Chapter 1 INTRODUCTION: An elusive profession

How did 'chemical engineers' acquire a professional identity, and what was their role in inventing chemical engineering itself? These terms became increasingly common from the late nineteenth century to describe certain work practices in the chemical manufacturing industries – principally the design, adaptation and operation of chemical plant and processes. A body of knowledge with that name was being taught regularly in a handful of American and British colleges by the first decade of the twentieth century.[1] From a meagre presence in Britain before the first world war, chemical engineering became, by the end of the century, one of the 'big four' engineering professions, and a major contributor to the British economy. Yet this 'success story' is not a mere parallel of its better known American counterpart. Its sources are dissimilar and complex. In Britain, different industries harboured the malcontents who promoted the specialism; the competition of established technical professions were more obstructive; the role of the state was considerably more explicit; industrial cultures were a more heterogeneous mixture of home-grown, European and American traditions; and educational provision evolved more centrally, if episodically. In this quagmire of competing factors, the would-be profession struggled for an identity. The role of the Institution of Chemical Engineers (IChemE) proved central to this evolution, articulating a public identity while remaining alert to the exploitation of new opportunities.

Until the second world war, the nascent profession grew in the shadow of that of chemistry and, to a lesser extent, those of civil, mechanical and electrical engineering. Chemical engineers wished to take over from these professions the tasks of scaling up manufacturing processes from the laboratory to the industrial level, and activities concerning chemical plant. In 1922 the foundation of the Institution of Chemical Engineers gave an organisational focus for these claims. It institutionalised these ideas, not least by contrasting them with opposing visions of chemical and process specialists. The small association was, however, no match for

[1] We will adopt a semantic difference between the terms *'chemical engineer'* and *chemical engineer*. The former (in quotes) is someone identified from outside (e.g. by contemporary non-practising observers or later historians) as performing certain occupational tasks; the latter is a self-conscious individual who promoted the project of professionalisation.

the might of the Institute of Chemistry, which commanded the loyalties of the majority of professional chemists working in industry. But working between the world wars in association with a tiny number of teachers in the universities and elsewhere, the IChemE defined a distinctive form of academic training. This made it clear that the chemical engineer was not to be regarded merely as a hybrid of a chemist and an engineer.

A novel conceptual framework – based on what came to be called 'unit operations' – understood the manufacturing of chemicals as a series of discrete physical operations. The principal tasks of the chemical engineer were to ensure the containment of chemicals during the manufacturing process, to secure their movement from one stage of the manufacturing process to another, and to provide the physical conditions that would permit chemical reactions to work efficiently and economically on the large scale. All of this required a knowledge of chemistry (particularly physical chemistry) greatly in excess of that required of other kinds of engineer. But the 'unit operations' distanced chemical engineers intellectually from chemists, and suggested that the new profession might have more in common with the older engineering disciplines. After the second world war, this tentative intellectual connection with the established branches of engineering was strengthened at the organisational level. In the 1950s, the IChemE was gradually accepted as a kindred body by the principal associations of professional engineers; while the Institution did not abandon its links with chemists, it did not develop them so assiduously. By the 1960s the IChemE was a member of the Council of Engineering Institutions, unlike its one time rival, the Institute of Chemistry (by now the Royal Institute of Chemistry, RIC). By contrast, when in the late 1960s the RIC started to canvass support for a similar federation of chemical associations, the IChemE had little to do with the scheme. By the end of the century, the IChemE was one of the most important bodies relating to the Engineering Council – the chemistry associations, by contrast, had nothing to do with the organisation.

The history of this subject is clearly of some interest to its growing number of practitioners – some 25 000 in the UK at the end of the twentieth century.[2] But there

[2] The IChemE in 1999 had about 21 000 members of all classes in the UK. The fraction of non-

are good reasons for wider attention. The subject had an intimate involvement with many British and international events during the twentieth century. It therefore illuminates that history, albeit from an unusual perspective: the story of chemical engineering reveals the 'underbelly' of British science and technology. A conventional history of intellectual discovery and technical advancement would fail to give prominence to the institutions, professional interactions, government policies, workplace categorisations and industrial pressures that were so important to changes in chemical engineering. And there are also deeper motivations for scholarly interest, which the remainder of this chapter will introduce.

