# Distance Education Programme in Chemistry for Developing Countries

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## Introduction

In retrospect, the single distinguishing feature of education in the last decade of the 20th century has been the huge increase in student numbers (Rao, 1996: 196). The opening up, access to school education and the expectation of higher education by an ever-increasing student market are the important features to be reckoned with the world over. The proportionate increase in resources to meet the demand, however, has not appeared. Educators and teachers have rapidly realised that the traditional methods of teaching and learning cannot cope with the changing profile and increasing size of the student body (Swamy, 2002: 15)

A parallel movement has come from employers and a general move in the expectation in students that higher education should provide a basis for successful employment. No longer would the 'knowledge' gained in higher education be adequate for a changing employment environment. Students must develop the means to learn and be able to apply learning skills throughout their working lives (Lewis, 1988, 89-103). The need for higher education to foster an ethos of independent learning has never been higher. One could argue that this need has always been catered for (at least to some extent) in undergraduate courses. However, chemistry has not been near the vanguard of such a movement. Teacher/student contact hours have always been high in chemistry (many lectures, tutorials and practical classes), an approach predicated by the belief that there are lots of facts and skills, that have to be compiled before any significant contribution can be made by the student.

As the traditional mode of teaching chemistry prevailed in most of the universities only a few could get benefits of higher education. Limitations in the laboratory facilities determined how many students could be admitted to this stream of education. Strict control over the admission to science faculties forced many students to keep themselves away from the benefits of acquiring chemical knowledge. Even for those who had the fortune to study the subjects formally the opportunities for updating their knowledge base and to get acquainted with recent developments are rarely available. All these aspects bring out the need for an open learning approach for chemical education.

## Distinguishing Features of Distance Education

Distance teaching has been practised in some sense or the other for a long time. Many institutions were running correspondence courses early this century. However, the importance and the potential of this method were fully realised only a few

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decades ago. This realisation has led to the establishment of institutions devoted to developing material for distance learning. The Open University in England is one such premier organisation (McKenzie, et al., 1975: 321-359). Many developing countries then went on to establishing similar institutions. They are trying to fulfil the growing demand of the ever-increasing number of learners. Some experiences in the preparation, disbursal and evaluation of distance learning material are now accumulated. Based on these experiences it would be useful to enumerate the distinguishing features of Distance Education (DE).

There is a qualitative difference between the distance mode of education and the traditional mode of education. The distance mode by its very nature lacks the benefits of face-to-face interaction between the teacher and the learner. Because of the absence of discussion between the learner and the teacher there is no possibility for the student to get the doubts clarified or to get the immediate feedback on his/her performance. Guidance has its own importance in learning. To fulfill this legitimate demand a mechanism needs to be developed to provide appropriate guidance to the learners. A variety of methods are being practised. Tutors are usually appointed to cater to the needs of local students. They keep contacts with the learners on a regular basis through telephone or through regular follow-up meetings. In some cases, where the internet facility is easily available two-way communication between the learners and teachers are maintained. Of course, mechanism to provide feedback to the learners will have to be worked out taking into account the technological developments of the region. The postal correspondence could also play an important role if the telephone link or the internet facility is not adequately developed.

Distance Education system is virtually open to all (Manwaring, 1990: 842-851). The only essential criterion to get enrolled into this education system is the desire to learn. There are no formal entry requirements based on educational qualifications. Hence, students span a large age range and come from all walks of life. Student population in this system is quite heterogeneous. Because of the diversity in their backgrounds students' requirements and expectations are also different. The curriculum for distance education, therefore, has to take into account these diversities among the learners. Material developed for formal education might not at all time be suitable for the distant learners.

The skill of independent learning is at the centre when one thinks of distance education. This skill is not easy to acquire and it takes time to develop. It is of little value transcribing lecture notes, adding a reference text and throwing this at the incoming undergraduate student. Materials for independent learning have to be designed and structured in a way that maximises the students' opportunity for success, although many of the factors that are important here are just as important in the design of more conventional learning programmes too. By its very nature, a distance education institution has to operate in a culture of independent learning (Mackenzie, et al, 1975: 87-91).

Motivation on the part of the learner is an essential ingredient of distance education. One can safely assume that since students come forward for learning on their own they must have some level of motivation (Dembo, 1977: 334-335). Nevertheless, it is important that their motivation is not thwarted for lack of appropriate stimulants. The

methods and material adopted in distance learning must provide adequate inputs to sustain the interest of learners. The choice of topic and the presentation of material, therefore, play a crucial role. It is observed that common people have a large number of questions in their minds regarding new material and new uses of old material (Agarkar, 2000). The learners would certainly welcome the information that satisfies some of their questions in these areas. Similarly, information about a variety of chemical processes that the learners encounter in their everyday lives would probably be welcome by a majority by learners. It has been observed that interesting anecdotes describing the situation that led to the discovery of a new material is often helpful in creating interest among the readers to know more about the material. Similarly, showing the relevance of information to solve the problems of the technological society helps maintain their interest.

