

Science and Technology in England and Wales: The Lost Opportunity of the Colleges of Advanced Technology

Abstract

This paper focuses on the Colleges of Advanced Technology (CATs), specialist providers of advance science and technology which existed in England and Wales for ten years after the 1956 White Paper *Technical Education*. Its central argument is that recasting the CATs as broader-based universities following the 1963 Robbins Report was a significant error which attenuated the progress of science and technology, and prevented the Colleges' development as viable providers of higher education (HE) outside the university sector. This decision, it is argued, was shaped by typically English views about the relative value of different forms of learning, the nature and purpose of HE, and particular beliefs about the primacy of the university. It also conflated the general desire to increase participation in higher education with the wish to promote science and technology in particular. A bolder option, it is proposed, would have been to build the CATs up as prestigious institutes of technology, along the lines of those found in the USA and continental Europe – although this, it is recognised, would have entailed a substantial shift in the role of the state and reduced the individual and collective autonomy of HE institutions in England and Wales.

Key words: science and technology; higher education; Colleges of Advanced Technology

Introduction

In England, anxieties about the threat posed by nations with more advanced systems of education and training stretch back to the mid-nineteenth century and events such as the Great Exhibition of 1851 and the 1867 Paris International Exposition, both of which demonstrated the technological prowess of industrial and military rivals in Europe and further afield. Such episodes proved something of a shock to the English psyche but also demonstrated the failures of *laissez-faire* in producing a workforce able to contend with growing overseas competition, especially in relation to science and technology (Musgrave, 1970). Thereafter, the 1870 Education Act began to establish state schooling in England and Wales, whilst the 1889 Technical Instruction Act and the 1890 Local Taxation Act encouraged the growth of vocational education and training. The 1902 Education Act created local education authorities (LEAs) which then became central to running both schools and post-compulsory education across the country, although it was not until the 1944 Education Act that LEAs were required to secure 'adequate provision' of the latter (Bailey, 1987).

The 1944 Education Act is best known for introducing new systems of primary and secondary education, and for increasing the minimum school-leaving age to fifteen but it also stimulated a significant increase in post-compulsory education and training. Much of this took place in LEA-run colleges of further education (FE¹), or technical colleges as they were then known, and by 1947 there were 680 major establishments of FE in England and Wales – approximately twice the number in existence in 1938 (Lucas 2004, p.14). It is, however, often forgotten that Rab Butler, President of the Board of Education, also appointed Lord Percy to chair a special committee on technological education. Subsequently, the Percy Report (MoE, 1945) recommended the establishment specialist colleges to provide advanced education and training for industries deemed to be of strategic importance and, by 1951, seven National

¹ FE college is used to describe institutions whose main purpose is providing vocational education to individuals over the minimum school-leaving age. Over time, these have included generalist institutions, known as technical colleges or colleges of further education, and specialist institutions for subjects such as art and design, business or construction.

Colleges, focusing on fields such as food science and aeronautical engineering had been designated. A few years later, the Royal College of Art became an eighth National College (Venables, 1955). These Colleges were, however, small mono-tech operations and soon merged into other higher education institutions (HEIs). It was not until 2015 that the idea of industry-specific National Colleges was revived² (see DfE, 2020).

The Percy Report also recommended significant growth in the provision of science and technology more generally. There was, however, little consensus in policy circles about how best to organise, fund and manage its increase. On one hand, senior members of the academic community – many of whom occupied senior positions in Whitehall during the War – favoured growth in the fundamental sciences in the universities (UGC, 1950). But the local authorities, supported by key figures in the Ministry of Education (which replaced the Board of Education in 1944) and the National Advisory Council on Education for Industry and Commerce (see NACEIC, 1950), wanted to build up provision in the technical colleges (Shattock, 2012). Either way, provision grew more rapidly in FE after the end of the War, and there were almost 9,000 full-time and over 11,000 part-time technical college students on degree-level courses by the end of the 1940s (MoE, 1950).

