Sixteen Years of Statistics at a Distance

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1.   The Open University

The United Kingdom's Open University was formally established in 1969 and admitted its first students in February 1971. It is unique amongst UK institutions of higher education in two ways. First, the vast majority of its students are taught by distance teaching methods. Most never even set foot on the university's campus during their studies, but study part-time, based in their own homes. Second, the university has no formal entrance requirements for undergraduates in terms of passing examinations. The only requirements for potential undergraduate students of the Open University are that they be aged over 18 and resident in the UK, or one of several European countries, at the start of their studies. Potential students who satisfy these criteria are admitted on a first-come, first-served principle. In 1988, 29% of the Open University's registered undergraduate students had no educational qualifications at GCE A-level when they entered the university, while many who did have A-levels would not have had sufficient to gain entry to many conventional courses (Open University, 1990a). However, the spread of qualifications on entry is very wide; of undergraduates registered in 1988, 9% already had a university degree (or the equivalent) on entry.

The Open University's first 21 years have generally been a period of success. In 1971, the first students were admitted to the undergraduate programme. New students are currently being admitted to that programme at the rate of about 18,000 per year. The number of registered students (undergraduates, postgraduates, and various non-degree students) in 1989 was about 97,000 (for these and further figures see Open University (1990a,b)). During this year, the university awarded 6,500 Bachelor's degrees and 487 higher degrees. For comparison, other UK institutions of higher education awarded a total of 124,700 first degrees in 1987-88, so that new Open University graduates account for about 5% of all new UK graduates each year. The Open University is by far the largest UK university in terms of undergraduate student numbers. The only UK university to produce more graduates each year than the Open University is London, with 8,700 first degrees and 4,900 higher degreees in 1988. Next down the list are Oxford, Cambridge, and Manchester, each with around 3,000 first degrees and 1,000 higher degrees in 1988.

Almost all the rest of this paper is concerned with courses within the university's undergraduate programme, so it is necessary to describe in a little more detail how this programme operates. New students entering the university must begin by taking a Foundation course in one of five broad areas (Arts, Social Science, Mathematics, Science, or Technology). These, like all other undergraduate courses, run once a year from February to October, during which time a student is expected to put in a nominal 440 hours study. In Open University terms, this amount of work is termed a full credit. After passing a Foundation course, a student can take one more such, or can move on to take courses at higher levels. Of these, the university as a whole runs 128, each prepared by a Course Team over a period running into years, and presented annually, largely unchanged, over a period of several years. There are courses at second and third level, and a few fourth level courses. Some are full credits (440 hours) and some are half credits (220 hours). There are very few constraints on a student's choice of courses. Once a student has accumulated a total of six credits, he or she is eligible for an ordinary BA degree. After this, students can go on to obtain a BA (Honours) degree by obtaining another two credits to make a total of eight, of which two must be at third or fourth level. Because of the lack of constraint on course choice, all students are awarded the BA degree. In fact, it is not possible to specialise in a single subject at the Open University to the extent that is usual in conventional UK universities. Thus, the Open University's BA (Honours) degree corresponds to the general honours degree that is available (though not commonly taken) at several other UK universities. In practice, the choice of courses of many students is considerably constrained by the fact that they wish their degree to be recognised by some external professional institution. These institutions specify programmes of study which a student must follow.

2. Statistics courses past and present

The Open University's first foundation course in mathematics, M100, included some material on probability and statistics. However, statistics teaching did not begin in full measure until the course MDT 241 *Statistics : An Interdisciplinary Approach* was first presented in 1974. Since then, the Mathematics Faculty has developed another five courses in statistics and probability, four of which are currently being presented to students.

