rather than having a (more highly paid) graduate do those tasks, it would be possible to free up graduates to focus on more demanding work, thereby increasing efficiency: 'The challenge is to get [more qualified] people to focus on focus on high value-added things.'

Similar views have motivated the recent decisions of two other contract analysis laboratories to take on apprentice laboratory technicians. Until very recently, both organisations had relied on recruiting graduates to fill laboratory technician roles. Consequently, both reported that many straightforward tasks were being carried out by over-skilled graduates. The two organisations have responded to this issue by beginning to recruit apprentices, primarily because they believe that doing will enable them to save money by reducing their reliance on over-skilled graduates. As one of the two employers put it, 'lots of [jobs] are being done by graduates that could be done cheaper [by specialist technicians]', so that the resultant cost saving 'offsets the investment in training.'²⁴

In one case, a relatively large, multi-site contract analysis company has adopted an approach to apprenticeships similar – but not, as we shall see, identical – to that taken by the company described in the first paragraph of this section. Twenty-two apprentices were taken on towards the end of 2011. They were required to have GCSEs passes in maths and English. There were around 600 applicants and, in practice, those selected had a mixture of qualifications, ranging from GCSEs to 'AS' and 'A' levels. The apprentices are working towards an NVQ3 in Laboratory and Associated Technical Activities, in order to certify their practical skills, and are acquiring the associated underpinning knowledge by studying for a BTEC level 3 Diploma in Applied Laboratory Science (the 'technical certificate'). All of this training is being carried out as part of the government's Advanced Apprenticeship programme. The on-the-job training sees apprentices being rotated around various departments and laboratories within the organisation, so that they gain a broad range of practical experiences and competencies. Significantly, tuition for the BTEC Diploma is not being provided by further education colleges. Indeed, the employer found it impossible to persuade a further education college close to any of its sites to teach that technical certificate. The reason is straightforward. Although the employer in question recruited 22 apprentices, these are spread over five sites, so that the number of apprentices at any one site is too small, given the prevailing funding regime, to make it worthwhile for colleges to put on the course in question. This problem, to which we shall return below, was resolved only when the employer was fortunate enough to find a private training provider who was willing to have one of its tutors travel around the various laboratory sites, teaching the technical certificate in the employer's own training rooms at each of those sites, and also assessing the apprentices' practical skills (as required for the award of the NVQ part of the apprenticeship training 'framework').

²⁴ One of the two laboratories noted that taking apprentices might also help it to win contracts from the government, given moves to make government decisions over procurement depend in part upon whether the organisations bidding for contracts are involved in apprenticeship training.

The second case involves a small contract analysis laboratory that is part of a larger engineering/construction firm and which currently has one trainee laboratory technician. The approach adopted in this instance is rather different from that taken by the two employers considered above, principally because – given the relatively low number of apprentices it wanted to train – the organisation was unable to find a local college that was willing to offer an Advanced Apprenticeship or HNC in chemistry. The organisation decided instead to send the trainee, who was required to have five GCSEs at grade C or above (including English, mathematics, and a science) and ‘A’ level chemistry at grade C, to do a Foundation degree in chemistry at a local university, via day release. While the training does not fall into the category of an Advanced Apprenticeship, the laboratory – which is located within the construction industry, broadly understood – nevertheless does receive financial support, via an ECITB discretionary award (that is to say, the funding for the training is raised and administered via the ECITB levy-grant system).

Echoing themes discussed above, the fourth contract analysis laboratory would like to take apprentices, but does not currently do so because it has been unable to find a provider willing to offer the relevant technical certificate. Like the other contract analysis laboratories, this organisation has tended to rely on recruiting over-skilled graduates to fill laboratory technician posts. However, problems caused both by the fact that graduates sometimes lack practical skills, and also by their unhappiness at having to carry out a lot of mundane work with little scope for swift promotion, led them to try to set up an apprenticeship training programme. However, not only was the employer unable to persuade a local college to offer an ONC or HNC in chemistry, but its efforts to work with a university to set up a Foundation Degree in analytical laboratory science, involving a combination of distance learning and summer schools, did not come to fruition. In both cases, the problem was – once again – that the number of apprentices was insufficient to make it worthwhile for the educational institution to incur the fixed costs of setting up the relevant courses. At present, therefore, although this employer would like to take on apprentices, either at level 3 or level 4-5, it is unable to do so.