Intense debate about the development of science and technology continued throughout the 1950s. Progress was slow and uneven but a pattern of expansion emerged incrementally in the colleges. In 1952, the Ministry of Education began providing technical colleges with a 75 per-cent grant for higher-level technological courses (Venables, 1955); in 1955, a National Council for Technological Awards (NCTA) was established; then, in 1956, the White Paper *Technical Education* proposed that twenty-four technical colleges in receipt of 75 per-cent grants should become Colleges of Advanced Technology (CATs), dedicated to providing

² In 2015, the Department for Education announced plans to establish five National Colleges for 'key growth sectors' – high-speed rail; oil and gas; nuclear power, digital skills; and creative industries. By 2020, four Colleges had opened but a National College for oil and gas does not currently exist.

degree-level qualifications, postgraduate education and research in applied science and technology. They would, it was argued, play a key role in ensuring that Britain did not fall behind its traditional competitors in Europe and the USA, and new 'cold war' rivals, especially the USSR. Yet, despite all this, only ten CATs were ever established and all were gone ten years after their designation (Burgess and Pratt, 1970, p.37).

The central argument of this paper is that the failure to develop the CATs as specialist technological HEIs along the lines of those found in the USA and Western Europe was a significant lost opportunity – both in terms of increasing the quality and profile of science and technology, and in developing a viable alternative to university-based higher education in England and Wales. Whilst the CATs were hindered by significant errors in their initial design and operation, a key error, it is argued, was recasting the Colleges as broader-based universities – a decision, which it is argued, was foreshadowed by a particularly English conception of the nature and purpose of higher education, but also an expedience which conflated the ambition to increase general participation in HE with the desire to improve the quality and supply of advanced science and technology (Shattock, 2012). A bolder option, it is argued, would have been to continue to build the CATs up as specialist institutes of technology, separate and distinct from the universities.

The first section of the paper locates science and technology in the landscape of English higher education, and considers its historic relationship with the universities on one hand and technical colleges on the other. The next section focuses on the Colleges of Advanced Technology, their formation and growth, and the changing makeup of their staff and student body. It also deals with the qualifications the CATs offered and matters of governance – both of which, it is argued, were inherently problematic and only served to make university status appealing to the Colleges of Advanced Technology. The third section explains how the CATs were recast as universities following the Robbins Report. It also highlights another of the Report's key proposals which went unfulfilled: the creation of specialist **institutions for**

scientific and technological education and research (SISTERS). This, it is argued, could have provided a viable future for the Colleges of Advanced Technology as high-profile alternative providers of higher education had policymakers chosen to develop the colleges as SISTERS. The paper concludes by placing subsequent developments in their broader policy context and by critically considering some of the barriers – and potential resolutions – to the progress of science and technology in England and Wales.

Technological education in England and Wales

Burgess and Pratt's (1970) book *Policy and Practice: The Colleges of Advanced Technology* outlines two traditions of HE in England: the academic tradition associated with the universities and the service tradition of the technical colleges. The service tradition they describe as open and inclusive, as focused on vocational or work-related learning, and as orientated to the needs of business and industry. The universities, in contrast, they see as more independent, autonomous institutions, as socially selective, and as being largely concerned with the pursuit of 'pure' or abstract knowledge. Such a dichotomy was crude even at the time Burgess and Pratt were writing but is particularly difficult to reconcile with the current landscape of further and higher education in Britain. FE has always been a complex, diverse sector but the number of universities (and university staff and students) has multiplied over time, and nowadays different universities have significantly different missions and often serve quite different constituencies of students. Many academics are closely managed and monitored, and universities are much more performative institutions than in the past (Tight, 2019). Individual universities have different histories and trajectories but many effectively started out as technical colleges and went through various incarnations before eventually becoming universities, a process which Pratt (1997) described as 'academic drift'. This, of course, includes the polytechnics and many former teacher-training institutions but even various members of the elite Russell Group³ can trace their roots back to technical institutes of

³ The Russell Group is an association of twenty-four 'research intensive' universities, generally regarded as the most prestigious HEIs in the United Kingdom.

