THE EVOLUTION OF COMPUTER SCIENCE TEACHING AND RESEARCH THE UK

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Scope

I intend to cover some developments in higher education during the period 1948 to 1970. The starting date of 1948 is easily explained, that is when we first started having electronic computers at all. My finishing date of 1970 is much more arbitrary. By then most universities and polytechnics had computer services of some kind. Some undergraduate degree courses were already in existence, there had in fact been some graduates from these. Further, in 1968 the British Computer Society had established professional grades, backed by an examination structure.

For some of the material I am drawing on personal experience, having worked in three universities over the period, when we were setting up courses. I have also had assistance from several friends, who were involved in similar activities.

Something about British university level courses

It may be helpful to give a little background to the environment in which we worked. In 1948, there was only 18 universities[1] in the UK, of which the largest was London, with some 20,000 students spread over several 'colleges' such as UCL, Imperial, King's, LSE, QMC, then Oxford and Cambridge with about 8,000 each, and the others mostly had fewer than 4,000. These figures include undergraduates and research students. In all, the number of university students was around 60,000, a number that was still somewhat swollen because of the number of ex-servicemen. Until about 1949 for most subjects about 95% of the places for undergraduates were reserved for ex-servicemen. All of this had settled down to a steady state, of slow expansion, by 1950. London had – and still does – an 'external degree' system, used by several smaller 'university colleges' elsewhere in the country and also in other parts of the world.

In addition there were 'technical colleges' in most parts of the country, covering a wide range of levels, ranging from technician training to very small numbers of external London degree courses.

In the early 1950s several of the university colleges became independent universities in their own right, giving their own degrees. For instance, Southampton became a university in 1952, with roughly 1,000 students: interestingly, it had an engineering faculty, as well as arts, science and law. This is relevant to the initial placing of computers, as described later.

In the early 1960s some of the larger technical colleges became 'Colleges of Advance Technology' ('CATs'), with the bulk of their work at degree level and a special body was set up, the Council for National Academic Awards ('CNAA'), so that these would no longer be tied to the London degrees. The CNAA exercised considerable power over

[1] Birmingham, Bristol, Cambridge, Durham, Leeds, Liverpool, London, Manchester, Oxford, Reading, Sheffield, Wales, Aberdeen – where there were 2, Edinburgh, Glasgow, St Andrews, Belfast.

standards, syllabuses and examinations. Universities were not subject to any similar controlling body, there was – and to some extent, still is - the belief 'that a university knows what is expected of it'. The British tradition of having 'external examiners' helps as a quality control system of sorts.

In 1963 the 'Robbins Report' discussed the future of universities in the UK and laid the foundation of a major expansion. In spite of misgivings in some quarters, expressed by the phrase 'more means worse', the expansion went ahead very rapidly. Several totally new universities were established, for instance Essex, Kent, Lancaster, Sussex and Warwick, and the CATs became 'technological universities' – although most dropped the 'technological' label fairly quickly, without necessarily having arts faculties. Being independent universities, giving their own degrees, they were no longer subject to CNAA supervision. Student numbers went up very rapidly to about 200,000, or even more by the end of the 1960s.

At the same time many of the technical colleges were re-styled as 'polytechnics', still under CNAA supervision. In the 1990s, well outside my period of 1948-1970, the polytechnics became independent universities, so that there are now about 100 universities in all. Student numbers are currently near 1 million, roughly one third of the age group 18 to 23.

The standard first degree course is 3 years (4 in Scotland but there students tend to leave school about a year earlier than in the rest of the UK), leading to a 'Bachelors' degree (BA, BSc[2]). Certain subjects have longer courses, for instance medicine, but this need not concern us. There is currently a move for first year courses, especially in science and engineering subjects, to be extended to 4 years. Polytechnics (and their successors) often had a 4 year course, as a 'sandwich', where the students would spend 1 year, usually the 3rd, in industry. It is worth remarking that this scheme is educationally very good and personally I have often felt it is a pity that it is not used by the 'traditional'. In addition, there are higher degrees, Masters (MSc or MA) and doctorates. Originally, all masters degrees were research degrees but in the 1960s several 'taught masters' degree courses were started, especially in computing, as so-called 'conversion' courses, for people who had a first degree in another subject. Initially they led to a 'diploma' but the name MSc was generally adopted. (This led to a research master's degree becoming an 'MPhil', again outside our terms of reference.) As well as conversion MSc courses there are also 'Advanced courses' for students who already have a first degree in the subject, also denoted by MSc (or MA).