None of the manufacturing firms currently train apprentice lab technicians, though one – which has a large, long-standing apprenticeship programme for its process technicians and maintenance engineers – is thinking of starting such a scheme as a means of dealing with the problem posed by frustrated, over-skilled graduates. As noted in Section 3.4 above, two of the specialist research and development laboratories visited for this study offer training programmes that allow school-leavers with ‘A’ levels to proceed to a degree via a part-time, work-based route, as does one of the chemical manufacturers that has its own research and development laboratory. A second manufacturer, which also has its own specialist research and development facilities, is considering following suit by taking school-leavers post-‘A’ level and supporting them to do a part-time degree on day release, again in the hope that doing so will yield research scientists with good practical skills. Thus far, however, this second manufacturer, has – like the contract analysis research laboratories – struggled to find a college or university willing to offer the relevant course on a day release basis.²⁵

25 For similar reports, see RSC (2012: 8-9). The difficulties that these two manufacturers, and the contract research laboratories referred to earlier, have had in finding colleges or universities willing to offer sub-degree level chemistry courses for part-time students no doubt reflects the fact that the number of educational establishments offering such courses fell from 34 to 8 between 1996 and 2006 (RSC 2012: 8).

4.2.6 Vocational training for degree-level engineers

The previous section of the report discussed how some employers acquire the degree-qualified research scientists who work in their research and development laboratories via their own training schemes. A similar approach has also been adopted by one of the large chemical manufacturers visited for this study as a means of obtaining some of the graduate-level engineers it needs. Trainees enter the 5-year training programme at the age of 18 and are required to have As and Bs at 'A' level (or the equivalent). They do an Advanced Apprenticeship and HNC in engineering via day release at a local college in the first two years of the programme, before moving on to study part-time at a local university for three years to acquire an B.Eng and, finally, an M.Eng. The programme began in 2008 and there are currently 23 people in training. The creation of the scheme was motivated, the employer stated, by the expectation that the graduates who come up via the work-based route will be more familiar with the employer's plant and systems, will possess better practical, problem-solving skills, and will have better 'behaviours' (attitudes and values), than their counterparts who acquired their degree via full-time study at university. They will therefore be more 'work ready' and so more able to 'hit the ground running' than those graduate engineers who have come via the traditional, university-only route.

At present, one other chemical manufacturer is considering adopting a similar scheme, for the same reasons. As noted above, these employers are (considering) following a path that is becoming increasingly popular in UK industry, where employers in the automotive and, in particular, the aerospace industries are realising the benefits – in terms of a more skilled, and more loyal, workforce – to be had from taking able and industrious young people post 'A'-level and enabling them to take a degree via a work-based route (Lewis 2012a: 29-33).

4.3 UPGRADE TRAINING

Two manufacturers make extensive use of in-house upgrade training for acquiring the level 3 process technicians who operate their plants. (One currently has 24 such trainees.) Recall from Section 3.4 that upgrade training is normally provided only on-the-job, with little if any off-the-job vocational education; tends to be closely tailored to the specific requirements of the particular job role for which the person is being trained; is often uncertificated; and tends to be given to trainees with a variety of ages and (initial) levels of skill.

In both cases, the manufacturers train people – some of whom are school-leavers, others of whom have done apprenticeships in trades such as engineering – and put them through a structured, in-house training programme designed to equip them with level 3 skills in chemical process operations. The programmes average 2-3 years in length. The training is delivered entirely on site by the manufacturers' own staff and involves no off-the-job vocational education, a feature that – given the centrality of the blending of technical (occupational) knowledge and practical (occupational) skills for apprenticeship – implies that the programmes in question do not count as apprenticeships. Both training programmes were designed with reference to the requirements for NVQ3 and have subsequently also been mapped onto the COGENT 'Gold Standard' for level 3 skills.²⁶ However, although the skills imparted by the training programmes are – as we have seen – pitched

²⁶ The 'Gold Standard' is a set of standards describing the skills required to fill various key roles, at different levels of skill, in the process industries. As the examples mentioned in the main text indicate, it can be used as a benchmark by reference to which firms can assess the skills of their existing workforce (see http://www.cogent-ssc.com/Gold_Standard/).

at level 3, concerns about the poaching of skilled workers by other firms have deterred the employers from fully certifying those skills. Consequently, although the process operators are skilled tradesmen, their skills are not fully certificated. More specifically, in one case the workers in question receive no formal qualification whatsoever, while in the other they receive only NVQ2s.