Victorian Britain. Fewer observers will, however, be aware of the CATs' short but winding journey from local authority colleges to fully-fledged universities. But the value of this paper lies not only in highlighting the particular story of the Colleges of Advanced Technology, but also in its alternative vision for the development of advanced science and technology in England and Wales – a field in which provision has long been regarded as deficient, especially vis-à-vis comparable nations.

The university tradition

One of the peculiarities of the English university system (if system is the right term) is that it consisted of just two universities, Oxford and Cambridge, for almost 600 years. This situation was due largely to their opposition to the establishment of rival universities and, for much of its history, England had fewer universities than comparable nations. By the Seventeenth Century, there were fourteen universities in Germany, eight in Spain and seven in Italy, whereas England's third university, University College London, did not open until the 1820s (Willetts, 2017). This situation had far-reaching implications for English education and society more broadly. On one hand, it meant that going away to university became associated with a privileged minority, and Oxford and Cambridge acted, for much of their existence, largely as finishing schools for the landed elite (Collini, 2012). They were moreover always sceptical about 'practical' or applied knowledge and focused mainly on the liberal arts, although the emphasis was on 'character formation' rather than academic rigour (Argles 1964). There are various reasons for this but the notion that those from different social backgrounds are more or less suited to particular types of learning can be traced back to ancient views about the relative value and status of different Forms of education (see Plato 1955). Such ideas have been influential across the Western world but especially in England where education has played an important role in maintaining and reproducing social divisions since the Middle Ages (Simon, 1960). Either way, the Oxbridge model has always provided a social and cultural reference point for English HE and even the civic universities, established in the late-

nineteenth century to deliver more vocational higher education, soon drifted towards the abstract and the theoretical.

Rising international competition and political pressure at home meant that science classes were finally introduced at Oxford and Cambridge following the Devonshire Commission on the Instruction and Advancement of Science. The Cavendish and Clarendon laboratories were founded in the 1870s, and Oxbridge began admitting a wider but still relatively narrow range of students. The new civic universities and university colleges were more active in matters scientific but there were still less than 3,000 science and technology students at university in England and Wales at the beginning of the twentieth century, compared to 15,000 in Germany (Burgess and Pratt, 1970, p.7). It was, however, not only the paucity of British university graduates that was seen as problematic. Employers often regarded them as too concerned with theory and divorced from the rigors of industry (Roderick, 1967, p.9).

Britain's industrial and military shortcomings were badly exposed during the Great War and the 1919 Thomson Committee called for increased expenditure on science and technology via the newly-formed University Grants Committee (UGC). The return of ex-servicemen also meant more demand for university places but FE was still producing more advanced technologists than the universities at the beginning of World War Two (approximately 1,700 a year in FE and 1,250 a year in universities). Whilst British universities received a substantial proportion of their income via state throughout the Twentieth Century, it is important to note that they have never officially been part of the public sector in the way that FE colleges were. There was, until the 1980s, also a general reluctance to attempt to compromise the independence of the universities (see Shattock, 2012). Either way, many technical college students were enrolled on more 'applied' courses such as higher national certificates (HNCs) and diplomas (HNDs) rather than degrees (Burgess and Pratt, 1970, p.17).

The Technical tradition

FE colleges are complex, multi-purpose institutions but their chief concern has traditionally been providing work-related education and training, whether for the engineering workshop, the construction site or for the salon, shop or office – as is more likely today. Their *raison d'être* has therefore always been about responding to external demand in one form or another rather than the pursuit of knowledge 'for its own sake'. FE has moreover traditionally mainly been concerned with teaching rather than research, and so further education colleges have always been predominantly working-class institutions, even if they traditionally catered largely for relatively-privileged sections of the working class (Lucas, 2004).

Higher education in the UK has, over time, become located mainly in the universities but traditionally large amounts of HE took place in other establishments – in, for example, polytechnics, teacher-training colleges and technical colleges. In England and Wales there were, immediately before the 1992 Further and Higher Education Act, actually fewer HE students in the universities than in other institutions (Pratt, 1997). Nowadays, FE colleges run a diverse range of courses from special needs education to advanced professional qualifications but their involvement with science and technology can be traced back to the mechanics' institutes of Victorian Britain and notions of 'useful knowledge' for the working classes which became popular among some sections of society (Ainley and Bailey, 1997). Some technical colleges began offering external degrees of the University of London in the late-nineteenth century but it was the introduction of HNCs and HNDs, validated by the institutes of science, building and engineering which drove a great expansion of advanced work in FE from the 1920s onwards (Burgess and Pratt, 1970, p.17).