## Special Features of Chemistry Teaching

Chemistry teaching is expected to serve four different objectives. Firstly, it should provide information about various chemicals and chemical processes. Secondly it should build a strong conceptual base. Thirdly, it should inculcate laboratory and problem solving skills. Finally, it should aim at creating social awareness among the learners. The material that is prepared, therefore, should aim at fulfilling all the four objectives. None of these alone would serve the purpose. It is the judicious combination of information, concepts, skills and awareness that would make the learner chemically literate. Let us now see how these objectives can be met.

Informative chemistry has long dominated chemistry textbooks and classroom interactions. It has, however, been realised that a mere presentation of information about various chemicals and processes one after the other does not interest the learners. In fact, this style of presentation often leads to creating nausea towards the subject. Information should, therefore, be presented in a manner that would attract the attention of a learner. A variety of methods have so far been tried. Some textbooks attempt to provide illustrations wherever possible. A few multimedia manufacturers have arrived at a format of presenting the information by a cartoon teacher. Experiences from these attempts need to be pulled together and research needs to be conducted to find out the best ways of presenting informative chemistry for a distant learner.

Conceptual chemistry requires an ability of abstract thinking on the part of the learner (Herron, 1996,105-118). In the absence of such a faculty and the lack of a teacher to guide at every stage, the distant learner would not be able to appreciate pattern incorporated in the theoretical formulation. The material and the guidelines should take this aspect into consideration. Attempts need to be made to bring out the abstraction very clearly in the material itself. If required appropriate illustrations and examples must be provided to clarify the nature of abstraction. A supporting material might serve the purpose of developing necessary learning skills.

Schools and colleges in the traditional mode of education attach high importance to laboratory work in chemistry education. The need for highly equipped laboratory is often put forward by many for the effective learning of chemistry. In the distance

mode of education one must look into the role of laboratory critically. There are basically two questions that are to be addressed. What part of the laboratory work that is being prescribed in the traditional education is essential? How to provide opportunities for the essential lab work? Such a critical review would hopefully lead to the development of a core lab programme using easily available materials. Efforts are being made at variety of levels to design low cost experiments. Some of these experiments could be adapted. In some cases new experiments will have to be designed and field-tested. Such a work, although essential for distance education, would eventually feed into the traditional education also.

The fourth objective of social awareness mentioned above needs some elaboration. The society is nowadays becoming material oriented. In order to fulfil the rising demands new materials are being made and supplied. The implication of the material race on society, economics and environment is not fully understood yet. These implications might lead to problems that people will have to tackle in the near future. Possible repercussions of growing chemical industry all over the world must be brought out for the benefit of the learner.

Chemistry is not seen to be dynamic or alive. It is probably because chemistry education demands learning of lots of facts and abstract ideas then reproduce them in examinations. A comparison with the study of literature is informative. In literature, there is an opportunity for opinion and discussion from the beginning. Hence, skills of argument and interpretation are rapidly developed. To get to this stage in chemistry takes years and it is not until the end of an undergraduate programme that the black and white image of the subject begins to recede. It is certainly a long time to wait to have intellectual fun.

There is a common feeling that chemistry is difficult. There is a lot to learn and it is not just chemistry. Mathematical skills can play a significant part and one needs a familiarity with a new language of terms, models and symbolism. We assume all of these (often without giving the student time to develop these skills) and expect the appropriate skills to be brought into play when the learning focus is on a new chemical area. There is ample evidence to suggest that the apparent inability of some students to perform well is not due to their inability to deal with a particular concept or idea but because they have been deflected by having to handle too many other things at the same time. A student who has failed to grasp the precise way in which we represent atoms and molecules is almost immediately in trouble. Is it reasonable for us to assume that all beginning students see S as a sulphur atom, N as a nitrogen atom but SN as a molecule and Sn an atom of a different element, tin? $S_2$ represents two sulphur bonded together but 2S is two separate sulphur atoms. There is also a problem to realise if we are talking about atoms and molecules or moles? We give no indication and there is the not insignificant factor of $6 * 10^{23}$ involved.

The image of chemistry is not good. Whilst the subject will inevitably be pilloried by the press for environmental problems such as the ozone hole, global warming, and industrial pollution, we do very little to help ourselves. How often do we counteract the pejorative images with emphasis on drug design, smart materials, non-polluting fuels and ways of improving the environment? These perceptions of chemistry

proved to be invaluable in balancing the content of and moderating the approach of the chemistry learning.