4.4. CAREERS: ONGOING TRAINING AND PROFESSIONALISM DEVELOPMENT

4.4.1 Ongoing training

This section reports on the kind of ongoing training provided for more established technicians.

Informal in-house training was mentioned by eight of the twelve manufacturers as playing an important role in the ongoing training of their established technicians, both as a means of refreshing and also of augmenting their skills. Such training is usually provided informally by experienced, senior staff within the company and is typically not externally certificated. Decisions about such training are usually informed both by the personal development plans of individual workers and also by the use of some kind of workforce skills matrix to identify areas of need on the part of the employer. Six of the manufacturers who commented on their use of such training reported that they use the Cogent 'Gold Standard' to benchmark the content and quality of their in-house training schemes, so they can assess – and identify any gaps in – the skills profile of their technical workforce compared with industry-wide standards.

Unsurprisingly, given the hazardous environment in which they work, all of the manufacturing firms visited for this study provide extensive ongoing training in health and safety (e.g. NEBOSH training). Three firms also use external providers to give workers training in BIT (business improvement techniques) and lean production. Finally, several firms report that technicians may receive training on new equipment from the engineering firms that make it.

In addition, ten of the manufacturers also said that they provided formal, certificated training for technicians who were willing and able to move up the firm's internal career ladder. For example, in the case of maintenance technicians, those ten firms all stated that they either had in the past, or were currently, supporting some of their level 3 maintenance technicians to acquire an HNC, HND or Foundation Degree in engineering, with a view to promoting them to fill more senior engineering roles – bearing titles such as 'Assistant Engineer', 'Maintenance Manager' or 'Project Engineers' – within the organization (see Section 3.1.2 above for more on those roles).

In a similar vein, six of the seven manufacturers whose process operators tend to have level 3 skills reported that they supported such people to take further qualifications, most commonly HNCs and less commonly Foundation Degrees in chemical process engineering, so that they were able to move up to more senior, supervisory roles such as 'production manager' or 'process engineer'. (Two companies also reported that they supplemented this technical training with formal, certificated managerial training in the form of ILM qualifications at level 3 and CMI qualifications at level 5.) Interestingly, two employers noted that, while they thought that such training and support for promotion was welcome and aided retention of skilled workers, it was nevertheless the case that process operators were sometimes reluctant to 'come off the line' and move into a managerial role.

The reason lay in the fact that, while process operators work a shift pattern and therefore enjoy additional pay, managerial roles tend to be daytime only and therefore are not accompanied by the additional pay associated with shift work. Initially, therefore, a worker's overall remuneration might drop when (s)he moved off shift work into a managerial role, even though (s)he has been promoted.

Finally, seven manufacturers report that they send support technicians to read for degrees, almost invariably part-time, either in electrical, mechanical or chemical engineering.

4.4.2 Professional registration

Worries both about the status of vocationally-educated technicians vis-à-vis graduates, and also about the coherence and visibility of career paths for vocationally-educated workers, have recently prompted policy-makers and professional bodies to develop and highlight opportunities for people with vocational qualifications to achieve various kinds of professional recognition. The aim is to demonstrate to young people in particular that the vocational route is not second best and that it can lead to a high-status occupation with good career prospects, thereby hopefully encouraging more talented young people to become technicians in the first place (Skills Commission 2011: 17-18, 30-35; Technician Council 2012).

At present, only one of the chemical manufacturers has had its engineering apprenticeship scheme accredited (in this case, by the IET). Consequently, its engineering apprentices are the only ones in the cases considered here who receive an EngTech award upon completion of their training. The equivalent award for science technicians, namely RSciTech, was only officially launched in April 2012 so it is unsurprising that none of the contract service laboratories or manufacturers visited for this study had used it. One, which already supports its scientists to become chartered chemists, had not heard from RSciTech but 'would probably support it' for its laboratory technician apprentices. A second contract services laboratory, which had also just begun to take apprentices, was also unaware of the opportunity for them to be registered but, upon learning of the possibility of registration, thought that it might be a good way of sending a credible signal to scientists within the organisation that the new technicians were competent at their jobs.

SECTION 5 SUMMARY AND POLICY RECOMMENDATIONS

This section summarises this study's findings on the six questions posed in the Introduction to the report.