The number and range of qualifications each college offered depended on various factors, not least the needs of local industry and commerce although the demand for science and technology was generally higher in the industrial conurbations. Some colleges were nevertheless more ambitious than others, and different LEAs differed considerably in their

commitment to post-compulsory education. Some authorities were munificent and proactive, whereas technical and vocational education was left largely undeveloped elsewhere (Bailey, 1987). Local peculiarities played a part too. Bradford, for example, always wanted its own HEI partly due to its long-standing rivalry with neighbouring Leeds where a university was established in the 1880s. More generally, the relative paucity of science and technology in the universities left something of a void for the colleges to fill. It was from this milieu that the Colleges of Advanced Technology emerged (Matthews, 1981).

The Colleges of Advanced Technology

Establishment

In early-1956, the White Paper *Technical Education* recommended re-designating twenty-four leading technical colleges as Colleges of Advanced Technology. The CATs, it was planned, would be much larger, more comprehensive institutions than the National Colleges, and provide work equivalent in standard to the universities. They would, it was proposed, be devoted purely to higher-level science and technology, and work closely with employers to meet the needs of industry. Significant investment in staff, premises and institutional infrastructure was, government recognised, necessary to build the CATs up into credible HEIs (MoE, 1956). Commentators in the *Journal of Education*, however, doubted whether there were four colleges, let alone twenty-four, capable of matching such ambitions (Silver, 2007, p.302). Subsequently, Minister of Education, Sir David Eccles, designated eight CATs – with two more ‘in sight’ (Hansard, 1956). Seven of the initial eight Colleges were located in large cities: Birmingham, Bradford, Cardiff, Salford and London (Battersea, Chelsea and Northampton), Loughborough was the exception. In 1962, Bristol and Brunel also became Colleges of Advanced Technology. Each CAT was based on an existing local authority college, although Loughborough College of Technology had already been removed from municipal control having built up a large proportion of advanced work, extensive residential

accommodation, and a student body from across Britain and overseas under its buccaneering principal, Herbert Schofield (Matthews, 1981).

There are now over 130 UK universities so creating ten new HEIs may seem rather tame by today's standards. We should, however, remember that there were only sixteen universities in England and Wales in the 1950s (although the Universities of London and Wales were federal institutions with twelve and four constituent colleges respectively). The colleges chosen to become CATs were also sizeable establishments, some having 5,000 students at the time of designation (Matthews, 1981, p.142); Britain's first post-war university, Keele, had just 1,200 students when granted university status in 1962 (Kolbert, 2000, p.119). Technical colleges have, however, always offered more part-time courses than universities, and approximately sixty per-cent of CAT students were part-time learners at designation (Burgess and Pratt, 1970, p.50). Most attended college on a 'day-release' or 'block-release' basis so the Colleges of Advanced Technology already had strong links with business and industry. On the other hand, few FE lecturers were graduates and significant investment in staff, premises and equipment was needed for the CATs to become credible HEIs (Venables, 1967). Qualifications were, however, also a challenge in other ways.

Qualifications

The Colleges of Advanced Technology were established to deliver higher education at a standard comparable to the universities but they were never able to award their own degrees. The CATs would instead offer the 'degree-equivalent' Diploma in Technology (Dip Tech), validated by the NCTA, as their principal qualification. The Percy Committee had been split over the question of degree-awarding powers but Percy himself argued that the technical colleges lacked the necessary institutional breadth and maturity to award degrees (see MoE, 1945, Note para 4). The university lobby, for its part, saw local authority colleges as lacking not only the staff and facilities but also the vision, gravitas and general wherewithal to offer their own degrees (CVCP, 1950). Arguably, the Diploma was a step forward in some ways

though. Traditionally, the external-degree system provided colleges with little control over course content or assessment whereas the Dip Tech was designed and examined by the Colleges and approved by the NCTA. In England, however, the bachelor's degree has always been regarded as the gold standard and the external-degree system proved remarkably durable. In fact, Chelsea continued to offer London degrees as its main award until it was taken into the University of London itself. The other Colleges continued to offer degrees alongside Dip Techs. Whilst there were variations between the different CATs, the number of degrees awarded to their students remained fairly stable between 1955-56 and 1965-66 at around 500 a year (Burgess and Pratt, 1970, pp.70-71).