Precisely because of its tortuous evolution, British chemical engineering is of considerable historical and sociological interest. The tribulations and regional detours of the subject demonstrate that it was in no sense 'destined to be'. The profession was not a natural or inevitable consequence of technological progress. Its history is therefore much more than a linear sequence of dates, discoveries and developments. What, then, can its troubled growth reveal? British chemical engineering is ideal for examining the balance between professional aspirations and historical contingency in what historical sociologist Andrew Abbott has called 'the ecology of the professions'.[3] Its identity was defined perpetually by its neighbours: between chemistry and engineering, between science and engineering, was its 'proper' identity that of a hybrid, a convenient compromise, or an unique specialism? In its gradual insinuation as a sort of 'Goldilocks profession' – neither too big nor too small, neither so weak as to fail nor powerful enough to command authority, and not entirely convincing as either a 'theoretical discipline' or 'indispensable occupation' – this staking of the middle ground was long-lasting and characteristic.

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member practitioners is not known accurately but is estimated to be between 10% and 30% of all practitioners.

[3] Andrew Abbott, The System of the Professions: An Essay on the Division of Expert Labor (Chicago: Chicago University Press, 1988).

Survey of analytical studies

Abbott's insight that professions must be understood as co-evolving in a changing environment is near the theoretical centre of this book. He dismisses earlier claims by historians and sociologists that the attainment of professional status – 'professionalisation' – follows a regular sequence of, for example, ethical codes of practice, academic training programmes, entry examinations, vocational qualifications and licensing or, alternatively, that it can be interpreted as reflecting a straightforward strategy of the consolidation of social and economic power. Indeed, he argues that the emergence and development of professions cannot be understood at all adequately as isolated movements; instead they must be analysed in their particular historical contexts as parts of evolving systems of interdependent yet competing occupational specialisms. Within this social ecology, Abbott urges an initial focusing on groups that undertake common work rather than on the separate ways they might organise institutionally: only then should we shift the focus of our analysis to discover how the link between an occupational group and 'its' work is created and anchored by formal and informal social structures, practices and discourses in such a way that the group comes to gain the degree of social and economic authority characteristic of a 'profession'.

Abbott's key argument is that the historical development of professions hinges on 'jurisdictional disputes' between occupational groups; jurisdictional claims over 'professional' tasks in the workplace motivate and shape subsequent organisational developments. Survival in the competitive system of the professions is promoted by the particular tactics adopted by practitioners to strengthen their collective claims to authority. The history of chemical engineering as a profession supports the view that the achievement and maintenance of jurisdiction over technical tasks may require the endorsement of several social groups, including, for example, employers and government.

Yet sociologists of the professions such as Abbott and Keith MacDonald have thus far treated the engineering professions cursorily.[4] Historians, for their part, have long been concerned to understand the politics of organised interest groups that has characterised the workings of the British state. But even the most important work

[4] Keith M. MacDonald, The Sociology of the Professions (London: Sage Publications, 1995).

has virtually ignored the part played by the professional institutions of the technical occupations. Keith Middlemas's magisterial three volume study, Power, Competition and the State does not appear to contain a single reference to the engineering institutions, although it mentions on numerous occasions the Engineering Employers' Federation and the manual engineers' trades unions.[5] Middlemas's work does, however, draw our attention to the shifting alliances and tensions that exist between different parts of the state and government. Perhaps it is even more surprising that Harold Perkin's The Rise of Professional Society: England Since 1880 is almost as neglectful of technical professions.[6]

There is as yet no comprehensive study of the interaction between the various parts of the state, the associations of professional engineers and related scientific workers, and engineering employers in Britain. The politics of those technical occupations that lay claim to professional status remains a surprisingly neglected area of the historiography of modern Britain. Nor have there been studies by analysts of historical and sociological processes dealing with the emergence of 'sub-professions' – particularly important in Britain – such as nuclear engineering, which for a time after the second world war was seen as a logical territory for expansion by chemical engineers. It is significant that engineering professions since the second world war, led by the chemical engineers, have been increasingly dominated by a scientific perspective. The evolution of explicitly scientific professions has attracted the attention of some historians of science and technology.[7] Yet the failure of researchers in 'mainstream' history to engage this issue of the gradual but nearly continuous shifting of the balance between technical 'art' and 'science' may explain the absence of substantive work on these newer engineering specialisms.