Associated with any technical presentation there is an issue of technical term (Herron, 1996: 161-182). In the formal mode of education one gets students who are exposed to technical jargon in their previous education and are in a position to cope with the technical language. The curriculum is also arranged in such a way that a child climbs a step at every stage of education. In the open or distance mode of education we cannot assume the previous capability of linguistic ability especially ability to decode technical terms. This fact makes it necessary that the material written should make use of minimum technical terms and if necessary, clarification a term or a phrase used should be given. In the audio or in the audio-visual presentation it is essential that the material be presented in a language palatable to common audience. This demands skill and clear understanding of the subject on the part of the presenters. He/she cannot hide behind the technical jargon. Every step needs to be explained clearly and logical discontinuities avoided.

## The Starting Point

The two vital features of the design of a learning programme are the starting point and the finishing point: what do the students know and what can they do at the beginning of the programme and what do they know and what can they do at the end of the programme. There is perhaps an analogy here with thermodynamics where 'success' is judged only by the starting and the finishing points. As teachers we additionally have a responsibility of the route, as the choice of route can be an important factor in reaching the destination for some students.

The first step is to turn our attention to potential students. These people are the consumers but what do we really know about them? What are their needs and requirements? Answers to these questions are to be found before one embarks upon developing suitable material. The main reason for profiling the student body is to try to design the material so that it takes into account the range of their backgrounds (Sahoo, 1993: 71-96). Students have different learning styles. Some learn better from simply reading material, others through working on tasks and assignments, and others through peer group interaction (either directly or by remote communication). Additionally, students bring 'baggage' with them that affects the way they learn. Learning is an active process and students' past experiences will affect the way they construct their knowledge. Profiling (perhaps via diagnostic tests) helps define the skills and the knowledge of the student body that can be assumed as the entry behaviour. Any shortcomings can be pinpointed and individual students can be directed to bridging or preparatory material ahead of time.

Often the independent student is a mature person who is trying to fit studies into a busy programme that may include work and family commitments. So, motivation to study may be tempered by other demands on the students' time. Perhaps more importantly, the independent student tends to study in relative isolation with a limited peer group contact and this can lead to a sense of isolation. What can independent learning material do to address these problems?

Through its design it should

- Inspire and motivate the students (possibly through conceptualisation),
- Build confidence by letting the students assess themselves just how much they really know,
- Be student-friendly and interactive,
- Be sympathetic to the cultural, social and economic backgrounds of students.

## The Destination

There are essentially two ways of approaching the design of a new course or module. The first is to decide what should be in the course, what topics should be included. This is a common approach and is often predicated what a following module 'needs' by way of student preparation. The great danger here is one of information overload.

Teachers of chemistry are outstandingly successful at introducing students to new ideas, to new research and to new information. In the span of a few years, an area can go from being at the forefront of research to featuring in every chemistry undergraduate syllabus. The identification of the Buckminster fullerenes is an obvious example. However, we are rather poor at removing old material. Our expectation of the capacity of students to absorb ever-increasing quantities of information is greatly misplaced. An indication is in the brief comparison of two classic inorganic chemistry texts: *Advanced inorganic chemistry* by Cotton and Wilkinson (1988) and *Textbook of Inorganic Chemistry* by Partington (1943). The former exceeds the latter in number of pages (by a factor of 1.40), in total page area (2.36), in index entry (2.46) and even in mass (2.05).

An alternative approach is to initially ignore content. Ask what the student should be able to *do* at the end of the module, focus on outcomes and, more specifically, on objectives. There is a fashion in all branches of learning, and education theory is no exception. In the 1970s, the behavioural objective represented a buzz term and no self-respecting teaching document would appear without a comprehensive list of objectives. As the decade progressed, there was a change of thinking (Dembo, 1977: 255-294). The behavioural objective was seen to be unnecessarily restrictive in that, in isolation, it appeared to limit creativity and the development of those skills that are not easily defined and quantified. Courses appearing with a set of general aims, although useful, did not identify the outcomes of the course with much precision. Since then, there have been changes in terminology and for some time 'goals and outcomes' is an expression that has enjoyed popularity. In distance education, the behavioural objective has, and continues to have, a major importance. It is an aid both to the student and to the teacher.