The Diplomas were introduced as 'sandwich courses', which meant integrating industrial placements with academic study. Whilst this fitted with notions of vocational relevance and responsiveness, securing sufficient work placements could be challenging. Consequently, full-time Diplomas normally lasted four years whereas most degrees were three-year courses (NCTA, 1959). Dip Tech students were moreover obliged to undertake liberal studies and organisational studies, and an independent project in their final year – none of which was usually required to obtain a degree. Arguably then, more was required of Dip Tech students even though their qualification was regarded as an inferior qualification in some circles. Either way, the White Paper made clear that the Colleges of Advanced Technology should prioritise advanced, full-time provision and the number of full-time CAT students rose from 6,000 to 15,000 between 1956-57 and 1964-65. Part-time enrolments fell from 26,000 to 8,000 at the same time (Burgess and Pratt, 1970, pp.49-53).

Entry requirements for degrees and Dip Techs – two A-levels or an ordinary national certificate or diploma – meant that CAT students were generally younger and more middle class than those who attended their precursor institutions (Burgess and Pratt, 1970, pp.78-79). 35 per cent of CAT students were over 21-years-old at designation but their student body was broadly similar to the universities by the early-1960s (Committee on Higher Education, 1963. Appendix

2). Prioritising advanced study meant that whole departments containing work deemed unsuitable for HE were lost or removed to neighbouring technical colleges. Abandoning subjects such as bakery, chiropody and domestic science also meant fewer female students. Initially, 20 per-cent of CAT students were women; ten years later the figure was just 8 per-cent. It is probably fair to say that the Colleges of Advanced Technology became less socially-inclusive institutions than their antecedents (Burgess and Pratt 1970, p.59).

Governance

Some of the world's most-renowned HEIs are specialist technological institutions, including the Massachusetts Institute of Technology (MIT) and the California Institute of Technology (CalTech) in the USA, RWTH Aachen in Germany, and the Swiss Federal Institute of Technology. In Britain, only Imperial College can be properly compared to such places. The history of Imperial College, founded under the patronage of Prince Albert, is, however, rather more august than the Colleges of Advanced Technology. But keeping seven of the eight original CATs under local authority governance was a mistake which should have been avoidable given the example of Loughborough, which was removed from municipal control in 1952 having already 'outgrown' its LEA. Perhaps understandably though, many local authorities wanted to maintain control of institutions in which they had invested considerable energy and resources. Meanwhile, central government saw municipal control, at least initially, as a way to ensure the CATs remained responsive to the needs of industry and society (MoE, 1956). Significant tensions were, however, evident from the beginning.

LEAs differed significantly in their style and function but there was always a degree of conflict between municipal systems and notions of academic freedom traditionally associated with higher education in England (Burgess and Pratt, 1970, pp.175-176). LEA procedures could be long-winded and cumbersome, and conflict between College principals and local authority officers, over both strategic and operational matters, was commonplace. The Burnham salary scales in place at the time of designation initially hindered the appointment of staff. The CATs'

academic workforce nevertheless effectively trebled between 1956 and 1966, with substantial pay rises for teaching staff. First, some of the lower Burnham grades were abandoned and higher ones created; then, in 1964, the National Incomes Commission recommended that CATs' salaries become comparable with university pay, thus enabling the recruitment of younger, better-qualified academics. Meanwhile, the Colleges began divesting themselves of non-graduate teachers inherited from predecessor institutions. Older staff retired, others were transferred to neighbouring FE colleges or otherwise encouraged to leave (Burgess and Pratt, 1970). Local authorities were, however, also required to run schools, technical colleges and other educational establishments, and to provide services and functions ranging from health, housing and social services to public transport. It is therefore unsurprising that they could not focus sufficiently on developing the CATs (Matthews, 1981). Either way, College principals wanted more independence and eventually it became clear that existing arrangements were untenable. In 1962, all extant Colleges of Advanced Technology were removed from municipal control, and Brunel and Bristol were designated as CATs outside the framework of local government (Matthews, 1981).