Q1: In what roles are technicians employed in the chemicals industry in the UK?

On average, technicians account for 35-40% of the total workforce employed by the chemical manufacturers visited for this study. All manufacturers have a small number of technicians in laboratory technician and, in greater numbers, maintenance engineering roles. Here, however, the common ground ends. The average figure for the share of the total workforce which is comprised of technicians conceals an important difference in the size of the technician workforce between two categories of chemical manufacturer: those whose process operators mostly have level 3 skills, and therefore do count as 'technicians', and those whose operators are typically trained to level 2 and therefore do not contribute to the technician workforce. Technicians account for around 50% of the total workforce in the former case, but only about 15% in the latter.

In contract analysis laboratories, the key role for which intermediate skills are required is that of a basic (junior) laboratory technician. Data provided by the contract analysis laboratories visited for this study suggest that somewhere in the region of 30% of the jobs in such organisations are suitable for technicians. This contrasts markedly with the three specialist research and development laboratories visited for this study, all of whom indicated that people occupying STEM roles in their organisations have to possess at least a first degree (that is, a level 6 qualification). Consequently, these organisations do not employ specialist technicians.

Q2: What levels of skill and qualifications do the people occupying technician roles in the chemical industry typically possess?

In the vast majority of cases, rank-and-file maintenance technicians tend to possess certified level 3 qualifications in mechanical, electrical or control and instrumentation. Only in two manufacturers is a level 4 qualification (HNC) the norm for maintenance technicians. Maintenance technicians who occupy more senior roles – variously known as 'Assistant Engineers', 'Maintenance Managers' or 'Project Engineers' – will typically be more highly qualified, possessing HNCs, HNDs or Foundation Degrees in engineering. Process engineers may possess level 2 or level 3 skills, depending on the complexity of the processes they operate, on how hazardous are the chemicals and processes with which they work, and on the range of tasks they undertake within the firm. Standard laboratory technician roles typically require people to have no more than level 3 skills. However, in practice many of those technician-level laboratory roles are occupied by (over-educated) graduates whose skills are under-utilised.

Q3: How do chemical employers acquire the technicians they need?

It proved difficult to obtain accurate data on this issue. Bearing that caveat in mind, it appears that a majority of firms had relied primarily on external recruitment for most roles. The in-house training of workers appeared to have made a significant (25-70%) contribution to filling technician roles in only five firm-role cases: in the case of a large manufacturer whose apprenticeship schemes had made significant contributions to both its process operator and maintenance engineer workforce; in the case of a second large manufacturer, many of whose maintenance engineers had been developed via its long-standing apprenticeship scheme; and in the cases of two manufacturers, who had made notable use of upgrade training to develop their level 3 process operators. Elsewhere, recruitment had made by far the biggest contribution to the process operator and maintenance technician workforce, with only a small contribution having been made by in-house training. Both manufacturers and contract analysis laboratories indicated that the majority of the current laboratory technician workforce had been recruited, often as graduates. Finally, it is also worth noting that while the evidence gathered here suggests that research and development laboratories do not make use of laboratory technicians, a significant proportion (up to 20%) of their research scientists have been trained in-house, acquiring their degrees via a work-based route that combines practical experience with attendance at a local university on day release. One manufacturer also develops some of its research scientists in this way, while another manufacturer has also begun to develop degree-qualified engineers in a similar fashion.

Q4: Fourth, are there skills shortages?

Manufacturing firms are finding it increasingly difficult to recruit skilled maintenance technicians from the external labour market, especially in control and instrumentation engineering. Mechatronic skills also appear to be in short supply. Chemical manufacturers are responding to these problems by relying more heavily than in the past on apprenticeship training, with two firms having started apprenticeship training schemes for engineers within the past five years. In contrast, it appears to be relatively straightforward to hire skilled chemical process operators from the external labour market.

Both manufacturers and contract analysis laboratories have found it easy to fill laboratory technician roles via external recruitment. Advertisements for such positions typically receive many applications, with a high proportion of applicants possessing degrees. As a result, more often than not recruits even to relatively junior laboratory technician positions have been graduates, whose level of qualification typically exceeds that required for the role. This may lead to problems, because such graduates may lack practical skills, because they expect to be paid 'graduate' wages, and also because they may become frustrated at the often very mundane tasks they are required to carry out. Some contract analysis laboratories are responding to these problems by beginning to (try to) develop apprenticeship training schemes for junior laboratory technicians, though the poverty of the relevant training infrastructure means that establishing such programmes is challenging.