Objectives can assist teachers in the design of a course, deciding on the contents, sequencing the contents, selecting the teaching media, designing learning activities, developing assessment material and evaluating the course. Similarly, objectives can assist learners in deciding whether a course suits their needs, knowing what will be demanded of them, focusing on key areas of teaching, planning of study time,

checking developing competence, measuring progress and reviewing work on the programme

So, how do we begin designing objectives? One useful approach is to ask series of questions that you would want students to be able to answer by the end of their study of the module. For a different module, it would be equally valid to ask questions that were intrinsic to the study of chemistry as a discipline. However, it is essential to keep an emphasis on outcomes rather than content in the selection of questions.

Over the last decade, many face-to-face and distance learning institutions have moved towards modular programmes. The need for well-defined objectives that accurately delineate competencies is paramount for a student who is attempting to assemble a programme of learning. However, these objectives are also essential for teachers who increasingly work in teams to produce a module. For example, two teachers may agree that one outcome of a course is that the student should 'know how to use graphs'. There is a big difference between the plotting of data to give a straight line and interpreting a three-dimensional probability function based on polar co-ordinates. Exactly what is it that the student should be able to do? Members of a team must be clear about what each of them understands by a particular competency. A defined behavioural objective is an effective way of achieving this goal. There should, in general, be qualifications in objectives that help to confine scope. It is best to avoid terms such as 'know, understand, be familiar with, have a good grasp of, appreciate, believe', which give little direction. Better terms are 'state, explain, evaluate, outline, compare, apply and assess'.

It is when questions have been devised and objectives defined that the content of the module becomes apparent. Certainly, there is a level of iteration required between content and objectives but in this (second) approach; content is not the driver. At this stage, it is worth looking at the skills that we wish students to develop. The important feature is that skills cannot be developed in a quantified way; they are developed progressively through the module. Each skill can be broken down into components and tests devised for each of them. An example of a chemical skill is the representation of molecules. Again to ensure that the student is not overburdened, different representations are introduced progressively. The basic idea of the 'Lego' brick is quite adequate right at the beginning of an introductory course and this can be followed by the 'ball and stick', the symbol and stick', the 'contraction' (such as $CH_3CH_2CO_2H$), the 'skeletal' and the 'three dimensional flying wedge' styles. There is no need to have a separate section of the module on molecular representation. A new form can be introduced to run briefly alongside an existing form, which is subsequently phased out.

## The Approach

Having defined the 'challenge' and having taken a look at outcomes and objectives we can start on the process of design, *achieving* the outcomes. In some respects a module for independent learning is not very different from a conventional face-to-face module. However, it is even more critical that the independent learning module enjoys good design as the delivery method necessarily implies that there is limited

opportunity for amendment and for student's query. To this end, there is a strong argument for using a team approach rather than assigning the responsibility to an individual. It may seem that this is extravagant in use of resource but a high quality of product is needed for the independent learner.

The team should be brought together right at the beginning of the design process, certainly before objectives are defined. There is no doubt that the collective approach can produce something that could not be done by the individual. At its best, it is a creative process like the solving of a crossword, which may be impossible for one person, but two working together, feeding off one another, have a good chance of solving it. There is a criticism levelled at the team approach by sceptics in that it may produce a camel. This will only happen if compromise is made to members' hobbyhorses (to mix metaphors) rather than focusing on the students' exit behaviour. This is not the place to go into the structure of a team and the selection of members. However, the team does need to have individuals who have *collectively* a range of skills. Success is achieved by playing to individual strengths and ignoring weaknesses. Working on a team can be traumatic for some in that a person is exposed to peer-group criticism in a way that the face-to-face teacher rarely is. It is essential, therefore, that each member is valued and that each member of the team has ownership of the project.

Once objectives and skills have been defined the next stage is to decide on content. It is usually the case that content is uppermost in the educator's eye. It should not be overlooked that particular objectives can be achieved through a variety of materials. Given that we were starting with 'chemically' inexperienced students, there were a number of traps that lay in wait. We had to attract the students' interest and then retain it. This challenge meant writing material in a way that perhaps bucked some of the conventions of formal chemistry teaching. Learning from how articles are written in the 'popular' scientific press and from colleagues in other disciplines could be a source of many useful ideas.

It is useful (at this level) to ask the question 'Why does chemistry have limited popularity?' This should be asked not just to chemistry colleagues (who presumably think that chemistry is fun anyway), not just to chemistry students (who have chosen to study the subject for whatever reason) but also to students who are not studying chemistry and to adults who never had an opportunity to learn chemistry. The outcome of this exercise is to lead to a damning indictment of chemistry as perceived by many. We may argue that the picture that emerged would not be fair but that is not the point. It is our responsibility to try to change (or at least alleviate) the basis for criticism.

In addition, we should ensure that student's entry and exit behaviour for the course is clearly defined, the material is kept error free, logical discontinuities are avoided and concept maps are constructed to identify links and hierarchies. Due regard is given to *progressive* skill development, the number of new tasks; ideas or concepts that the student is expected to handle at one time. It is also necessary that a realistic assessment of student's study time be made.

