DOCUMENT RESUME

ED 047 488 EM 008 614

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TITLE The Teaching of Science to Students at a Distance.
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PUB DATE 70
NOTE 10p.; Paper presented at Annual Conference of the American Association for the Advancement of Science (Chicago, Illinois, December 27-30, 1970)

EDRS PRICE EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS Adult Education, Audiovisual Centers, Correspondence Study, Educational Radio, Educational Resources, Higher Education, Instructional Media, Instructional Systems, *Instructional Television, Mass Media, *Multimedia Instruction, Open Circuit Television, Science Curriculum, *Science Education, Science Experiments, Scientists, Social Responsibility, Summer Schools, Summer Science Programs, *Telecourses, Tutorial Programs, *Universities
IDENTIFIERS BBC, British Broadcasting Corporation, Great Britain, *Open University of Great Britain

ABSTRACT

The University of Great Britain will soon open, with an enrollment of 25,000 students. Within three years, 40,000 undergraduate students are expected. The instructional system of the Open University is unique: it employs a multimedia approach and stresses the interdisciplinary nature of the foundation courses. Weekly radio programs and open-circuit television programs will give support to the course work. Part-time class tutors will give regular tutorials at 250 local study centres scattered throughout the country. The Open University was established for social, political, and economic reasons: to give a second chance to adults who were eliminated by the highly selective secondary system in Great Britain. This chance can be given more economically through the Open University than through a conventional British university. The implications of teaching at a distance depends on the country in which it is happening. In developing countries it may afford a short-cut to a higher education; in the United States, where educational opportunities are more liberally provided, it may represent an alternative to be taken by those who prefer it. (MF)

THE TEACHING OF SCIENCE TO STUDENTS AT A DISTANCE.

Our Chairman, Professor Ravin, has suggested that scientists are reconsidering their roles as teachers. More than that, scientists are reconsidering their general role in society.

These introspections are going on in many institutions in many countries, but nowhere more so than at the Open University of Great Britain.

At the Open University, such introspection is essential. Teaching roles have to be reconsidered because a unique instructional system is being used, in which the conventional academic has little place. Scientists' general roles must be examined on account of the large numbers of students likely to be taught and influenced by the system, which, at a stroke, will greatly increase the university population in the country taking science courses.

The instructional system is unique. Not only does it employ a wide range of media that impose their own disciplines on Open University academics. It also incorporates aspects of course content and design that are novel, from the inter-disciplinary nature of the foundation courses to the complex integration of home study, face-to-face tuition and broadcasts.

The numbers to be reached are great. The University begins in a few days time to teach 25,000 undergraduates, after a two-year planning period, and is likely to be up to 40,000 within three years. The limit is likely to be set more by available finances from Government and other sources than demand. The system will become increasingly cost-effective, of course, as numbers climb. Ten thousand students taking science courses in 1973 is a conservative estimate. In the United States this would not be a particularly large number. In Great Britain it certainly is. Open University scientists have to be keenly aware of what they are teaching, as their influence is to be considerable.

The Instructional System.

As background, more should be said about the instructional

system of the Open University before considering some of the pressing questions about teaching science to students at a distance.

First, the system is designed for adult students, persons over 21, who have not gained or seized the opportunity on leaving high school of going to university. For the January, 1971, intake the modal age is likely to be 27, and almost all will be in full-time employment. Many of them will not have studied for fifteen or twenty years.

Second, the system employs several media, carefully combined. At the core of the courses are the packages mailed regularly to students. They contain written course materials that have been through lengthy development and testing, plus a wide variety of self-instructional and assessment items. The best parallel in the United States would be the products of the curriculum reform projects of the 1960's, so far as layout might be concerned. Of course, the content is at a different level, and more up-to-date.

Unlike the curriculum project products, however, the Open University materials are supported by open-circuit (BBC) television and radio programmes at weekly intervals. The content of these programmes is controlled by the academics of the University; in fact, all the programmes are presented by them too. The production is in the hands of the BBC, and that Corporation is also responsible for the transmissions, which cover most of the British Isles.

Further support is offered through face-to-face contact. Students meet part-time class tutors in regular tutorials at 250 local study centres scattered throughout the country, and in residential summer schools employing conventional university plant during vacation time. In the case of science and technology courses, home experiment kits are mailed to students too.

Third, the system has an elaborate network of "fail-safe" strategies to correct errors in the instruction soon after these are discovered, to improve the standard of instruction year by year, and to help students to stay in the system when they are having difficulties in keeping up.

Much more could be said about these and other aspects, but there are three main questions that should be answered in this paper:

Why teach science to university students at a distance?

How can it be done and what are the problems?

What are the implications of teaching science at a distance?

Why teach science at a distance?

The fundamental reasons for the establishment of the Open University were social and political. Changes in educational provision are usually made for such reasons.

Perhaps not in quite the same way as in the United States, lack of educational opportunity has been severe in Britain for many years. The situation has begun to improve only very recently.