It is also necessary to say a little about how British universities are financed, because this had an impact on the way computing became a university subject. Our universities are largely funded through a government body that is independent of the Ministry of Education – this is not the current name but it changes so frequently that it is difficult to keep up. But we all know what is meant. The university funding body has also changed its name frequently, originally (in the 1920s) it was the 'University Grants Committee' (UGC), which then became the 'University Funding Council' (UFC), more recently the 'Higher Education Funding Council for England' (HEFCE) with similar bodies for Scotland, Wales and Northern Ireland. For a long time the non-university sector was funded either by local authorities or (later) by the 'Polytechnic Funding Council' (PFC). On the whole, institutions receive a 'block grant' which does not specify too closely student numbers in particular subjects (apart from medicine), merely subject groupings, although there is much stricter control currently. The funding body, in all its manifestations tried to

[2] Confusingly, Oxford and Cambridge use BA for all subjects and their MA is awarded to graduates some years after they receive their BA, without any further work. There are reasons for this but we do not need to know them today.

avoid specific ‘ear-marked’ grants, although they were sometimes used to start an activity. There is no explicit ‘manpower planning’ at government level in this respect, although there may be ‘encouragement’ for certain subjects at certain times. The block grant system and the specific encouragement I have mentioned were very helpful in allowing universities to introduce new subjects and courses as they felt was necessary, so Computer Science benefitted. (As also did Molecular Biology, for instance.)

So, how did CS come into university course?

Initially, the only universities with computers were Manchester (whose first experimental machine worked in June 1948) and Cambridge (where the ‘EDSAC’ first worked in May 1949). Computing services of a limited kind were in operation by summer 1949, in both places. At that stage there certainly was no possibility of teaching anything to students, of any level. Programming courses, if they existed at all, were very limited in scope.

Even people who, with hindsight, should have known better were of the opinion that research in computing was not possible, a view that lasted for a surprisingly long time in some places. What was new was engineering, basically use of digital techniques, or numerical mathematics, and nobody doubted that such work could be regarded as research. There were research students working for doctorates at Manchester but these were all engaged on hardware design but also a small number who obtained an MSc for some very basic programming – such as designing subroutines for trigonometric functions (which could be disguised as numerical analysis). What we now regard as essential, such as theory of programming languages, software engineering, interfaces, data structures and the like just did not exist, not even as thoughts in some people’s minds. Alan Turing’s famous work on logic was just that, nobody thought of that as ‘computing’, certainly not ‘electronic computing’, in any recognisable sense. And yet in the late 1940s, when the Manchester group was building its first machine, Turing was in Manchester, working with them. (He had also worked at NPL on the design of ACE.) By the early 1950s things had changed slightly, and the original pioneers, for instance David Wheeler (1952) and Stanley Gill (1953), at Cambridge were able to get doctorates for work on programming design on EDSAC, with theses on control systems and debugging techniques.

The first, rather hesitant, steps towards including computing topics in courses for students were all at postgraduate level, usually leading to a diploma. The first properly organised such course, leading to a Postgraduate Diploma in Numerical Analysis and Automatic Computing, was started by the Mathematical Laboratory Cambridge, in 1953. The course lasted 1 academic year. It covered a great deal of numerical analysis, some programming in EDSAC machine code, a little on the operation of digital circuits. Interestingly, an extended practical project was included, starting a tradition that is an integral part of computer science course to this day. That would cover just about everything that was known at the time. That course – clearly with many changes in syllabus and outlook – is still in existence. That the Mathematical Laboratory was an independent unit was important, because there was no need to compete with existing departments for students or space in a syllabus.

At Manchester, computing – academically and initially as a service to the university – was part of the Electrical Engineering department. However, the final year electrical engineering and physics courses included lectures on Digital Electronics already in 1947/8 (before their first computer was actually working!). By 1954 this had become ‘Digital Techniques’ for 2nd year students and in 1955 a course on ‘Memory Systems’ had been added, with ‘Computer Architecture’ a year or so later. These, however, should really be classed as ‘Computer Engineering’ rather than Computer Science as we know it now. In

1959 a postgraduate course on Numerical Analysis and Computing was established, as a joint venture between Mathematics and Electrical Engineering, with content similar to that of the Cambridge course. By then, others were also offering such courses, as described below.

