SECTION TWO

Distance Learning and Electronic Media in Teaching Astronomy

Distance education in astronomy: at-a-distance and on-campus, a growing force

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1. *Introduction*

Distance education has a track record in astronomy and is already making a significant contribution worldwide. It will make an even greater contribution in the future, not only at-a-distance, but through greater use of self-study materials on- campus, where it will liberate staff for more appropriate forms of face-to-face teaching, and help overcome the need to do more and more with less and less resource. Distance education offers huge promise in meeting the educational needs of a burgeoning world population, and because low costs can be achieved there is no need for people in areas of material deprivation to face mental deprivation also. The IAU and The Open University can be proactive in promoting the spread of distance education, and of self-study on campus.

2. What is (successful) distance education?

Distance education is NOT as shown in Figure 1, though its distinctive feature is that the student is remote from the university or college! But in place of a megaphone a mixture of media is used in which printed texts usually carry the bulk of the educational material. There can also be audiovisual and computing media (including use of the Internet and of "multimedia"), and practical work. It is important to play to the strengths of the various media - a current pitfall is that multimedia can turn out to be little more than an expensive book.

It is unusual to find already-published textbooks that are suitable for the distance learner. Common shortcomings are

- inconsistent assumptions about the previous knowledge and skills of the student
- insufficient student activity such as "stop-and-think"questions, and opportunities for self testing
- too much content, leading to the need to omit material that is be essential for the study of later, included topics.

On campus these are less problematical because of the support readily available from teachers, peers, and an academic library. For the distance learner these shortcomings are severe, and therefore specially written texts usually have to be produced.

Though support is less readily available for the distance learner, the student should NOT be unsupported or there will be large drop-out or failure rates. Effective means of support include

- study guides
- a tutor for remote contact (by phone or computer), to mark and comment on assignments, and perhaps to offer a small amount of face-to-face contact
- self help student groups (via phone or computer or by meeting)
- pacing, in which assignment deadlines play a prominent role
- perhaps a residential school (for extra tutorials and supervised practical work as opposed to unsupervised practical work that can be carried out at home)
- perhaps a counsellor for general guidance and advice.

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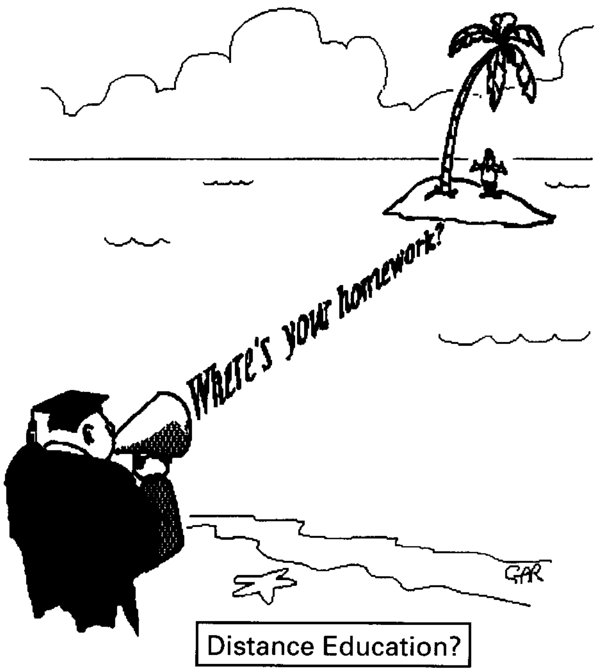

FIGURE 1. This is NOT distance education!

With a modest level of support, and high quality educational materials, over 70% of students will be successful.

To achieve such a high success rate organised feedback from the students is essential, and the institution must be prepared to improve its materials in the light of the feedback.

2.1. *Advantages and disadvantages of distance education*

Though distance education has the disadvantages of a lower level of support, less contact with teachers and peers, and only a small amount of supervised practical work, it does have several advantages, of which a major one is that it reaches people who are unable or unwilling to travel to a campus. Such people include those with job or family commitments. This advantage is reinforced because distance education facilitates study at a time and at a rate that suits the student. A related advantage is that students can support their education without having to find work close to campus. This also enables students to gain work experience alongside their degree, thus improving their career prospects. Full time work is not essential: the cost to the student can be low if the course population is high, and even lower if expensive media are avoided. Related to this is that the cost per student to the institution can also be low.