By the early-1960s, all Colleges of Advanced Technology were self-governing institutions; substantial improvements to buildings and estates had been made; staffing significantly strengthened; and arguably the CATs were becoming recognised as a viable alternative to the universities. Yet their development as specialist institutions of science and technology was effectively halted after the Robbins Report. In 1966, the Colleges of Advanced Technology at Bradford, Loughborough and Salford became universities bearing the name of their host city. Birmingham CAT became Aston University and Bristol and Battersea relocated to become the Universities of Bath and Surrey. Brunel shifted further out of London to Uxbridge; Northampton CAT became City University, London; Chelsea was taken into the University of London, eventually becoming part of King's College; Cardiff CAT became part of the University of Wales before being absorbed into Cardiff University.

Discussion

The Robbins Report is generally recognised as a pivotal moment in the development of HE in Britain. It is also often presented as socially progressive, particularly in relation to its recommendation that all those qualified to pursue higher education should have the opportunity to do so (Committee on Higher Education, 1963). Whilst there had been some expansion since the end of World War Two, the introduction of free secondary schooling for all, rising levels of attainment and the post-war baby boom meant that demand for HE increasingly outstripped the places available. Still, by the early-1960s, only around 8 per-cent of young people went onto higher education, with roughly half attending universities and half in other institutions (Layard, King and Moser, 1969). In France and Sweden, roughly twice the number of young people went into HE and, in the USA, the proportion was almost six times greater than Britain (Committee on Higher Education, 1963, table 19). The great expansion of HE which took place after Robbins meant that the number of full-time university students rose from just over 100,000 at the start of the 1960s to 235,000 by the early-1970s, with similar increases in participation outside the universities (Social Market Foundation, 2013). The Committee's commitment to expansion was, however, driven by economic imperative as much as anything else, with concerns about Britain's relative performance vis-a-vis its international competitors once again to the fore (Layard, 2014).

The Robbins Committee was not, however, concerned solely with student numbers. Its remit included an examination of different forms of higher education, and the planning and development of different types of institution. In this respect, the Robbins Report was more conservative, not least in terms of its hierarchical conception of higher education rooted in beliefs about the pre-eminence of the universities over other forms of HE (Pratt, 1997). In some ways, this is understandable. Almost inevitably, the Committee was informed by the peculiar history of higher education in England and the dominance of the Oxbridge model in particular (Willetts, 2017). Essentially, it now saw the Colleges as fit to become full members of the 'higher education club' (Burgess and Pratt, 1970).

In some ways then, the recommendation that the CATs should become universities was expected. Responsibility for funding shifted to the UGC in 1965 and the ten Colleges were awarded Royal Charters in 1966. (Burgess and Pratt, 1970, pp.43-44). The Robbins Report encouraged a growth in student numbers and suggested that the proportion of postgraduates at the former CATs should rise from under 5 per-cent to 15-20 per-cent (Committee on Higher Education, 1963). But, whilst it suggested that the CATs should retain a technological bent, only Bath and Loughborough kept 'technology' in their title, and both institutions eventually dropped the term from their name. Over time, all the former CATs grew to offer a much greater range of subject disciplines, although some more than others. Aston University, for example, retains a higher proportion of technological courses than most former CATs but also offers English literature, history and law – often alongside science, technology or business studies as joint degree programmes (Aston University, 2019).