The centrality of identity

[5] Robert Keith Middlemas, Power, Competition and the State (Basingstoke: MacMillan, 1990) .

[6] Harold Perkin, The Rise of Professional Society: England Since 1880 (London: Routledge, 1989).

[7] See, for example, C. A. Russell, Noel G. Coley and G. K. Roberts, Chemists by Profession: The Origins and Rise of the Royal Institute of Chemistry (Milton Keynes: Open University Press, 1977).

We attempt to redress these deficiencies through a detailed study of chemical engineering from a particularly fruitful perspective: that of individual, professional and institutional identity. Such an approach is timely in two respects. First, identity has increasingly served as the starting point for a wide variety of investigations in cultural history and sociology. And second, a self-conscious awareness and promotion of identity has been a phenomenon of modern times, as argued by Anthony Giddens.[8] The extension of the professional identity of chemical engineers from the workplace and university successively to regional, national and international institutions is mirrored by larger-scale changes in society.[9]

As suggested by the capsule history above, and developed as the underlying theme in the following chapters, chemical engineers have assumed multiple identities through their history. These characterisations have alternately been claimed by the practitioners themselves and imposed upon them by others. While seeing themselves as a social or professional 'group', others nevertheless relegated them to a mere 'category' of worker, if indeed they were singled out at all. Indeed, the more common practice of chemical firms in the early years was to promote a 'corporate' or 'industrial' identity – attaching employees to a particular firm or chemical process for their entire working lives. Hence the identity of the 'chemical engineer' could not be established unilaterally. As Richard Jenkins has discussed, identity is the result of negotiation or agreement between parties.[10] Nascent 'chemical engineers' had to work out not only in what respects they were similar to each other, but how they all differed as a group from others.

Different identities have also been serial and concurrent. The definition of the 'chemical engineer' evolved episodically in the eyes of industry and the state, yet was simultaneously different for various engineering and scientific communities. This heterogeneity and malleability of these identities was influential in the ultimate success of the profession.

The profession's identity had several dimensions which delimited its frontiers. The chemical engineering profession adopted a succession of positions along the

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[8] Anthony Giddens, Modernity and Self-Identity: Self and Society in the Late Modern Age (Cambridge: Polity, 1991).

[9] See Jonathan Friedman, Cultural Identity and Global Process (London: Sage, 1994).

[10] Richard Jenkins, Social Identity (London: Routledge, 1996).

science/engineering axis, for example. Another distinctive attribute in the profile of working chemical engineers was their particular educational background, which had an enduring relationship with social class. During the past quarter century, too, gender has become a significant variable refashioning their professional identity. And the content of 'chemical engineering' practice has been strongly circumscribed by local industrial conditions, hence the importance of considering regional variations. Regionalism has also delineated the profession by introducing tensions between the organisational centre of the IChemE and its peripheries in Britain and the Commonwealth, and between the IChemE and American and European institutions. Abbott's metaphor of professional jurisdiction as territorial competition draws explicitly on this geographical dimension for good reason.

Similarly, certain aspects of identity have been advanced by particular tactics. The cognitive identity of the discipline of chemical engineering was strengthened by the innovative concept of unit operations. The courting of patronage from government departments and industrial associations advanced the validation the profession; the organisers explicitly recognised a political dimension. So, too, were the affinities of professional chemical engineers strengthened by links (at various times) with other professional engineering and scientific societies. By contrast, an occupational identity was asserted with difficulty, given the established employment categories of 'engineer' and 'chemist' favoured by industry and state institutions alike.