A different type of advantage is that a small number of astronomers gifted in teaching can prepare materials that reach a huge number of students. Given the widespread interest in astronomy and the small size of the professional astronomical community, particularly in certain countries, this is another important advantage. Local, part-time tutors need not be astronomers and yet can provide excellent student support if the educational materials are well thought out and the tutors properly briefed.

Distance education is complementary to on-campus education.

3. The world scene in distance education in astronomy

There are at least 837 institutions around the world offering distance education. Of the 837, there are 625 universities or colleges, and the great majority of these operate mainly or wholly at tertiary level. Not all of the 625 list their courses in enough detail to tell if astronomy is included, but of those that do, astronomy features in about 40% of them. Applying this fraction to the 625, we obtain a rough estimate of 250 educational institutions world wide offering astronomy courses at university or college level.

The mean number of students per course can only be an educated guess. For a subject as popular as astronomy my guess is several hundred, which gives an order of 100 000 students studying astronomy world wide at-a-distance at university or college level. This includes students that are taking individual courses rather than a complete degree programme. For those in degree programmes, astronomy is typically a component of the degree, frequently a significant component.

Though the 100 000 figure has an accuracy somewhere between that of Hubble's constant and the amount of missing mass, it is clear that distance education is already a force in astronomy.

Lets have a look at the biggest distance teaching institutions, the so-called "mega-universities".

3.1. *The "mega-universities"in distance education*

A "mega-university"in distance education is defined as one that has at least 100 000 students in distance education *degree* programmes. In most cases there are comparable or even larger numbers of students on diploma or masters programmes or taking individual courses. Moreover mega-universities tend to be national institutions, and as such can have a powerful influence on the shape of a country's higher education.

It so happens that all of the mega-universities are devoted almost entirely to distance education. Table 1 includes all ten of them and lists some of their features (Daniel, 1995). Note that three continents are represented, Europe (four of the ten counting Turkey as Europe) , Africa (one), and Asia (five). These huge universities have economies of scale, and as a result the unit cost (expressed as a percentage of the average cost per student for other universities in the country) can be low. In general, the higher cost mega-universities are those where the level of student support is also high.

At least four of the ten have astronomy courses The Open University (UK), The University of South Africa, CNED (France), and UNED (Spain), the courses of the first three being described in these proceedings. The Indira Gandhi National Open University is to introduce astronomy, though Anadolu University, STOU, and the Korea National Open University has no plans to do so. I have no information yet on the other two.

There are several universities that are just below the mega-criterion, but as distance education is growing and institutions are increasing in size, there is no doubt that the number of mega-universities will at least double by the turn of the century. Let's look more closely at astronomy at of one of the mega-universities - The Open University in the UK.

Table 1. The mega-universities (as at the end of 1995).

INSTITUTION (Alphabetical order)	Degree students	Grad'tes per year	Annual budget/ 10^6\$US	% of budget[1] stud't fees	gov't grant	Unit cost/%
China China TV University System	530 000	100 000	??	5	95	40
France Centre National d'Enseignment à Distance	105 000	??	113	65	35	50
India Indira Gandhi National Open University	242 000	8 000	10	30	68	35
Indoneisa Universitas Terbuka	353 000	3 000	2.5	66	34	15
Korea Korea National Open University	196 000	10 000	48	62	38	10
South Africa University of South Africa	130 000	10 000	128	39	60	50
Spain Universidad Nacional de Educación a distance	110 000	1 500	??	60	40	40
Thailand Sukhotai thamm -athirat Open University	300 000	13 000	32	49	23	30
Turkey Anadolu University	567 000	14 000	15	76	6	10
United Kingdom The Open University	150 000	17 000	300	31	60	50

[1] There can be other sources of income other than the two quoted.