## Use of Media

This is a critical part of the design process. There is a range of ways available to the distance teacher: text, video/audio, home experiments, residential school, computing, etc. Each one has its strengths and weaknesses and also its costs both in terms of material and human resource vary considerably. The question that has to be answered is what medium is best able to deliver a particular concept or idea within resource constraints. The course package based on a range of such media can be termed *multiple-media.* The expression *multi-media* is reserved for computer-mediated packages which embody text, graphics, video (and sound) in an interactive environment. A multi-media component is now considered to be a part (and often is a vital part) of a multiple-media package. A consequence of this package is that the student can be faced with a non-linear study pattern. There is little planning (on behalf of the student) required for a series of lectures supported by an 'adopted' text. When confronted by an array of media, the student can experience great difficulty with navigation. A route map must be developed which plots study progress.

However, in the presentation of any material the language of communication plays a vital role. It is now well known that the information presented in a local language can be understood easily (Janardanan, 2002: 63-65). The use of foreign language or a bookish variety of regional languages often creates difficulties in concept formation. In the countries like India where different languages are spoken in different states it would be advisable to prepare material in the regional languages. It is sometimes argued that technical subjects cannot be presented in regional languages. This belief has been refuted by a large' number of voluntary organisations engaged in India. As a part of their science popularisation programmes they have been successfully imparting technical information through regional languages (Deshpande, 2001). Experiences of these organisations would be of immense help in preparing chemistry material in regional languages.

In terms of study material hard copy text has been and probably will remain for some time, the most important medium. Reading text from a screen does not yet have the convenience of, nor is as friendly to the eye as the printed word. It is here that we shall begin a brief survey of the media.

### Text

Currently, this is the most important medium for the distance learner. For students used to inputting information through the written word, diagrams and equations text becomes a very flexible medium. It can also be accessed anywhere; no special facilities are required and the text can be easily annotated with notes by the student. For the independent learner, the text must be carefully designed. It has to be structured to aid the learning process. It must be interactive, student friendly and attractive.

The student needs to be told just what they are about to study by way of an introduction. The teaching itself should have lots of examples and opportunities for reinforcement. Students should be asked to make their own summaries and compare them with summaries that embody the points considered important by the author.

Self-assessment questions should appear regularly and be linked to specific objectives. This represents the main way in which the student is able to assess whether they are meeting the standards and criteria set for the module. The link to objectives makes it possible for the student to focus on revision and reinforcement.

All learning is predicated on previous experience. Whilst you may assume that recent material will be fresh in the student's mind, material from earlier in the course or from earlier courses will need to be cross referenced so that the student can access it if necessary. Within a piece of text you may wish the student to be referred to an experiment or video section. Make sure that this is signalled in advance and mark the appropriate spot with a suitable icon.

Style of writing can have a major effect on study. Keeping it to short sentences and using simple words where appropriate are useful. It is advisable to limit the concept density by introducing no more than one idea in a single paragraph. It is a good plan to apply a test to the text that will identify the worst excesses of convoluted writing. There are several so-called 'fog indices'. One that we have found to be effective is given by:

Fog index = 0.4 (Average number of words per sentence + Percentage of words with more than two syllables)

A fog index with a value greater than 12 is an indicator that the text may be too difficult and complex.

Another check to make is with student's workload. This is important not only in the context of a particular module but also with the other modules that the student may be studying in parallel. Time needed to master particular skills will vary from one student to another but there is value in using a common currency.

As the text is the medium with which the student is likely to spend most time, it is here that the time assessment starts. Again, as with the fog index, there are several ways of doing this and most involve an assignment of text into one of the three categories. Easy text represents prose that can be read and assimilated with a single passage. The difficult end of the scale is probably more appropriate to much chemistry material and texts involving symbols, equations, complex ideas and a precision of language.

Each difficulty category is assigned a reading / study rate:

- Easy 100 words per minute
- Moderate 70 words per minute
- Difficult 40 words per minute

Then time is allowed for figures, diagrams, questions, activities, other media, assessment, etc.

In addition to the main text, you may find a data book or glossary useful. Data books have a tremendous value in that they provide a range of data in one place. Identifying, selecting relevant data is a valuable skill to develop among the students and the data book ensures that all the students are using the same data when carrying

out calculations. A glossary can aid the student with the jargon of science. If a term crops up, a simple glossary definition is often enough to help the understanding.