Q5: What provision do employers in the chemicals industry make for the ongoing training and career development of their technicians?

Informal, in-house training is an important part of ongoing training in all the organisations visited for this study. In addition, almost all of the manufacturers visited are willing to sponsor technicians for formal, externally certificated training on a part-time basis, leading to HNCs, HNDs, Foundation Degree and full Honours degrees, usually in some form of engineering. These opportunities are typically linked both to career progression for the recipients of the training and also to the relevant employer's efforts to (plan to) fill more senior technician and managerial roles within their organisation. Little use appears to be made of professional registration for workers at the technician level.

Q6: Sixth, what – if anything – should government do to help employers in the chemical industry in their efforts to acquire skilled technicians?

Perhaps the most obvious area where policy-makers might be able to assist with technician training concerns the case of laboratory technicians. As we have seen, some of the contract services laboratories in particular have been attempting to reduce their reliance on over-qualified graduates to fill junior laboratory technician roles by establishing apprenticeship schemes that will enable them to develop such technicians in-house. However, those organisations have found it difficult to find colleges or universities willing to offer the relevant training and assessment services, principally because the colleges they have approached have found the number of apprentices too small to make it worthwhile for them to do so. A number of possible courses of action are open to policy-makers. First, there needs to be better dissemination of information about the availability of the relevant modules. One of the employers which had struggled to find a college willing to training its laboratory technician apprentices was simply unaware of the existence of a college, located within 20 miles of its premises, that did offer a Laboratory Technician Apprenticeship programme. A second contract services laboratory, which failed to find an education provider to deliver the off-the-job training for its putative apprentices, was seemingly unaware of the HNC by distance learning offered by one educational provider and used by some employers in the nuclear industry to train their technicians. What these two cases suggest is that there needs to be better dissemination of information amongst employers about the availability of training, both via day release and by distance learning and block release/summer schools. In addition, closer collaboration between employers, and between employers and educational institutions, should help to aggregate demand from them, so that student numbers exceed their minimum required to make it worthwhile for universities/colleges to offer the relevant modules. Beyond this, as argued by Lewis (2012a: 38-39, 2012b: 34-35) and by Richard (2012: 107-08), policy-makers need to consider changing the funding regime facing colleges so that they are confronted with sharper incentives to offer training for apprenticeships in STEM subjects.

It is interesting to note that, in contrast not only to the experience of the contract research laboratories but also to employers seeking to establish engineering apprenticeships in other sectors such as space and aerospace, the chemicals manufacturers visited for this study who have taken on engineering apprentices have not struggled to find colleges willing to offer decent quality training. This may reflect, at least in part, the regional concentration of much of the chemical industry. The development of large concentration of chemical firms, most notably in the

north-west and north-east of England, has been accompanied by the development of specialist training providers that are aware of the industry's needs and who, because of the concentration of firms wishing to train apprentices, still find it worthwhile to maintain their own training workshops and to offer high-quality engineering training²⁷. In such cases, the relatively large number of firms wishing to take on apprentices implies that, although the number of apprentices taken on by one firm is relatively small, the total is large enough to make it worthwhile for the college to offer high-quality training.

Another possibility worth exploring in this regard is the 'over-training' of apprentices by large, well-established providers. This is exemplified by one of the chemical manufacturers visited for this study which has its own training facilities and which has begun to play a role in the training of apprentices for other (usually, smaller) firms. Allowing small and medium-sized firms that wish to take apprentices, but who have struggled to source high-quality college provision, to 'piggy back' on the established training schemes offered by larger employers is another way of over-coming the problem of small numbers which all too often bedevils attempts to provide high-quality training in engineering and other STEM subjects.

Finally, the careers advice provided in schools requires improvement, so that young people are made aware that the vocational route can lead to high quality training, that taking it does not preclude going to university at some point, and that it offers the prospect of high-quality training and swift progress along a well-defined career path. This is perhaps most clearly exemplified by the way in which three of the research and development facilities visited for this study have established work-based routes to degrees for aspiring research scientists, and also by the way in which one of the chemical manufacturers has created a work-based route to an engineering degree. It is also demonstrated by the way in which almost all of the manufacturers visited for this study sponsor ex-apprentices to further qualifications post-apprenticeship, up to and including engineering degrees. However, while these possibilities are on offer, their existence is seemingly not well known to schoolchildren and teachers. Greater awareness of the opportunities available via the work-based route is essential.