4. Astronomy at The Open University

Figure 2 shows the course materials of the main Open University (OU) astronomy course "S281 Astronomy and planetary science". In addition there are all the features of the student support system outlined in Section 1 with the exception of residential schools. There is one tutor per 20 students and an active computer-based self-help group based on the First Class software (see the posters in these proceedings). We also send out a list of astronomy Web pages and astronomy software. However, none of the course materials is computer based, because when this course was being designed in 1992-1994 we were unwilling to place the financial burden on each student of the purchase of computer hardware for S281: computer activities are thus optional. Home-based computing is now

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FIGURE 2. The materials for The Open University's main astronomy course, "S281 Astronomy and planetary science".

appearing in several OU courses that S281 students would also be likely to take, and so the hardware cost is spread over several courses. Therefore, when S281 is revised it is probable that we will build in CD-ROM activities.

S281 is the equivalent of two-thirds of a term of full time study (half a semester), and so represents a substantial piece of a three year degree. Like all Open University courses, in addition to assignments marked by the tutor, there is a three hour examination at the end of the course, taken under the usual controlled conditions.

The course is aimed at the equivalent of first year science, maths, or technology students at a conventional university and is therefore somewhat above the level of many of the "liberal-arts"courses in the USA. However, in being aimed at science, maths or technology students it is of broad appeal and accessibility. It is certainly capable of adaptation to the needs of a wide variety of institutions.

An indication of its accessibility is that it assumes zero previous knowledge of astronomy, it uses simple algebra but no calculus, and it assumes a level of physics no more than that acquired by many 16 year old school students.

Table 2 lists some of the characteristics of the 1200 or so undergraduates who take S281 each year a remarkable number for a science-based course, particularly as there are a further 200 students per year not taking it as part of a degree course. About 70% of the students starting the courses obtain passes. Of the 30% who do not, most of them drop out of the course early on: it is a feature of some OU students that they take on one more course than they can handle and then drop the one that, for a wide variety of reasons, is least suited to their immediate needs.

Table 2. Some characteristics of the 1200 undergraduates per year on the OU astronomy course S281 Astronomy and planetary science.

STUDENT BACKGROUND	
(on entry to OU)	
less than the minimum entry qualifications to conventional UK universities	27%
(on entry to the course)	
previously read astronomy, from occasional articles upwards	91%
regularly take more than a passing glance at the sky	65%
regularly watch science fiction at the cinema/on video/on TV	55%
regularly read science fiction novels	39%
have made quantitative celestial observations	9%
have been active members of amateur astronomical societies	5%

PARTICULAR INTERESTS		AGE & SEX OF STUDENTS	
the origin of the Universe	47%	under 30	20%
observing the night sky	29%	30-34	20%
the Solar System	22%	35-39	18%
extraterrestrial life	20%	40-44	15%
history of astronomy	13%	45-49	11%
UFOs	3%	over 49	16%
astrology	2%	female	26%

STUDENT ASPIRATIONS	
to enrich their interest in astronomy	73%
to get a job in astronomy or space science	8%
to introduce astronomy examples into their teaching	7%
to go on to postgraduate study in astronomy	6%
to get promotion in a job in astronomy or space science	< 0.5%

More than 70% of the students starting the course give very positive feedback on it, and the course scores well on various in-house quality ratings.

Among the data in Table 2 note that 6% of S281 students intend to go on to postgraduate study of astronomy: this is about 70 students per year, a considerable fraction of the UK total of postgraduate students in astronomy. S281 was first presented in 1994 so it will not be long before this cohort starts knocking on the door of postgraduate study in astronomy at the OU and elsewhere. It is also remarkable that 8% intend to get a job in astronomy or space science - a substantial change in career in most cases.

Another datum worth highlighting is the 20% of the students under 30. Among these there is an increasing number of students in the age-range 18-21. This is the age at which most students are educated on-campus rather than at-a-distance. The increasing number is testimony to the effect of the decline in the UK of maintenance grants and the worsening job prospects for graduates with little work experience. On the positive side it is testimony to the growing realisation of the effectiveness and advantages of distance education.

The results of a survey of a few aspects of the astronomical knowledge of S281 students is given by Broughton (1996). It is important to note that this survey was made BEFORE the students studied S281.

FIGURE 3. Making observations to determine the difference in length between the sidereal day and the mean solar day.