Text should be 'friendly' for the student. This does not mean that the style appears to be patronising. The use of 'we' rather than 'one' and sticking largely to active rather than passive use of verbs can help. Language should be kept simple. Seeded questions that cause the student to stop and think are useful in breaking up text, as are illustrations. The text should also be produced to the highest standards possible. Quality production seems to carry weight in students' eyes.

**Video**

Under this head come both broadcast television and the videocassette. Access to cable or national networks, represents an opportunity for essentially free publicity for courses and programmes as well as representing a pacing device for the student.

If one can make the assumption that students have ready access to video players, the videocassette becomes a versatile medium. To make high quality video is relatively expensive but there are roles for which it is uniquely appropriate. Dynamic processes, creation of a three dimensional image by movement in two dimensions, experimentation including time lapse, expensive or potentially dangerous procedures, contextualization, authoritative speakers in a particular field are all possible. It should not be forgotten that video, an essentially linear medium could be made interactive. Supply of data from an experiment can attach the student directly with the medium.

**Audio**

Audiocassettes are cheap to produce and the playing equipment is ubiquitous. Audiocassettes, therefore, have tremendous potential for use in distant teaching in developing countries. This mode lacks the facility of interactivity and visual aids. Nevertheless, audio media can be used effectively in conjunction with printed material for providing useful information or to motivate the learner to undertake an activity. Whenever necessary one could think of developing a cheap version of a cassette player for its use on a large scale.

Radio network in most of the countries is now well developed. This mode of communication can also be used to cater to a large number of audiences simultaneously. The programmes prepared for radio broadcast should take into account its limitations. Information should be provided in such a way as to maintain the attention of a listener. A story telling approach might prove useful in this case. Many radio stations run a programme to answer listener's questions. Such a programme can specifically be planned for the distant learners too. Through these programmes it should be possible to offer some feedback and guidance to the learners. Audio is particularly useful for discussing approaches to problem solving and argument construction.

**Practical work**

Laboratory and fieldwork is essential that this time is used effectively in the context of a programme. Traditionally, in distance learning, experimental skills have been developed through limited laboratory/field work access and the home experiment kit supplemented with the use of video. Use of cheap, mini-scale, disposable equipment

can provide an economic and safe way to develop experimental skills particularly for introductory courses. The crux is to realise that many of the skills traditionally taught in a laboratory environment can be developed (to some extent) outside that environment. Multi-media have opened up a powerful route to the development of some of the skills of experimentation, particularly in the area of experimental design.

### Computing and multi-media

The value of multi-media in the practical work arena is without question. It is technically possible to include text, audio, and video on screen in an interactive context. This might seem very attractive but there are drawbacks. On-screen text in large amounts is not easy to the eye and lacks some of the versatility of the printed page. However, the biggest problem is the teacher time required to produce good quality material. This has to be supplemented by professional designers to give the material a professional and user-friendly image. Access issues are more restrictive than are other media. Nevertheless, Multi-media will become increasingly important in independent learning but its introduction should be treated to all the same critical as other media. The computer has a significant role to play in the area of data acquisition and database access in experimentation and has a valuable role in computer-mediated learning. Remote communication between tutor and student and between students is set to become a major teaching mode.

## Mode of Assessment

Students of most independent learning courses are assessed by a combination of course work and an end-of-course examination or a thesis. There are safeguards in this combination as it limits the possibilities of impropriety and provides a range of assessment modes that should not unduly disadvantage a particular student.

Student-produced work can be of a conventional written kind or be of a computer-marked nature. This latter has limitations but nevertheless is able to test a range of non-hierarchical objectives. Grading is relatively inexpensive and can have a rapid turn around. The grading of written work is time intensive but higher learning objectives are easier to test by this method. Both modes of continuous assessment have an important teaching role and represent an opportunity for *individualised* feedback to the student.

## Delivery, Evaluation and Quality Assurance

There is little value in designing a course with care if the delivery system is flawed. Just how the students are to study the course is a vital factor to include in the initial planning process. The convenience and nature of back up is predicated by resource but must have regard for the material being studied, the location, circumstances and the time constraints of the student. There is no prescription here except to say that any good system seems to evolve from a close liaison with potential students and teachers.

Evaluation is probably the most neglected area of distance teaching (Quimbo, 2002). Checks have to be built into the design process, the individual course components and their collective whole, the delivery system, the assessment system and a system devised to close the loop and enable action on findings. Further, one has to decide who are the appropriate people to be involved in these processes.

Overall, there is little difference between producing a new course and a new chocolate bar. First research the market. Is there a demand for the course, what are the expected outcomes and how does it fit into existing offerings? The next step is to assemble the design team, which should have some external input. At the Open University it has been the norm to have external assessors (from other universities) for each section of the course and at least one assessor to cover the course as a whole. Draft materials should be commented upon by all members of the design team and by student assessors. We have found that many changes that students have suggested have contributed greatly to the quality of the course.