MDT 241 Statistics : An Interdisciplinary Approach: This half-credit (220 hour), second-level course was presented in the undergraduate programme from 1974 to 1983. It was developed by a team drawn from the Faculties of Social Sciences and of Technology as well as Mathematics. Most of the first half of the course dealt with basic probability and probability distributions in a fairly formal way; the rest dealt more with statistical applications. MDT 241 was successful in attracting reasonably large student numbers throughout its life (see Figure 1). Its broad aim kept student numbers up and ensured that there was something in the course of relevance to almost anyone. However, the course was really trying to serve two fundamentally separate purposes, to provide an appropriate foundation for further study in theoretical and mathematical statistics, while also acting as a kind of service course. Neither audience was, therefore, served as well as it might have been.
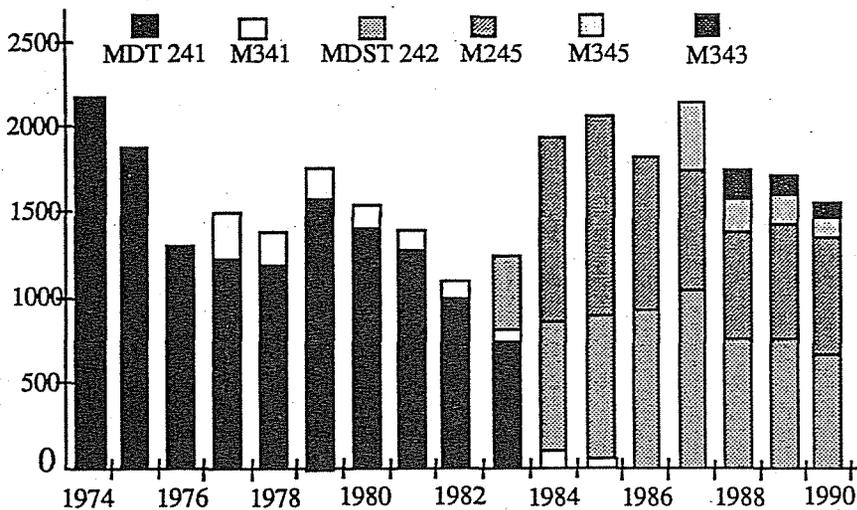
FIGURE 1
Numbers of registered undergraduate students on Open University
statistics courses, 1974-90[1]

M341 Fundamentals of Statistical Inference: The next statistics course to be presented was M341 *Fundamentals of Statistical Inference*, a half-credit third-level course which was presented from 1977 to 1985. The course dealt with univariate and multivariate distribution theory; the theory of inference discussed from both frequentist and Bayesian viewpoints; and the general linear model, including some material on experimental design. Overall, it has to be said that M341 was not a success. Student numbers were low. It regularly achieved the lowest pass rate of any undergraduate course. It was a fairly difficult course from a mathematical point of view, and yet it was taken by many students (particularly in its first few years) who were not principally interested or experienced in mathematics. However, in its later years, the course attracted a more appropriate audience, and the course materials were used in several other universities.

MDST 242 Statistics in Society: The next teaching project was to plan courses to replace MDT 241, and it was decided to separate out the two audiences referred to above, and prepare two courses instead of one at second level. The first of the two new second-level courses to appear was MDST 242 *Statistics in Society*, a half-credit course which appeared first in 1983 and is still being presented. This course was described in some detail in a paper given at the first ICOTS (Bibby, 1983). MDST 242 aims to provide an introduction to statistical thinking and practice for anyone interested in statistics, and is perhaps the nearest thing in the Open University system to a statistics service course. MDST 242 has been one of the Open University's most successful courses. It has been able to take many students who saw themselves as statistically and

mathematically illiterate to a reasonable level of understanding of statistical ideas, and a level of competence in basic statistical methods. Student numbers and pass rates have both been reasonably high. Two main criticisms have been levelled at it. First, that it is insufficiently demanding, and second, that it is not taken primarily by the students majoring in non-mathematical areas for whom it was mainly written. In fact, the students who pass it need to develop a level of competence similar to that in basic service courses elsewhere, while some imbalance is fairly inevitable, given the Open University's liberal system of course choice, and that no course has set MDST 242 as a formal prerequisite (though many recommend it informally). Plans are just being implemented to rewrite MDST 242.

M245 Probability and Statistics: The other new second-level half-credit course to appear in the 1980s was M245 *Probability and Statistics.* This course was first presented in 1984 and is still available. Its general aim was to provide an appropriate introduction to probability and statistics for students who had studied some mathematics, and it was intended both for students who would not study probability and statistics further, and for those who wanted a firm basis for further studies in the area. The course has a calculus prerequisite. The topics covered are fairly standard, though there is more material on simple random processes than might be found in similar courses elsewhere. The course makes relatively heavy use of simulation, television, and audio-cassette teaching, with the supporting written material being fully integrated into the main course texts (see below, and also Lunn and Saunders (1986)). The course generally succeeds in providing a good preparation for study at higher levels, but it teaches more, and harder, mathematical material than is really necessary as a foundation for the applied *statistics* (but not applied *probability*) taught at the Open University, and it takes a less applied standpoint than is ideal for most of its students who will study no more statistics. Currently, a new course team is working on a course to replace M245 that will be more data-based than M245 and will contain a major computing element, which M245 does not.