4.1. *Practical work in astronomy at-a-distance: how much can be achieved?*

I noted in subsection 2.1 that only a small amount of *supervised* practical work is feasible at-a-distance. This is because of the huge expense of supervising students spread all over the country. For supervised practical work a residential school is best but this is a rather expensive course component and therefore only a small amount of student time is spent at such schools. It is therefore fortunate that a considerable amount can be achieved through *un*supervised practical work.

In S281 about 10% of the student time is spent on unsupervised practical work. All of this is achieved with a planisphere being the only item that we send (in addition to a project book and project sheets). Binoculars or a telescope are not essential for the two key projects. Even though these projects are very specific a considerable range of general practical skills are developed, largely because we insist on quantitative analysis of the key projects and a project write up that is marked and commented upon by the student's tutor.

The first of the two key projects is the measurement of the difference in length between the sidereal day and the mean solar day. The measurement procedure is only outlined by us, the details being left to the student. The procedure is hard to distinguish from loitering against a wall, as Figure 3 shows! The student measures the mean solar time at which a star passes behind some obstruction (such as the chimney in Figure 3) and repeats the procedure on several dates over a period of a few weeks. A graph is plotted, with error bars, of disappearance time versus date, and from the gradient of the best fit straight line the difference in length between the two types of day is obtained, along with the observational uncertainty. Extremely accurate values are obtained by many students. They also learn by experience that the night sky is not the same at a given hour of mean solar time on different dates.

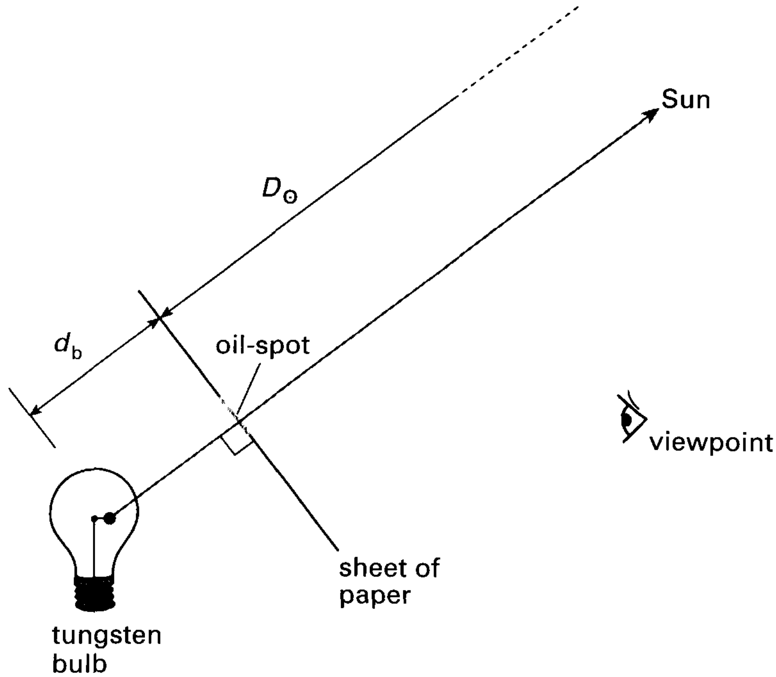

FIGURE 4. Measuring the solar luminosity.

I developed the second of the two key projects from outlines given by others (e.g. Percy 1995). In it, the student improvises what, in essence, is a Bunsen grease spot photometer to measure the luminosity of the Sun. The procedure is outlined in Figure 4. The distance of the electric bulb filament from the oil spot on the sheet of paper is adjusted until the oil spot (illuminated from behind the paper by the bulb) looks to the eye as bright as the surrounding paper (illuminated by the Sun). The luminosity of the Sun can then be calculated from the distances of the Sun and the filament from the paper and the luminosity of the filament. There are many corrections that the student has to estimate to get a more accurate value, the largest coming from the eye being sensitive to a greater fraction of the solar spectrum than the filament spectrum.

Values within a factor of two are obtained (remarkable!) and the students are guided to attach a large uncertainty to the value. The usefulness of this experiment is not so much the value of the solar luminosity obtained, as the general skills of measurement and project write-up that it develops.

There are four other projects, all of which are also carried out successfully in unsupervised mode.