One of the criticisms that is sometimes levelled (with some justification) at independent learning is that response to feedback is slow. So delivery of the course must be monitored by tutor and student questionnaire *and* provision be made to act on the findings. Questionnaires have to be designed professionally so that responses to sets of questions suggest action. It is of little value to know that 30 per cent of students found a section difficult if there is no information on just why that section was found to be difficult. You will also need information on the quality of the material, time of delivery to the student, ease of access of the student to formal sessions, etc. Another area that must be included relates to students' performance. Although, this type of statistical indicator is often used for exclusion of others, it is only of real use in a 'value added' context. The student-input criteria have to be used as a baseline.

The design and production of quality distance learning material is an expensive and time-consuming process. Effort spent is never lost and usually results in savings further down the line. Look at existing books and other materials and see if it is possible to incorporate such material into your design. Think about multi use, flexible contextualization and access. Try to plan the totality at the same time, the course overall, the components, assessment, evaluation, and above all, never lose sight of the view from the students' eyes.

The tradition of formal education has been in existence for many centuries. One can learn from the experiences of such universities to make new programmes or projects. In case of the distance education the experiences are sporadic. The UK Open University (UKOU) has been in existence for nearly three decades. On the lines of UKOU many institutions have been established world over in the last two decades. One can learn a lot from the successes and failures of these organizations. The methods followed by these institutions would certainly be useful. Nevertheless, it is necessary that methodology suitable to a specific country be designed. Even within a country one might need to adopt different methodology taking into account the academic environment, socio-economic status and technological development of the region.

## Summary

New materials and new uses of old materials are being discovered everyday. In order that these materials are used profitably people must be made chemically literate. Formal education has many limitations. It caters to only a small number of persons in developing countries. The task of spreading chemical literacy must, therefore, be undertaken through distance mode of education. Developing such a programme is, therefore, the need of the day. Experience gained in the past few decades has shown that it is possible to create awareness among common people regarding ever changing material world.

Along with developed countries the distance education has now taken roots in developing countries too (Braimoh, 2001; Ding, 2001). Both to enhance educational qualifications and to keep pace with rapid developments in industry people are taking up courses through distance mode. It is, therefore, necessary that proper material be prepared to enable the distance learner to benefit from it. A variety of subjects could be tackled taking into account the needs and requirements of the student population.

Availability of suitable learning material would solve the problem of those who cannot attend regular classes in schools or colleges due to their job requirements or due to the distances involved. Housewives are the potential targets as few of them have an opportunity to study science at tertiary level as pointed out by a Human Development Report (2000: 256-258). Unskilled and semiskilled labourers are the other targets. It has been noted in World Development Report (2003: 73) that the unskilled workers fetch a poor salary. One of the aims of preparing distance-learning material could be to change unskilled labour force into the skilled personnel.

Although the internet facility is not easily available, the network of radio and television is well established in many developing countries. The judicious use of media like the radio, and television in the implementation of distance education programme could be planned to enhance learning. Packages involving audio and videocassettes can enable the learner to use the material at his leisure. Such a material, it is hoped, would be welcome by a large number of persons from developing countries. In most of the developing countries we find a wide disparity between haves (elites) and have-nots (downtrodden). Availability of suitable distance learning material it is hoped will help us to narrow the gap. It would thus be a step forward towards achieving equity (Goel, 2002).

In preparing material for independent learning one needs to ensure that the learner should be able to use it without much support from the tutor. Apart from the core content the material must provide guidelines for activities and for self-evaluation. The design, production and delivery must be taken care of seriously. A sample material on 'plastic' is given in the appendix.

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# Appendix

## An Exemplar on Preparing a Module on Plastics

### Enlisting of objectives

The material must enlist objectives to be achieved through the study of material. In the context of present topic the following objectives could be relevant. Students should be able to

1. Explain the concept of polymers and the process of polymerisation
2. State the importance of plastics in everyday life.
3. Outline the methods used in making plastics on a large scale.
4. Evaluate the role of plastic industry in the economics of the country.
5. Assess the ill effects of non-biodegradable plastics on environment.
6. Apply his knowledge to work out a scheme to bring down the pollution problem.
7. Think of ways of preparing biodegradable plastics.
8. Explain the importance of recycling plastics.