For decades, a selective secondary school system has eliminated almost everybody's chances of university education. Roughly 75% of the primary school population has been graduating into high schools that did not prepare students for the nationally-organised university entrance examinations. The remaining 25% was decimated before taking the examination, and less than 5% of the class of 1940, let us say, gained the right to enter a university in Britain. The combination of high entry standards and a selective school system gave few people the chance to try their hand in the university sphere.

Today, although the situation has improved so that more gain the entrance qualification, there are not enough places within the universities, and the Government does not wish to build enough new institutions to provide the extra places. By 1975 the situation will be quite serious, with up to 50% of those qualified unable to get in.

At present, however, science in the universities presents a slightly different picture. Many of the institutions could take more science students, as the fact is that not enough of the children taking the entrance examinations are on the science side, and not all of those who qualify for entrance do

actually go on to a university. The emotional mood has turned against science, and is running strongly in the direction of the social sciences and, to a lesser extent, the humanities.

The picture is one of strong demand for university education, but signs of aversion away from science. The Open University could help to meet the demand, and perhaps change the anti-science mood. But the demand that the Open University has been set up to meet is not from the 18-year-old high school graduate, but from the man or woman who wants a second chance, who was probably cheated by the school system.

The applications for admission to the Open University indicate a strong desire for a second chance. In science, for example, of the 7,000 applicants to whom places have been offered for 1971, 17% have already obtained some qualification as engineers or scientists since leaving high school. Leaving high school does not mean graduating with university entrance qualifications. The 17% now wish to go further and obtain a degree. Of the 7,000, 25% are teachers wanting to upgrade and update their qualifications through the inservice education that the Open University offers. Another 17% fall in the categories of draughtsmen, laboratory assistants or technicians. Only 6% are housewives.

For most of these people, learning science at a distance is the only way, at university level. Unlike in the United States, in Britain most students are full-time non-earners. The universities are geared to such full-time people. Part-time courses for credit are comparatively rare.

Another reason for establishing the Open University may be an economic one. Without doubt, the cost to the country of one graduate through the Open University will be far below the cost of one graduate through a conventional British university. Even taking into account the higher dropout rate that the Open University can expect, the cash cost will be one-third to one-half of that in the conventional setting. The cost to the economy will also be far less, of course, as few British undergraduates earn normal salaries while studying.

Many of the economies are, in fact, those of scale. As an example, the McArthur microscope, produced specially for the

Open University, has been reduced in price to the student by a factor of at least ten, and for Open University students is actually loaned as part of the home experiment kit.

How can it be done and what are the problems?

The traditional image of science teaching in a university includes professors in white lab. coats and vast arrays of apparatus in which the undergraduate is lost for a good many hours a week. How can science be taught to students at a distance? What has the Open University done to destroy the old image and what does the new image look like?

Some facets of the instructional system of the Open University have been described already. But now the science foundation course, due to be taught in 1971 for the first time, must be examined in particular.

Since the Open University's white coated professors are teaching in public in every sense of the phrase, the correspondence units have to be examples of good pedagogical design. Within the units there can be few secrets, if any, kept from the students about what is expected of them as learners. Right at the start of the unit, the students are told what scientific terms, concepts and principles are used in the unit. They can also see which are developed in later units. Next, a conceptual diagram portrays for them the main concepts to be taught through the unit. Then a set of unmistakeable signposts appear, in the form of a list of learning objectives. The students may refer back to these after going through the unit, of course, to check upon their learning.

Throughout the main text of the unit there are frequent questions. Students can use these as additional checkpoints.

In Unit 1, as in many later units, the students are asked to conduct experiments using items from the home experiment kit. For this unit, Galileo's inclined plan experiment is replicated and students complete exercises relating to it.

As might be expected, a book list is also given, showing both required and recommended reading.

To provide for students not sure about some aspects of

probability, or some other matter related to but not central to the main text, extra remedial sections have been prepared. For those who wish to know more, perhaps about underlying theory or mathematical proofs, there are extra enrichment sections.

A glossary is added to complete the exposition.

The unit is not considered to be a proper teaching tool until the self-assessment questions, with their accompanying answers and comments, have been worked out too. They are printed along with the main text.

For yet further help, the students are directed when appropriate to two books written specially for them, Mathematics for the Foundation Course in Science and The Handling of Experimental Data.

To test the students' learning, there are 32 objective, multiple-choice tests which are marked by the University computer. These are returned by the students at the rate of about two a month during the academic year, which runs from early January to early November. Many of the questions test various levels of recall or memory, but some have been specially designed that test students' powers to analyse and synthesise.

Students will also be asked to send to the University a total of 9 written assignments, which the University will send to part-time tutors on its payroll. The tutors will score the scripts and write comments on them to help the students, who will get their assignments back. The students' laboratory notebooks are among the assignments.

The television programmes for science have been designed with three specific criteria in mind. First, that they should be used wherever there is a need (as in Galileo's experiment) to portray motion visually. Neither text nor radio is adequate to demonstrate rotational kinetic energy, for example.