It is possible, however, to imagine an alternative future for the CATs. Some principals, most notably those at Birmingham and Loughborough, envisaged their Colleges becoming elite institutes of technology rather than broader-based universities. This, in some ways, would have chimed with the spirit of the times - expressed, for example, by the future prime minister, Harold Wilson, in his *White Heat of Technology* speech (Wilson, 1963), and articulated in popular discourses about nuclear energy, computer science and the space race. The Robbins Committee was also cognisant of alternative ways of organising HE. Chapter Five of its Report considers the organisation and delivery of higher education in Europe, the USA and the USSR, and the role of specialist institutions in such nations – especially in relation to science and technology. It is moreover often forgotten that the Robbins Report recommended the establishment of five specialist institutions for scientific and technological education and research, comparable to the German *Fachhochschule*. Imperial College and two university colleges in Manchester and Glasgow (later UMIST and the University of Strathclyde) would, it was suggested, form three of the SISTERS; the other two, the Report proposed, would be

developed from one of the CATs and by creating a totally new institution as a fifth SISTER (Burgess and Pratt, 1970, pp.42-43).

Arguably, it would have been more logical to build all ten of the Colleges of Advanced Technology up into SISTERS rather than them becoming more generalist universities of varying repute. This would, however, have required policymakers to decouple two of the Robbins Committee's key recommendations from one another – the desire to increase general participation in HE and expanding the provision of science and technology. This would, however, have required a degree of forethought and rational planning which is often lost in messiness and complexities of the policymaking process (see, for example, Lindblom, 1965; Minogue, 1983). It is moreover fair to say that education ministers have, in the UK, always been more occupied with schools than higher education policy – and this was particularly so when HE was effectively a minority endeavour (Shattock, 2012, pp. 2-3). It is also important to recognise that the 1960s were a time of great expansion and renewal across the public sector more broadly, in terms, for example, of health, social services and the nationalised industries as well as education. Government priorities and calls upon the exchequer were therefore complex, multiple and extensive.

There have, of course, been other attempts to establish HEIs as alternatives to the universities in England and Wales, perhaps most notably the creation of the new polytechnics from the late-1960s onwards. But, the polytechnics always offered a wider range of subjects than the CATs and eventually their curriculum overlapped substantially with the universities, with which they suffered unfavourable comparison (Pratt, 1997). The proposed SISTERS would, in contrast, have been dedicated specifically to science and technology. Some creative thinking about nomenclature may also have helped. The Percy Report had suggested Royal Colleges of Technology over ten years before the CATs were designated (see MoE, 1945) and, whilst Royal endorsement may not appeal to everybody, it nevertheless carries prestige, especially in the Anglophone world. Continued specialism would probably have meant the CATs remained smaller institutions than the universities which superseded them but MIT has only

4,500 undergraduates (MIT, 2019) and Caltech under 1,000 (Caltech, 2019). The specialist nature of such institutions, however, means most of their students are postgraduates and much of their income comes from business, industry and the military.

The Robbins Committee was, perhaps correctly, concerned about the general status and standing of the CATs. The Colleges had, however, already secured independence when they were removed from LEA control and became 'direct-grant' institutions funded by the Ministry of Education in 1962. Such an arrangement would have allowed their further development – either as SISTERS or Royal Institutes of technology. Alternatively, they could, as many principals favoured, have been funded via a dedicated Technological Grants Committee operating alongside the UGC (Burgess and Pratt, 1970, p.44). It would, admittedly, have required a great deal of additional funding to enable the former Colleges of Advanced Technology to compete with the likes of MIT. It could, however, have been possible to maintain them as specialist institutions along the lines of the *Fachhochschule* within extant budgetary constraints. One way of resolving the conundrum of degree-awarding powers could have been through using the newly-formed Council for National Academic Awards – an organisation which eventually became the UK's largest degree-awarding body (Open University, 2019) – to validate qualifications.

Conclusion

The central argument of this paper is that the decision to recast the CATs as more generalist universities was a significant error which conflated a general desire to expand higher education with the drive to improve the provision of science and technology in particular. We should, however, also recognise that important mistakes were made when the Colleges of Advanced Technology were first established, not least the initial placement of most CATs under local authority control. Meanwhile, the fact that the Colleges had to rely on the universities in order to offer degrees was emblematic of their relative lack of prestige vis-à-vis the universities. Whilst the latter was largely due to the universities' wish to retain monopoly over

degree-awarding powers, it should have been possible to avoid the former given that Loughborough had already been removed from LEAs due to the operational and strategic constraints associated with municipal control. Yet such problems re-emerged soon after the CATs became universities when the new polytechnics were established under LEA control.