In concert with such tactics went the invention of a professional image, which included the elaboration of legends of pioneering antecedents and critical events to buttress a sometimes fluid identity.[11] Such self-conscious image building even employed potent symbolic elements, utilising the award of medals based on founding fathers, the iconography of institutional seals and the rhetoric of Presidential addresses and institutional mottos. Engagement with the past, however, varied through the century, as reasons altered for praising or neglecting past events and representations. Considering such constituents, the history of this specialism bears

[11] To speak of 'invention' is not to imply any cynical promotion, or to dispute the importance of the subject and its reality to practitioners and beneficiaries, but to stress that it is a product of history and culture as much as a 'natural' technological category.

notable parallels with that of some national and ethnic groups.[12] Just as Gerard Delanty has written of Europe, 'the European idea emerged and was sustained more by conflict and division than by consensus and peace' and arguing that it was 'a contested concept. . . about exclusion and the construction of difference based on norms of exclusion', so Andrew Abbott contends that professions evolve by competition and territorial definitions.[13] More generally, the analogy of professions as struggling nations is strengthened by the imprecision of their definitions. Hugh Seton-Watson's observation that 'no "scientific definition" of the nation can be devised; yet the phenomenon has existed and exists', is equally apt for professions.[14] And just as for nationalism and nations, professionalisation is not necessarily a process of formalising pre-existing and natural groups of specialists, but rather the invention and maintainance of such groups. Questions of authority and representation are at the heart of the creation of professions.

As suggested by this brief discussion, our point of departure is a view of the identity of chemical engineers as 'non-essentialist', that is, as not having a fixed, authoritative meaning. Their identity has always been subjective, contested and shaped by their relationships with 'others'. As such, it reveals much about not only those who became 'chemical engineers', but of those who did not.

The importance of the chemical engineering profession

[12] See, for example, Benedict Anderson, Imagined Communities: Reflections on the Origin and Spread of Nationalism (London: Verso, 1991); Gerard Delanty, Inventing Europe: Idea, Identity, Reality (Basingstoke: MacMillan, 1995); and, Murray G. Pittock, The Invention of Scotland (London: Routledge, 1991).

[13] Delanty, op. cit, pp. vii and 1.

[14] Hugh Seton-Watson, Nations and States (London: Methuen, 1977), p. 5.

Our work aims to tie together previously isolated empirical data and disparate analytical approaches. A contextual history of a British engineering specialism can be considerably more than the sum of its parts, disclosing as it does the interactions and linkages between players that are as important as the individual professions themselves. A similar objective pertains for the bases of our analysis. The sociology of the professions has for too long presumed a simple model of scientific and technical expertise, taking it as universal, progressive and uncontroversial.[15] Sociologists of scientific knowledge, on the other hand, while more sophisticated in their treatment of such evidence, have tended to neglect the organised social structures – the professions – often responsible for and underlying its generation. To fully explain the nature of these entities in the British context, we therefore consider professional bodies, their members, their work and their productions as equally important components in an historical milieu. The third fertile research tradition that must be incorporated is the flourishing history of technology, which recently has brought new perspectives for understanding the technological aspects of society. Several writers acknowledge the success with which science and technology have been harnessed to the task of modernising the British economy. A fine-grained study of the historical development of one of the major professions could not be more propitious.

There are other questions that a study of chemical engineering history can illuminate. It is often said, for example, that the performance of the British economy is damaged by the influence of political structures and occupational organisations dating from the earliest days of industrialisation. In particular, a good deal of criticism has been levelled at the organisation of professional engineers. Some commentators point out that the engineering associations – established from the early nineteenth century on the model of the self-governing bodies of the legal and medical professions – are unusually distanced from the concerns of business and the state. Critics compare this state of affairs unfavourably with those among Britain's industrial rivals in Europe, North America, the Pacific Rim economies, and elsewhere; there, it is argued, engineers are much better integrated with wealth-producing institutions

[15] E.g. Peter Whalley, The Social Production of Technical Work: The Case of British Engineers (Basingstoke: MacMillan, 1986).

and structures. In this context, chemical engineers are of particular interest since they tend to work in one of the few industrial sectors – chemical and allied manufacturing – where Britain's economic record clearly bears comparison with that of its competitors.