Second, the programmes are used to replace some of the "missing" laboratory experience. This is done not simply by demonstrating to students what they would have done for themselves in a conventional university, but rather by getting the students as viewers to participate, perhaps by taking readings for use in exercises, or by noting the behaviour of animals.

Third, the students' experience can be widened greatly, vicariously, by using the television camera to show places and apparatus that undergraduates would not normally have access to, such as CERN near Geneva.

Thus the television programmes in science are integral parts of the course, not merely enriching ancillaries. They are essential to the students' understanding.

The radio programmes have other roles. For one, they are excellent vehicles for remedial action. In production terms, they have short run-in periods of preparation, and are much less expensive than television programmes. They can be used at short notice to correct errors, help students over patches of instruction that they have found difficult (as reflected through the assignments, the class tutorials, or through computer-marked tests), and to knit together apparently disparate portions of the course. Radio is a good medium too for discussions between famous scientists, and a number of these discussions have been included.

Once the Open University science student has benefitted from all the learning resources already mentioned, he can still attend classes twice a month at his local study centre. If he is having difficulty getting used to studying again - after perhaps 20 years away from the game - he has access to a counsellor also. (He is assigned to the same counsellor for most of his degree, but class tutors will change as the subject-matter changes through the courses).

Lest any should think that Open University students lack actual laboratory experience in which they can learn to manipulate apparatus that is more complex than that supplied in the home experiment kits, the summer schools must also be mentioned. These are 7-day residential courses, held in conventional universities. For science students, they will be devoted to laboratory work.

What are the problems of teaching science to students at a distance? There may not be very many for the foundation course. Naturally, there will be shakedown problems, but it seems reasonable to expect that the course will be operating quite efficiently within a year or two. In that time, the Science Faculty may have found that too much is being asked of

students in some parts of the course and perhaps not enough in others. Adjustments will be made, and the Faculty is prepared for that.

The problems become more pressing when students "graduate" from the Foundation Course to second, third and fourth level courses. The economies of numbers are reduced as students specialise. Provision of class tutoring and laboratory equipment in particular, become difficult. Home experiment kits can get too complex and expensive. On the other hand, co-operative arrangements with other universities, industrial concerns and the like may be feasible if only a handful of students are concerned in any one part of the country.

These and similar problems are now being worked on by the second level course teams. Between them, they hope to offer science students a wider range of choice than in many British universities, through a modular system of quarter, half credits.

What are the implications?

Finally, what are the implications of teaching science to university students at a distance? From one point of view, it depends on the country in which it is happening. In the developing countries, the Open University system can bring higher education in science where there was none. The new Institute of Technology in a certain city in West Africa has recently purchased enough components of the system to be able to provide, instantly as it were, a science course in 1971. That Institute was unable to secure staff in time, lacked adequate laboratories and had students waiting to take the course. For the cost of three or four professors for one year, the Institute has placed a foundation course in science among its offerings.

In Great Britain, thousands of students will launch on science degrees. Most of them could not or would not have done so had the Open University not come into being.

In the United States, where educational opportunities are more liberally provided, the Open University system may become an alternative, to be taken up by some who prefer to study that way. A degree in science may become more easily accessible for

those who are culturally disadvantaged, since the Open University system is specifically designed for those who lack normal university entrance qualifications.

Of course, once transplanted the system may be modified (and perhaps improved) to suit better the local circumstances. But the experiment is a bold one, without doubt, and has other implications too that bring us full circle to the question of the role of the scientist in society.

The Open University's science courses must show a sense of social responsibility. Too many people are being influenced for the matter to be otherwise. The social responsibilities of scientists must be taught along with the science. In the Foundation Course this marriage has been brought about in a variety of ways. One or two examples will be enough.

First, the students will join together in a nationwide study of air pollution. Each student will measure regularly the amount of sulphur dioxide and other gases in the atmosphere in his neighbourhood, using a colorimeter. The readings will be sent to the University and processed by computer. The resulting "pollution" map will become the subject of one of the television programmes, giving the students the satisfaction of seeing science at work on a problem with many social implications.

Second, the students will examine how decisions are made for the setting up of large science projects. They will examine, for instance, the British decision not to participate in the funding of the 1968 European 300 Gev accelerator project. Each student will receive a "decision-making kit" containing material from Government reports, Parliamentary statements, and points of view for and against. From these materials they will be asked to select the factors for use when deciding whether or not to participate in the funding of a project.

In summary, the Faculty of Science at the Open University is taking its social responsibilities very seriously.

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In the time available, it has not been possible to go into great detail. (Nor am I able to answer many questions myself about course content). But enough has been said to show

there are eminently good reasons for teaching science to university students at a distance, that there are good chances of the Open University system being able to take on the task, and that it is being done in a socially responsible manner.

Prepared by David G. Hawkridge, Professor of Applied Educational Sciences and Director of the Institute of Educational Technology at the Open University, for the Annual Conference of the American Association for the Advancement of Science, Chicago, December 27th-30th, 1970. The help of Professor Michael Pentz of the Faculty of Science at the Open University is gratefully acknowledged.