Northampton Polytechnic (not in Northampton as the name suggests but in London, at Northampton Square, and later to become City University) was the site of another diploma course, the diploma to be awarded by London University, which had no computing departments at the time[3]. Starting in 1956 this was a part-time course, spread over 2 years, with lectures being given mostly by staff from the National Physical Laboratory, who had also built a own machine, the 'pilot ACE' which subsequently was marketed by English Electric as 'DEUCE'[4]. Like the others, this covered mostly numerical methods and a certain amount of hardware (but no programming). I attended some of that course, with lectures on numerical work by J.H. Wilkinson and F.J.W. Olver, with E.A. Newman dealing with hardware.

In 1956/7 there was a dramatic change. The UGC provided funds for machines to be placed at a number of universities. These were (going from north to south):

Glasgow	English Electric DEUCE,
Durham[5]	Ferranti Pegasus,
Leeds	Ferranti Pegasus,
Manchester	Ferranti Mercury,
Oxford	Ferranti Mercury,
Cambridge	EDSAC 2 (home-made),
London	Ferranti Mercury,
Southampton	Ferranti Pegasus.[6]

The spread of universities involved was partly geographical but it is useful to note that all of them had an engineering faculty, although some others with engineering did not receive machines at the time. Other universities had to make arrangements to use facilities at one of these, starting a tradition of co-operation in computing which lasted for several years and led to a national committee of computing academics, still in active existence. Significantly, the new installations were to be called 'Computing Laboratories', which was to emphasise the practical nature of the subject. More, they all had a certain number of academic staff, at least 3, generally a senior lecturer in charge and 2 lecturers. The bigger units had slightly more staff, perhaps 3 or 4 in all. The establishment of these units with academic staff was intended to bring teaching, and research, into the universities. In some universities the new laboratories were independent from the start, elsewhere they were sub-departments of existing departments, generally Mathematics or Electrical Engineering. In practice, all behaved as totally independent groupings and before long they were so in fact.

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[3] Apart from a small scale effort at Birkbeck College, led by Andrew Booth who was also engaged in the construction of equipment.

[4] 'ACE' and 'DEUCE' were acronyms for 'Automatic Computing Engine' and 'Digital Electronic Universal Computing Engine', actually also a neat pun, as in tennis a 'deuce' is the second 'ace'.

[5] Actually in Newcastle upon Tyne, as Durham University was in 2 parts, which became separate universities in the early 1960s.

[6] Within 2 years there were DEUCEs at Liverpool and Belfast and a Pegasus at Sheffield, shared with the United Steel Company. Northampton Polytechnic managed to install a Pegasus and some other polytechnics began to give serious thoughts to how computers could be financed. Among the early ones were North Satffordshire and Leicester.

Apart from programming courses, initially in machine code but soon in a symbolic 'autocode', we all – except the unit in London which did not have access to undergraduates – started to introduce courses in numerical analysis with emphasis on how one could do real calculations on a machine, also 'smuggling' a little computing into those courses. And within two years we all had started postgraduate courses, based on the Cambridge model, but we were already able to include some material beyond numerical analysis and logical design of computers[7].

Although there was nothing like enough material for offering a complete degree course (which was a blessing in disguise) the degree structure of some universities was sufficiently flexible that one could introduce 'options', probably at final year level, to cover some genuine computing topics, even if only something about digital circuits and logical design. None of us in the academic world at that time knew anything about commercial work and the equipment we had was in any case far too limited any real work of this kind. In passing, however, it is worth noting that by 1960/1 the three universities with Pegasus machines had programs to help the university administration with the process of registration of students for courses at the beginning of the year, producing complete class lists, lists of students in university's residences, lists giving the local authorities paying fees and student grants, doing more in a week than the administration would be able to do in a term. So we did learn, and fairly quickly at that, even if the equipment was totally unsuited for the task

The other relevant event of 1957 was the foundation of the British Computer Society, which brought together many who were interested in the potential uses of the new machines. Universities were in a curious position in this regard, some of us had equipment and some knowledge of programming as well as technical applications[8], whereas local industry and commerce had equipment on order but no experience. Initially, therefore, the local branches of the BCS became self-help and self-education clubs. For instance, in Newcastle where I was at the time, our machine was the first one in an area of heavy industry and jointly we learnt a great deal about how to analyse problems, what we would now call 'systems analysis'. So, we were able to extend our offerings, by introducing material such as 'sorting and searching'. And often we were able to sell spare computer time to local industry, as well as giving technical programming advice, which gave all of us experience of a variety of problems, as well as buying small items of additional equipment, mostly data preparation kit and as well library books. In some universities the additional income was enough to pay for extra staff.