An appreciation of the IChemE's relations with other professional groups is thus important for this book. 'Manpower' policy, for example, was a vital domain in which the IChemE had to persuade the various governmental, educational and industrial authorities of the distinctive character and value of the chemical engineer if the profession were to thrive. The Institution achieved this goal, particularly after the second world war, partly by mobilising support among groups of industrialists, politicians and high officials who were not persuaded of the adequacy of the provision made by chemists. The analysis of how this was done suggests that there has been a greater measure of agreement between the IChemE and certain industrial employers than one would expect from the arguments of the critics of the engineering associations.

This study is also of significance for the literature on the role of corporatism in British politics. In an important series of articles, Kevin McCormick has analysed the development since 1939 of new forms of state power intended to recognise, legitimate and incorporate organised interest groups.[16] He argues that corporatist structures should be conceived as lying along a continuum: at one end are those forms of organisation involving a high degree of state intervention, centralisation and coercion of the incorporated bodies ('state corporatism'); at the other, those in which relatively autonomous, representative bodies come together in voluntary association ('societal corporatism'). McCormick suggests that the degree of state intervention in a particular domain of policy has historically depended upon two factors. First, the changeable perception of industrialists' interests by politicians and different parts of Whitehall; and, secondly, on the degree of co-ordination between departments of state. He concludes that attempts to create durable corporatist institutions at the national level have foundered on the lack of corporate organisations at lower levels, including that of industrial employers, and on the tendency of the groups that are incorporated to pursue their own interests in their own way.

The history of the professional organisation of chemical engineers is grist to

[16] K. McCormick, 'Engineers, British culture and engineering manpower reports: The historical legacy revisited', Manpower Studies (1981), 131-135.

the mill for all of these points. The degree to which the IChemE became incorporated into formalised state structures of 'manpower' planning varied considerably over through the century. This was at least partly a result of the changing perception of employers' 'needs' by parts of the state. But it is important to realise that under certain circumstances, the IChemE played a large part in shaping the state's perceptions of these 'needs'. The institution was most successful when it functioned within the chemical and process industries as a kind of corporatist body of the 'societal' kind – it secured significant policy concessions when it was able to demonstrate to high officials a substantial measure of agreement among a representative body of industrial employers.

Our work suggests that it is necessary to attend to the particularities of historical episodes if we are to understand the circumstances under which a voluntary association like the IChemE can secure a consensus among industrial interests.

The making of chemical engineers

We devote considerable attention to the history of chemical engineering education. Our focus on the professional aspects of this process has an important bearing on the literature concerning the role played by universities and academic knowledge in the formation of technical experts. As discussed above,recent historians and sociologists have largely turned away from trying to agree on the characteristics that define a professional ideal type and instead have concentrated on the ways in which certain occupational groups struggle to achieve social and economic authority as 'professions'. There seems to be agreement among many commentators that a crucial stage in the making of any profession is the founding of a means of producing specialist, formalised knowledge. Simply put, control over the production of such knowledge is held to be *a* cause – if not *the* cause – of 'professionalisation'. One particularly influential version of this thesis holds that universities have become increasingly central to professional identity as practitioners have based their claims to social status on technical expertise underpinned by codified knowledge.

We do not seek wholly to dissent from this kind of analysis, which might be called the 'academic account of professionalisation'. But we agree with those analysts who suggest that it can be fruitful to consider more carefully the role played

by universities in the production of formal knowledge of practice. Historically, the codification of technical expertise is interesting because so often it has been the chief point of conflict in Abbott's 'jurisdictional' disputes between occupational groups. Yet theorists rarely acknowledge, other than in passing, that the loci and practices of the production and transmission of such knowledge are historically contingent and culturally specific. In particular, the growth of vocational knowledge and learning within the universities can only be properly understood if one considers the attempts by certain groups of academics to gain authority within the academy. In other words, academic accounts of professionalisation often turn out to rest on accounts of academic professionalisation that are themselves poorly grasped.