27 Indeed, in some notable cases such as TTE, these providers were originally established by large chemicals firms, or groups, though they may subsequently have become independent training organisations.

REFERENCES

BIS (2012). *Evaluation of Apprenticeships: Learners*. BIS Research Paper Number 76. London: Department for Business, Innovation and Skills. Available online at <http://www.bis.gov.uk/assets/BISCore/further-education-skills/docs/E/12-812-evaluation-of-apprenticeships-learners.pdf>. Accessed 9th June 2013.

BIS (2013). *The Future of Apprenticeships in England: Next Steps from the Richard Review*. London: Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190632/bis-13-577-the-future-of-apprenticeships-in-england-next-steps-from-the-richard-review.pdf. Accessed 10th June 2013.

Chapman, P.G. (1993). *The Economics of Training*. Hemel Hempstead: Harvester Wheatsheaf.

Chevalier, A. and J. Lindley (2009). 'Over-education and the Skills of UK Graduates.' *Journal of the Royal Statistical Society* 172 (2).

COGENT (2010a). 'Chemicals.' Warrington: COGENT.

COGENT (2010b). 'A Skills Report for the Chemical Industry.' Warrington: COGENT. Available online at: http://www.cogent-ssc.com/Publications/Cogent_Chemicals_Report_2010.pdf. Accessed 13th June 2013.

COGENT (2010c). Sector Skills Assessment. Warrington: Cogent. Available online at: http://www.cogent-ssc.com/research/Publications/SSA_22_March_2010.pdf. Accessed 14th June 2013.

COGENT (2011). *UK Sector Skills Assessment Summary*. Warrington: COGENT.

Green, F and Y. Zhu (2010) 'Over-qualification, Job Dissatisfaction, and Increasing Dispersion in the Returns to Graduate Education.' *Oxford Economic Papers*, 62: 740-763.

HM Treasury and Department of Business, Innovation and Skills (2010). *The Path to Strong, Sustainable and Balanced Growth*. London: HM Treasury and BIS. Available online at: <http://www.bis.gov.uk/assets/biscore/corporate/docs/p/10-1296-path-to-strong-sustainable-and-balanced-growth.pdf>. Accessed 24th April 2012.

HM Treasury and Department of Business, Innovation and Skills (2011). *The Plan for Growth*. London: HM Treasury and BIS. Available online at: http://cdn.hm-treasury.gov.uk/2011budget_growth.pdf. Accessed 24th April 2012.

House of Commons Library (2011). 'Apprenticeships Policy.' Standard Note SN/EP 3-052. Updated 04 November 2011. London: House of Commons.

HSE (2013). 'Control of Major Accident Hazards (COMAH).' Available online at www.hse.gov.uk/comah. Accessed 12th June 2013.

IER (2010). *National Guidance Research Forum: Chemical, Nuclear, Oil and Gas, Petroleum, and Polymer Industries*. Warwick: Institute for Employment Research. Available online at: <http://www2.warwick.ac.uk/fac/soc/ier/ngrf/Imifuturetrends/sectorscovered/chemical/>. Accessed 14th June 2013.

Jagger, N., M. Sigla and F. Sumption (2010). *SET Based Technicians: Lessons from the UK and European Labour Force Surveys. Report 475*. Brighton: Institute for Employment Studies.

Keep, E. and S. James (2011). 'Employer Demand for Apprenticeships.' In T. Dolphin and T. Lamming (eds.), *Rethinking Apprenticeships*. London: IPPR.