1960 onwards

By the early 1960s things had changed dramatically. In 1961 the UGC had a 'second round' of equipment, covering all universities. The existing installations were to be upgraded, typically with English KDF9 machines and Ferranti 'Atlas' installations at London and Manchester, with a modified 'Atlas 2' at Cambridge (but it was well over 2 years before any of these were actually delivered and started providing services), and small computers, such as Elliott 803 or IBM 1620 systems, were placed at other universities. Staffing was less generous than for the first machines in 1957. 'Computer Unit' often seemed to mean just that, a staff of one. Equally important, high level

[7] One of my colleagues of those early days recently remarked at a 40 year reunion that *all* of the original staff probably knew *all* the Computer Science there was to know.

[8] Many of the new staff had worked in engineering companies or the scientific civil service – we were still liable for military service and working in an occupation of national importance was accepted as a substitute. Many of us had worked with computers in government establishments.

languages were spreading, principally Algol and FORTRAN, so there was now some more material on compiler construction. This, in its turn, brought data structures and then operating systems. With these new topics we began to have enough to start courses that had 'computing' as a part of a degree title. Most universities had for years had joint courses, such as 'English with History', so there was nothing very new in starting courses with names like 'Mathematics with Computing'. Some universities began offering these around 1963, for instance Leeds had such a course (I remember that one, as I was an examiner for it!).

It is worth mentioning another 'culture change' of the early 1960s, when schemes like the 'School Mathematics Project' were started, with the aim of modernising what was taught in schools. This is not the place to discuss the successes and failures of such schemes but one consequence was making school teachers, and thus school pupils as well, aware of the possibilities of computers. It was several years before schools had computers in any numbers, it was only in the late 1980s when PCs became available at low cost, but the seeds were sown then.

And then, in 1964, North Staffordshire Polytechnic started a degree course in Computing, with Manchester University starting a similar course in 1965. The first graduates of these courses took their degrees in 1968[9]. After that, many others took the plunge. Interestingly, the new universities that were set up after the Robbins Report of 1963, mentioned above, were among the leaders in setting up Computer Science courses. As they had no established organisations there was little difficulty in fitting Computer Science into the university's structure from the beginning. Essex, Kent and Warwick were very successful pioneers in this respect.

At UCL I was able in 1968 to use the so-called course unit system to introduce optional courses for students in various disciplines. These were popular with students but we did not have a Computer Science department for some years to extend these. Other colleges in London were also rather slow to introduce undergraduate courses, the lead being taken by Imperial College, Queen Mary College and Royal Holloway College in 1968. The Institute of Computer Science, which is what London's original Computer Unit had become, had no undergraduates but ran a successful M.Sc. course, as did Birkbeck College (which caters largely for part-time, evening, students).

The Flowers Report

In the spring of 1966 the Labour government under Harold Wilson set up a committee, under Professor Brian Flowers, to look at the state of computing services in British universities. The committee worked remarkably quickly, reporting at the end of the year, with its report being published in January 1967. The principal recommendation was the injection of very large sums of money, over a period of 5 years, to provide up-to-date facilities for research, backed by a network of regional centres, equipped with 'super computers'. The rate of development of computer hardware has been such that the super computers of that time, such as CDC 6600, would be hard pressed to compute at the speed of some of today's PCs. The Flowers recommendations were for general computing services without specific mention of the needs of Computer Science departments. To the extent that they would need specialised equipment outside the main service this would have to come from the equipment grant that universities received through the UGC block grant or from research grants through the Science Research Council (typically to install a PDP9 or later a PDP45).

[9] North Staffordshire had a 4 year 'sandwich', whereas Manchester had the traditional 3 year course.

Although the new service machines were intended for general research work, all of us managed to bend the rules slightly to include student work. Compilers like the famous 'WATFOR' system, from the University of Waterloo in Canada, gave us the facility of handling student work cheaply and efficiently: at UCL about 60% of all jobs were run with this compiler, taking rather less than 5% of the machine's capacity[10]. It was, in fact, widely used by the research community as well because of its excellent debugging aids. For WATFOR jobs we could give batch turn-round measured in minutes, and there were several hundred per day. But these were not for Computer Science students, and they were not well catered for initially, as I have already mentioned[11].