Through the case of chemical engineering we seek to illuminate what Abbott aptly describes as 'the embarrassing British case' for academic accounts of professionalisation. Following Abbott, we agree that for much of the nineteenth century the association between the universities and, in particular, the evolving engineering professions, was not particularly strong. But we differ from him in his implication that this was more or less a constant state of affairs. In fact the universities became increasingly important from the middle of the nineteenth century, even for those branches of engineering that had already achieved a high degree of social status and economic authority without the benefit of a close association with the academy. This shaped the nature of the later relationship between the universities and the professions of civil, mechanical and electrical engineering. But with chemical engineering, matters were very different. The occupation emerged as an industrial specialism somewhat later, and the universities and codified knowledge played a very much more marked role in the struggles of the early practitioners in their jurisdictional disputes with cognate experts. The dynamics, and the eventual resolution, of the tensions between university academics and practitioners in the realm of chemical engineering also contrasted quite markedly with those in the other branches of engineering, and we attribute such variation to differences in the wider social, economic and institutional contexts of both academic and occupational practice.

The very success of these initiatives also raised problems concerning the appropriate mix of academic education and practical training. The production of codified knowledge and its transmission to would-be chemical engineers in the

academy was as much a kind of professional work as the forms of industrial practice that they underpinned. By analysing chemical engineering academics' efforts to assert their authority as professionals within the university, we lend weight to the more general claim that jurisdictional negotiations between practitioners and academics are an important, and probably inevitable, aspect of the making of any occupation once it becomes associated with 'a body of relatively abstract knowledge, susceptible of practical application'.[17]

Scope

Our study thus attempts a contextual history of the chemical engineering profession by drawing on economic, technological, cultural and sociological aspects. The essence of the story is the recognition of the 'chemical engineer' as a distinct type of specialist; attempts to claim intellectual and occupational tasks from chemists; and, the consolidation of these jurisdictional ties in the peculiar environments of twentieth century Britain.

As suggested above, this book concentrates on the social history of chemical engineering as a profession in Britain, and particularly the part played by the IChemE in its growth. The time period consequently focuses on the period from about 1880, when the first attempts to found such an organisation were made and when the expanding chemical industry began increasingly to employ such specialists, to the end of the twentieth century. We are not so insular as to suggest that indigenous developments were solely important, however. Comparative aspects of the subject, such as the intellectual and professional connections with chemical engineering in the USA and developments in Commonwealth countries, are treated where relevant but do not form our central thrust; we concentrate on the deciding factors for the British profession.

[17] MacDonald, op. cit.

The evolution of chemical engineering is studied as an organised occupational activity, as an academic discipline and (most intensively) as a profession. The activities examined include technical practice, working environment and social interactions. We explore the practical scope and demands of a career in chemical engineering – as an employee, designer, plant supervisor, consultant, academic and Institution council member. In addition, the interplay between chemical engineers and their peers, and with society at large, are highlighted. We nevertheless recognise that writing a balanced social history of the occupation is hampered by scattered and incomplete primary sources. The 'view from the coal face' was little documented in official records. Practitioner's reminiscences can suggest merely the variability and uniqueness of each job, firm and activity over the century. A representation of what it meant to practise chemical engineering in past decades cannot adequately be grasped from anecdotes.

The discipline, however, can more faithfully be mapped. We elucidate the conceptual attributes defined by chemical engineers, by educators and by their contemporaries, targetting the intellectual ideas that played a role in distinguishing chemical engineering from other academic subjects. These ideas included 'unit actions', 'unit processes', costing, and mass and energy transport. Vaunted in the period after the first world war, such conceptual entities fell largely outside the domain of practising chemists and mechanical engineers. This intellectual framework therefore distanced chemical engineers from chemists (and particularly from the closely related occupations of industrial chemist and chemical technologist), and suggested that the new profession might have more in common with the older engineering disciplines.

The investigation of professional aspects includes the social definition of chemical engineers as specialists. We have studied their visibility, status and perceived importance relative to other professionals. The standards of qualification defined by the IChemE were crucial to these questions, as were the continuing interactions with government and industry for recognition.

The context in which these aspects of chemical engineering evolved is highly relevant. We account for the role of the IChemE as a focus for a professional identity, as an activist for a disciplinary definition, and as a liaison between government, industrialists, practitioners and educators. And the study does more

than explain the past: by exploring the causes of the trajectory of British chemical engineers, it also reveals constraints on their future course.