M345 Statistical Methods: This third-level, half-credit course in the standard methods of applied statistics first appeared in 1987 and is still being presented. Roughly one-quarter of the course is taken up with computer-based activities; the package used is MINITAB (see below for more details). The course has been generally well-received by students and staff, though student numbers have never been high and are currently not much more than 100, which is very small in Open University terms. One reason for the current low enrolment may be the switching of students from statistics to computer science; this point is discussed further below.

M343 Applications of Probability: The newest of the Statistics Department's courses is M343 *Applications of Probability,* which first appeared in 1988. Again, it is a third-level half-credit course, and its topic is "the application of probability to modelling real-life situations". The course seems to be fairly unusual in the context of UK universities in that it provides a solid introduction to a wide range of areas where probability models are useful without going into the mathematical detail that is usual in such courses. Generally, the course appears to have succeeded in its aims; however, as with M345, student numbers have been disappointingly low.

Other courses: Most of the undergraduates in the university who are taught some statistics are *not* students on the courses described above, but on courses run from elsewhere in the university. The liberal system of course choice in the Open University

encourages course teams in areas like psychology or biology, where the students need to know some statistics, to write the necessary material into the courses within their area rather than expecting their students to study a course like, say, MDST 242. In some cases, the resulting statistical material is excellent. In others, it is not so good.

3.   Teaching media

It has been a feature of Open University courses since the university opened that nearly every course is presented in more than one teaching medium. The principle behind this is that no one medium is appropriate for the presentation of all types of topic. Within resource constraints and constraints imposed by university policies, the aim is to present each piece of course material in the most appropriate medium. A wide range of media has been used in the Statistics Department's courses, as described below.

Specially prepared texts: The primary teaching medium for all the courses described above, and most other Open University courses, is a series of specially prepared texts. Generally speaking, text is the default medium for teaching. It is flexible. It does not require students to become familiar with new technologies of any sort. It is far cheaper to prepare than, say, video material. The material can easily be accessed in any order, or annotated by the user. It is easily portable. On all the courses described above, the specially-written texts provide the backbone to a student's study of the course. Open University course texts resemble traditional textbooks only up to a point. Standard textbooks are basically there to *support* a course which is being presented primarily in lectures or classes, whereas distance teaching texts need to run the whole learning process. They need to provide a more structured set of activities for the student than is commonplace in normal textbooks; it is crucial that students do not simply read through them. Distance teaching texts need to anticipate and answer all the main questions that conventional students might ask of their instructor. They should give solutions, with all the working shown, for problems and exercises that appear.

Given the advantages, described above, of specially-prepared texts, one may well ask why other media are used. The answer is, of course, that there are some things that other media do better, as will be seen.

Existing books: The Open University's original statistics course MDT 241 was based round two standard textbooks. The supporting text material consisted of introductory passages, extra exercises and solutions, material covering topics not taught in the two textbooks, and so on. It is an appealing idea to build a course around a good textbook. Much of the teaching material has already been tried and tested, so that a course can be created more quickly. However, no other statistics course (and very few other courses in the Mathematics Faculty) has followed this route since MDT 241. This is because there are many important disadvantages of using existing texts, as follows. First and foremost, distance teaching texts need to differ from standard textbooks in important ways, as described in the last section. Although the extra teaching apparatus can be added in, as was done for parts of MDT 241, the resulting hybrid can be very unwieldy and difficult to use. Second, it is often impossible to find a single textbook that covers an appropriate syllabus at an appropriate level. Third, the extra teaching apparatus will need to make specific page references to the text. If the textbook goes into a new edition, or goes out of print, obvious problems will arise. For these reasons,

the only outside set book used on statistics courses written since 1974 has been a book of tables (Neave, 1981).