A potentially far-sighted but totally underfunded exercise was launched by the UGC in 1970, to provide some computer teaching to all students, whatever their discipline. To give an idea of the funding that was made available, London University received £5,000 per annum to provide teaching for about 40,000 students – even if we are to discount the science and engineering students there were still over 20,000 to cater for. All we were able to do was to pay for the production of limited sets of lecture notes.

There had, of course, been some other interesting activities between the UGC's computer funding in 1961 and the Flowers Report recommendations in 1967. In 1964 an IBM 7090 (later expanded to a 7094) was placed at Imperial College, as part of the company's scheme for providing large facilities in major centres of scientific work.

All of the story so far has been about computing based in technical disciplines. Mention must be made, however, of the London School of Economics (LSE), which is another of London University's constituent colleges. It had a long history of statistical computing, going back to well before the electronic era, some of it using punched card machinery. Some of this computing naturally moved to the London computers, as they became available. In 1967 the National Computing Centre offered modest sums to LSE and to the Management Department at Imperial College to encourage the development of teaching and research in systems analysis. Imperial bought a small computer whereas LSE invested their money in staff, in particular by appointing Frank Land to head the enterprise.

Professional Grades in the BCS

In 1968 the society established a structure of professional grades, comparable to engineering, accountancy and law, backed by an examination system for these. Such professionals also have to subscribe to a code of conduct and a code of ethics, aimed to give public some assurance that proper work is done.

Appropriate university courses would give exemption from part or all of the examination. At that stage, of course, there were already several such courses in existence – the Manchester and North Staffordshire courses were about to produce their first graduates and many others had already started complete, 'Computer Science', courses, without attaching these to other subjects. Without exception they all included material on programming, data structures, system analysis and design, operating systems, algorithms, compilers, machine structure, storage systems, some mathematics and numerical methods, frequently some statistics as well. Some included theoretical work such as logic and Turing machines. Data bases, software engineering, complexity of algorithms, graphics, networks, communications, human-computer interface, modelling,

[10] At UCL we were able to add similar compilers for PL/1 and Algol to the service.

[11] The Flowers Committee also laid the foundations for the continuation of a proper funding mechanism for procurement of computing equipment, which endured for nearly 30 years.

performance measurements, artificial intelligence, expert systems, robotics, real-time control, legal and professional matters were all still in the future.

This grading system still exists and professional members of the Society now become ‘Chartered Engineers’, approved by the (national) Engineering Council.

Research

The foregoing has concentrated on undergraduate teaching, with some comments on the postgraduate courses that were introduced over the years.

There is a very active Computer Science research community. The original impetus, deriving from the initial efforts to build computers, was hardware driven. Only the original pair, Manchester and Cambridge, do any extensive work now on hardware, it is just not practicable any more for a university to engage in this. On the other hand, topics like programming paradigms, such as object oriented languages, software engineering, management information systems, communications and networking, robotics, graphics, multi-media, artificial intelligence, secure systems, expert systems, databases, HCI and theoretical studies are all well represented. There is also much cross-disciplinary work, for instance on cognitive sciences and expert systems for medical diagnosis to name but two. There is no longer any doubt that these are real research topics worthy of a university. All of these areas are well supported by research councils and through collaboration with industry.

And Now?

As I have indicated, the original courses were dominated by numerical analysis. In the 1990s very few of our students have any interest at all in numerical work and many even resent having to learn anything at all about how computers do arithmetic. Very little numerical analysis is taught, not even to mathematics students, and the common attitude seems to be that it has little to do with Computer Science[12]. Personally I find this a matter of regret.

Numbers taking undergraduate course have grown rapidly. Now, in the late 1990s, there are almost 100 universities that have courses called ‘Computer Science’ or ‘Computer Studies’, so it is taught as a degree subject level at almost all of the UK universities. This makes it one of the most widespread subjects in higher education in the country. The total number of students is now roughly the same as the total number of mathematics students. But all that is another story.

[12] Why are computer scientists so uninterested in why their machines have floating point arithmetic? After all, that is both difficult and expensive to implement – correctly! – when compared with other instructions.