The polytechnics, like the CATs, effectively consisted of technical institutions 'promoted' from the ranks of FE (Pratt, 1997). They were also regarded as socially inferior to the universities, despite official discourses about parity of esteem (Robinson, 1995). In some ways, this is understandable. In England especially, vocational education has always been seen as second best to academic learning but the CATs were not generalist providers of vocational HE like the 'polys'. They focused on more prestigious forms of vocational learning drawing on singular and regional modes of knowledge rooted in mathematics and the natural sciences or amalgamations of such disciplines found, for example, in professional training for architecture, pharmacy and different branches of engineering (see Bernstein, 2000). Arguably, they were in a stronger position than the polytechnics to be developed as alternative providers of HE, separate and distinct from the universities.

In retrospect, the mistakes made when the CATs were established were elementary. The strategic error of recasting the Colleges of Advanced Technology as universities should, however, also have been avoidable. This would, on one hand, have entailed policymakers to step away from traditionally English conceptions of HE as a hierarchy of provision headed by the liberal university, and engaging more fully with competing conceptions of HE frequently associated with science and technology in continental Europe and the USA. Potentially, Robbins' proposed SISTERS could have provided a vehicle for developing the CATs as viable alternatives to the universities, although bringing such an initiative to fruition would have required substantial vision and resources. Such a strategy would, on one hand, have challenged some of the basic assumptions about the nature and purpose HE in England and Wales but also have required a more rational and objective approach to policymaking (see

Smith and May, 1980) detached from the 'complex interplay of context, ideologies, ministers and bureaucracies' (Kogan and Hanney, p. 235).

Fundamentally, the Robbins Committee saw creating more universities as the primary way of increasing participation in higher education. The idea of recasting the CATs as universities offering a broader range of subjects alongside courses of science and technology was central to this, although the Committee also recommended linking other HEIs, such as the colleges of education, more closely to the universities where it was not possible to convert them into universities – although many former colleges of education did eventually become universities after passing through various other incarnations (Simmons, 2017). Either way, the pattern of growth was not as expected. The UGC anticipated that two-thirds of the planned increase would be in science and technology yet most of the expansion took place in the arts and humanities. One reason for this being that many 'new' HE students were middle class and female – a demographic traditionally under-represented in science and technology (Willett, 2017).

A policy of 'expansion through specialisation' as exemplified in Clark Kerr's contemporaneous 'California Master Plan', would have provided an alternative strategy. Effectively, Kerr's initiative, which entailed allocating specific roles to different HEIs across the state of California, mitigated against the 'mission creep' which has long characterised English HE, but also guaranteed places at particular institutions for suitably-qualified applicants (Kerr, 2001). In England, such an approach would have entailed the state taking a much more 'hands-on' role in planning and co-ordinating HE. But, whilst this would have represented a significant break with tradition, it would, at least potentially, have allowed for an overall increase in participation *and* the promotion of science and technology in particular. The proposed SISTERS hinted at this, but a longstanding challenge to the expansion of advanced science and technology in England and Wales is that the narrow specialism of the A-level system means that, for many students, the possibility of pursuing science is effectively foreclosed at the age of sixteen

(Royal Academy of Engineering, 2016). A significant reworking of school-level examinations – perhaps through the adoption of a European-style baccalaureate – would therefore be necessary in order to allow more young people to engage with university-level science and technology. Then again, science teachers have always been in short supply and the quality of science and technology in both schools and FE has repeatedly been criticised as substandard (Orr, Hanley, Hepworth and Thompson, 2019). It is, more generally, also fair to say that science and technology has never been afforded the same level of respect in the UK as is the case in Germany and many other European nations (Royal Academy of Engineering, 2016). A commitment to specialist institutes of science and technology may have gone some way towards addressing such conundrums, although English attitudes to different forms of learning are, as has been described, deeply rooted in the peculiarities of its education system, history and culture more broadly (Winch and Hyland, 2007).

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