Radio and audio-cassettes: In the Open University's early days, most courses included several radio programmes, which were broadcast on the national networks of the British Broadcasting Corporation (BBC). MDT 241 and M341 both started life with radio broadcasts, which generally dealt with matters which would benefit from the fact that radio is less formal than print. There was supporting written material. There was evidence that many students found the radio broadcasts useful, and they made a valuable change of pace in their studies. However, no current statistics course (and very few Open University courses of any kind) use broadcast radio nowadays. The reason is that there exists another medium, the audio-cassette, which can do practically everything radio can do, and more besides. Audio-cassettes are cheap to make and to distribute. But their main virtue compared to radio is that students can stop them to consider a point that has been made, or replay them any number of times to listen to a point again. It is possible to design teaching materials based on audio-cassettes which use throughout the possibility of asking students to stop the tape and carry out some activity. In many mathematics courses, including three of the current statistics courses, audio-cassettes are used to drive study sessions which use specially-prepared written material appearing in a sequence of "frames" with boxes for students to fill in, or perhaps diagrams to complete. The idea is that the student is "talked through" a problem, or a tricky technical idea. Every now and then, the presenter speaking on the tape asks the student to turn off the tape, do some work on the problem, perhaps check some answers in another frame, and then turn the tape on again. In a typical session of this sort, the running time of the tape might be 10 or 15 minutes, but the student may spend up to an hour or more working on it. It is generally felt that these audio-tape sessions are successful in helping students work through problems and exercises, and in reinforcing difficult ideas that have previously been introduced in straight text. In text, it is difficult to be informal. On tape, one can speak less formally and more heuristically. In a recent course in numerical analysis audio-cassettes were used to talk students through practical computing exercises.

Audio-tape does have its disadvantages. It may be inconvenient for a student to use his or her cassette player at the time when the course expects it to be used. Students may resent being talked carefully through a problem if they find it easy anyway.

In a quite different way, the cassettes for the statistics course M345 are used to provide a series of interviews with statisticians working in various application areas. The aim is to make students aware of the range of application of statistics, and of the career opportunities in the discipline. However, most Open University students interested in these matters are, because of their experience, fairly knowledgeable about them already, and many see these tapes as a waste of time. The tapes have, though, been marketed outside the university with some success.

Television and video-cassettes: Since its inception, one of the Open University's most prominent features has been the use of broadcast television for teaching. The television programmes are produced by the BBC in collaboration with other members of the course team. They are broadcast on the two national channels of BBC television, outside peak hours, and are the main public showcase of the university. However, Open University students learn very early in their careers that on most courses television plays only a limited role in the teaching. Television is expensive to make. (A single

25-minute programme, the standard length for most Open University courses, costs around £60,000 to make on average, at 1990 prices.) It is also time-consuming to make from the point of view of the course team. It dates quickly. An eight-year-old piece of text can look as fresh as when it was written, but an eight-year-old television programme will look ten years old at least. The evidence is that students will not watch television programmes unless they see them as directly relevant to their other studies.

It is thus vitally important to use television only for those topics to which it is well suited. In statistics courses, effective uses of television have been in three broad areas. First, television can show statisticians at work "in real life". Second, television can show moving pictures made by conventional or computer-based animation techniques. Such animations, perhaps based on simulation, can often get over basic statistical notions much more effectively than pages of printed pictures or words. Considerable, and effective, use of such animations was made in the television programmes for M245 (Lunn and Saunders, 1982, 1986). Third, television can show a statistician working through a piece of algebraic manipulation. This sounds appallingly dull, but in practice (if it is used sparingly in a programme that includes plenty of material of other types) it can be very effective.

Most high-population Open University courses have television broadcasts. MDST 242 has eight 25-minute programmes, and M245 has sixteen, one for each teaching unit. Neither of the two third-level statistics courses has any. When the courses were being prepared, the usefulness of television in the context of these low-population courses was not felt to justify the necessary resource. M343 does, however, have a video-cassette which is mailed to students. The cassette consists entirely of material of the second type referred to above, that is, computer animations. Video-cassettes have most of the advantages over broadcast television that audio-cassettes have over broadcast radio. However, they are significantly more expensive than audio-cassettes to reproduce and distribute. At the Open University it is calculated that it is cheaper for courses with more than about 400 students per year to distribute their video material by broadcasting it than by sending out cassettes.

Computing: It is in the area of computing that the constraints of the Open University's distance teaching have been most apparent. Nobody does applied statistics without a computer nowadays; but a large proportion of Open University students do not have access to a suitable machine at present. Until 1988, there were three ways that Open University students could carry out practical work on a computer. On the majority of courses involving computing, they would do their computing on a remote terminal at a so-called "study centre", usually in a college or polytechnic relatively near their home. The terminals were linked through a network to the Open University's mainframe computers. On some courses students could mail in their input in handwritten form to the central campus, where it would be run as a batch job, and the results would then be mailed back. Finally, on a few courses students would be lent a microcomputer, owned by the university, while they were studying the course. None of these arrangements was very satisfactory. Many students found it difficult to get access to a study centre. Capacity constraints on the network and on the mainframe machines meant that some courses using this system had to limit student numbers. The postal batch system was obviously no good for computing activities involving any interaction. The third alternative of lending out machines was too expensive for the university except on certain specialised computing courses, subject to quotas on student enrolment.