In and around Orion, in which the student, with the aid of a planisphere, familiarises themself with objects in the constellation Orion, and, with home improvised equipment, measures the angular separation of Betelgeuse and Rigel, including an estimate of the measurement uncertainty. Binoculars are needed for some parts of this project.

Limiting visual stellar magnitudes, in which the student estimates the limiting visual magnitude of stars at various zenith angles under various seeing conditions.

Sunspots, and solar rotation, in which the student observes sunspots by projection and uses them to make qualitative observations about solar rotation.

The Moon, in which the student makes binocular observations of the Moon at various phases, comparing and contrasting maria and highlands, and observing crater morphologies and rays.

4.2. *Other aspects of astronomy education at the OU*

There are several other OU courses in which astronomy plays a significant role. The foundation course in science, with over 4000 students per year and equivalent to a whole semester of full time study, describes the Earth's place in the Galaxy and has a major case study, based on popular science articles, on the search for extraterrestrial life. It also has a substantial piece on the large scale structure of the Universe, supported by a "virtual telescope"on CD-ROM (Norton, 1996).

We also have a higher degree programme in astronomy, exclusively by research. There is a conventional aspect to this, with students working full time on campus, but there is also a distance aspect, with students working full or part time but at their normal place of work or at home. In this external programme we have graduates of a variety of universities, not just The Open University.

The external programme in astronomy has proved viable for various reasons. Among them are the following three. First, none-too-modest "amateur"equipment is available to support research on topics such as variable stars, asteroids, and the search for extraterrestrial intelligence at optical wavelengths (OSETI) (Jones, 1995). Second, there are library and computer based data archives, the latter including data from the Hubble Space Telescope, the InfraRed Astronomy Satellite, the International Ultraviolet Explorer, the 100"Hooker Telescope. Third, there are now robotic telescopes with public access (Baruch, 1996).

The possibilities of obtaining a PhD at-a-distance are improving all the time.

5. Expansion of distance education and the use of self study materials on campus

There is growth in the number of institutions largely or wholly devoted to distance education. There is also growth in the size of existing institutions, and it has already been noted that the number of mega-universities will at least double by the turn of the century.

Another important aspect of growth is in the distance education activities of *conventional* institutions. There is enormous potential here, but there are enormous pitfalls too. *Successful* distance education requires

- high quality materials appropriate for the distance learner
- a measure of student support as outlined in Section 2.

The Open University has also seen its materials adopted by other universities in the UK and abroad for self-study *on-campus*. This enables universities to meet the pressures to do more and more with less and less resource. Also, by reducing the need for lecturing it liberates academic staff for more appropriate types of face-to- face teaching such as tutorials and problem classes. The "golden rule"is that you do not leave the students alone with a book: books and other materials must be suitable for self-study, and there must be support in the form of tutorials, problem classes etc. Our experience with self-study on-campus has revealed that

- nearly all on-campus students are comfortable with the use of self-study materials
- self-study is a useful skill for students to develop
- face-to-face contact can be reduced by 20% and yet the quality of education is better

• the flexible study pattern is popular, with its liberation from the lock-step of the lecture course.

The Open University has long provided a consultancy service to other institutions, and this is now being expanded under the name Open University Worldwide. OU Worldwide is coordinating and promoting a variety of existing activity strands, including

• collaborative partnerships with other institutions

• direct teaching of students beyond the UK

• materials sales, including versioned materials and materials specially prepared for other institutions

• provision of a distance education system, a "railroad".

In the particular case of astronomy, considerable benefit would be obtained were the IAU and the OU to act together to promote distance education in astronomy, and also to promote the spread of self study on-campus.

6. Summary

Table 3 is a (whimsical) summary of the main features of distance education.

Table 3. Features of distance education.

Distance education	
• must be Open	O
• is best on a Big scale	B
• it is Affordable	A
• must build on the students' Foundation	F
• it is Growing	G
• must have courses of high Kwality	K
• must make effective use of the various Media	M
• is part of a growing worldwide Revolution in education	R
• is relatively New	N
• must provide Supported self-learning	S

In addition, distance education materials have enormous potential to support self-study on-campus. The IAU and the OU can together help promote distance education and self-study.

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