- Lewis, P.A. and H. Gospel (2011). *Technicians under the Microscope: A Study of the Skills and Training of University Laboratory and Engineering Workshop Technicians*. London: The Gatsby Charitable Foundation.
- Lewis, P.A. (2012a). *Flying High: A Study of Technician Skills and Training in the UK Aerospace Industry*. London: The Gatsby Charitable Foundation.
- Lewis, P. (2012b). *Space for Technicians? An Analysis of Technician Duties, Skills, and Training in the UK Space Industry*. London: The Gatsby Charitable Foundation.
- Lewis, P.A. (2013a). 'Apprenticeship.' In D. Guest and D. Needle (eds., 2013), *Wiley Encyclopaedia of Management, Volume 5: Human Resource Management*. 3rd edition.
- Lewis, P.A. (2013b). *The Overtraining of Apprentices by Large Employers in Advanced Manufacturing in the UK*. London: The Gatsby Charitable Foundation.
- Lewis, P.A. (2014a). *The Richard Review of Apprenticeships: An Analysis and Assessment*. Unpublished paper, King's College London.
- Lewis, P.A. (2014b). *The Simple Economics of Apprenticeship*. London: The Gatsby Charitable Foundation.
- Marsden, D. (1982). 'Career Structures and Training in Internal Labour Markets in Britain and West Germany.' *Manpower Studies*, 4: 10-18.
- Mason, G. (2012). *Science, Engineering, and Technology (SET) Technicians in the UK Economy*. London: The Gatsby Charitable Foundation.
- Richard, D. (2012). *The Richard Review of Apprenticeships*. London: Department of Business, Innovation and Skills. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/34708/richard-review-full.pdf. Accessed 27th December 2012.
- RSC (2012). *Professional Recognition of Chemical Science Technicians*. London: The Royal Society of Chemistry.
- Ryan, P. (1995). 'Adult Learning and Work: Finance, Incentives and Certification.' In D. Hirsch and D. Wagner (eds.), *What Makes Workers Learn: The Role of Incentives in Adult Education and Training*. Cresskill, NJ.: Hampton Press.
- Ryan, P., P.A. Lewis and H. Gospel (2007). 'Large Employers and Apprenticeship Training in the UK.' *British Journal of Industrial Relations*, 45: 127-53.
- SEMTA (2009). *Skills and the Future of Advanced Manufacturing: A Summary Skills Assessment for the SSC Advanced Manufacturing Cluster*. Available online at http://www.cogent-ssc.com/research/Publications/ADVMFG_FINAL_March2010publish.pdf. Accessed 12th June 2013.
- Skills Commission (2011). *Technicians and Progression*. London: Policy Connect. [http://www.policyconnect.org.uk/sites/default/files/Technicians%20and%20Progression%20-colour%20final\(2\).pdf](http://www.policyconnect.org.uk/sites/default/files/Technicians%20and%20Progression%20-colour%20final(2).pdf). Accessed 28th April 2012.
- Spilsbury, M. and R. Garrett (2011). 'The Future Demand for Technicians and Underlying STEM Skills.' London: The Gatsby Foundation. Available online at http://www.gatsby.org.uk/pdfs/Technical_Education_21C/The%20future%20demand%20for%20technicians.pdf. Accessed 13th June 2011.
- Steedman, H. (2011). *Apprenticeship Policy in England: Increasing Skills Versus Boosting Young People's Job Prospects*. London: London School of Economics Centre for Economic Performance.

Technician Council (2012). *Professional Technician*. London: The Technician Council. Available online at: <http://www.professional-technician.org.uk/about.php>. Accessed 24th April 2012.

UKCES (2010a). *Skills for Jobs: Today and Tomorrow. Volume 1: Key Findings*. Wath-upon-Deane: UKCES. Available online at: <http://www.ukces.org.uk/assets/ukces/docs/publications/national-strategic-skills-audit-for-england-2010-volume-1-key-findings.pdf>. Accessed 24th April 2012.

UKCES (2010b). *Skills for Jobs: Today and Tomorrow. Volume 2: the Evidence Report*. Wath-upon-Deane: UKCES. Available online at: <http://www.ukces.org.uk/assets/ukces/docs/publications/national-strategic-skills-audit-for-england-2010-volume-2-the-evidence-report.pdf>.

UKTI (2009). *Chemicals – The UK Advantage*. London: UK Trade and Investment.

Wolf, A. (2009). *An Adult Approach to Further Education*. London: The Institute of Economic Affairs.

Wolf, A. (2011). *Review of Vocational Education – The Wolf Report*. London: Department for Education.

Wolter, S.C. and P. Ryan (2010). 'Apprenticeship'. In R. Hanushek, S. Machin and L. Wössmann (eds.), *Handbook of the Economics of Education*, Volume 3. Amsterdam: Elsevier.

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

Copyright © Gatsby Charitable Foundation
November 2013