Both MDT 241 and M345 operated under the arrangements just described. In the case of MDT 241, the problems were not too important as computer use was minimal. The course teams for MDST 242 and M245 chose not to use computing, partly because of the unsatisfactory arrangements. However, this was not an option for a course in applied statistics like M345. Of sixteen study units on that course, four are largely based around computing activities. While studying each of these units, students were expected to make one or, in some cases, two visits to a study centre terminal, to carry out specified pieces of data analysis using MINITAB (Ryan et al., 1985). Because terminal visits are not easy for students, the course team had to "save up" computing exercises until there were enough to justify a visit. Clearly these arrangements are far from ideal.

In fact, M345 was one of the last courses to be prepared under these systems. While it was being written, the university changed its policies to allow certain courses to be presented on the basis that students had the use of a microcomputer satisfying a given specification (currently an MS-DOS machine with 512K memory and a single floppy drive). This change of policy is still controversial, mainly because it substantially increases costs to students. However, eventually M345 will be rewritten as a home computing course.

A wider problem for statistics courses arising from the introduction of the Home Computing Policy is that the quotas on computer science courses have been removed. As a result, student numbers on computing courses have increased dramatically, and, since the total number of undergraduates in the university is limited by government policy, the numbers on statistics courses have fallen quite substantially from their pre-1988 levels.

Face-to-face teaching and residential schools: An important feature of the Open University's distance education system is that almost all courses involve an element of non-distance, face-to-face, teaching. Each student is allocated a course tutor who marks the student's assignments (see below), is available to give advice by post and (usually) by telephone, and who gives face-to-face tutorials. The tutors are mostly employed part-time by the Open University; the majority of them have full-time jobs in other educational institutions. Tutorial groups are set up on a geographical basis. On half-credit courses like the statistics courses, there will normally be about eight to ten hours of tutorial time in the course of the year. This is obviously a tiny proportion of the time a student spends on the course, but a great number of students find the face-to-face tutorials very valuable. A somewhat lesser, but still substantial, number of students never attend.

Assessment of students: Open University undergraduate students are given a grade for each of their courses on the basis of performance on two components, a conventional three-hour examination at the end of the course, and a series of assignments carried out during the course forming an element of continuous assessment. These two components count equally towards the student's grade. Assignments come in two types. Tutor-marked assignments are pieces of work sent to the student's tutor, who grades the work and comments on it before returning it to the student. The commenting by the tutor is in many respects more important than the grading. It is often the only real personal feedback that a student receives. All the statistics courses described above have, or had, four tutor-marked assignments. In addition, the second-level courses each have four or five computer-marked assignments. These are basically sets of multiple-choice

questions which the students answer by making pencil marks on a special form which is read by an optical mark reader and graded by computer. The student receives a feedback letter indicating which questions he or she got wrong, but this feedback is rather crude and not always helpful.

4.   Conclusion

In this paper I have tried to indicate how decisions have been and are made in the Open University's Statistics Department on choice of teaching media and, with the benefit of hindsight, how some decisions were made on course content. I have tried to explain as far as I can how these decisions are influenced by institutional structures within the Open University, and in particular by the fact that it aims to be *open*[2] to all comers as well as being a distance teaching institution. At the Open University we have developed a system that generally works; but it is far from being the *only* system that would work. In institutions that operate according to other constraints, our methods could well be inappropriate.

Disclaimer

The opinions presented here are those of the author alone, and do not necessarily bear any relationship to policies of the Open University, of its Mathematics Faculty, or of its Statistics Department.

Footnotes

1.   In addition to registered undergraduate students, anyone can register for these courses on a one-off basis. These so-called "associate students" vary in numbers from year to year; in 1989 there were in all 202 associate students in total on the Statistics Department's four courses.

2.   It is important to note that teaching in the Open University's undergraduate programme is *not* generally Open Learning in the sense usually meant; that is, materials are *not* specifically designed or adaptable to fit individual students' needs, and individual courses are studied at a pace dictated by the university and not chosen by the student.

References

Note: In addition to the References listed below, texts to all the courses referred to are published by and available from the Open University Press.

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