### Introductory information

Plastics have now occupied almost all walks of our lives. It is seen everywhere and is used for different purposes. The first step, therefore, is to make the learner aware of all pervading uses of this material that came into existence only a few decades ago. An historical perspective on how the use of plastic grew over the years would help the learner to realise its potential. Incidences, where the same plastic with little modification is used for a totally different purpose could also be cited. For example, polystyrene is used to make hard balls as well as for making lightweight packaging material. Description outlining the variations in properties and uses of different plastics could make the learner aware of the scope of the subject.

An historical anecdote giving an account of how plastic was first prepared as a replacement to ivory for making billiard balls would be a good starting point to introduce the topic. An experiment that began as a competition has led to the development of a multi-million dollar industry. An audio taped narration of the historical anecdote would be useful. It must be emphasised that although the competitor could not qualify for the prize, as he could not achieve success in a stipulated time his work has resulted into a revolution in material science.

It would be informative to bring out variations seen in commonly used plastics. A statistical account giving information on how much plastic is manufactured in the world every year would be useful. For example, the world production of polythene and polyvinylchloride in 1991 was 23 and 15 million tonnes respectively. A video showing how plastics have replaced metals in different fields would enable the

learners to realise its importance. The use of plastics as containers, as packaging material, as machine components, as utensils for daily use, etc. should be brought out clearly. This exposure would create interest among the learners to understand about the nature of different plastics.

**Polymers and polymerisation**

The concept of polymers and the process of polymerisation should be at the centre of this unit. The idea of polymers could be best introduced through naturally occurring polymers like starch, sugar, cellulose, etc. The chemical structure of these polymers should be highlighted brining out the repetitive unit in them. Through these examples the idea needs to be brought home that polymers are created by the repetition of a monomer in nature. The important point that needs to be emphasised is that man has imitated nature in making the polymers that he/ she needs.

First, the idea of monomers needs to be introduced through examples. Some illustrations showing how monomers combine to form a long molecule would be useful. If possible the molecular weights of some of the polymers should be given to provide the idea of number of monomers in them. This discussion can cover a variety of plastics that are used in the everyday life. What is needed is to present a molecule of a polymer and to indicate its monomer. It should be explained that a monomer could be a simple molecule like ethene, a little bigger molecule like vinyl chloride or a molecule formed after the combination of two chemicals like ester or amide.

The process of polymerisation is an abstract concept. It should, therefore, be introduced through examples. An illustrative print material might help the learners to grasp the concept. There are a variety of issues related with the process of polymerisation. For example, reaction mechanism by which monomers get attached to each other, conditions determining the length of the polymer, role of catalysts in speeding or slowing down the reaction rate, etc.

The Chemistry has now reached to a stage that one can make polymer of required property by controlling the process of polymerisation. Factors responsible for offering certain properties to plastic needs to be discussed. An account of how these factors are controlled in manufacturing processes should also be given. Some examples of tailor made polymers would help the learners to appreciate how advanced the chemical industry has become.

**Industrial processes**

Although a reaction might seem very simple on paper its implementation on a large-scale demands intricate engineering design. It is necessary that learners be acquainted with industrial processes involved in making plastics. Videotape showing factory processes would enable the leaner to realise the intricacies to be followed in the manufacturing processes. The concept like catalysis, Le Chattelier's principle, chemical thermodynamics, etc. can better be illustrated through these video pictures. The scale at which the plastics are manufactured and distributed would also be evident through these video clippings.

For convenience a unit producing plastic of daily use be chosen. Starting from the acquisition of the raw material the processes involved in getting final product should be presented. Each step involved in the manufacturing of a material must be explained clearly by an expert. If possible the videotape showing the production of different items of daily use could be prepared. It must be evident through this video that the plastic, which is just thrown after a little use, has come into existence after lot of processing.

Raw material is required in large amount for manufacturing plastics to fulfil the present day needs. What are the sources of the raw material? Usually raw materials for plastic industries are obtained from petroleum products. In some cases components obtained from the fractional distillation of the petroleum is used directly. In many cases, however, the petroleum product needs to be modified. The plastic industry is thus closely linked with petro-industry. Because of this interdependence the prices of plastic depend on the prices of petroleum products, which eventually depends on the prices of petroleum.

**Economic Implications**

Plastic is now a major trade item of import and export of many countries. A large number of public and private companies are engaged in its manufacture and sale. Many of them are listed on important stock exchanges. The contribution of the plastic industry to the overall economy of the country is significant. This aspect should be brought out through statistical information showing how much plastic is produced in the country and what business opportunities this material offer.

The availability of plastics for packaging has made the preservation of eatables quite simple. As a result, things are made on a large scale and are sold on retail. This has resulted into the lowering of prices of essential commodities. The importance of plastic in packaging should be brought out through illustrations. As an example one can refer to the decreasing demand of newspapers in India. The easy availability of plastics for packaging has brought down the demand for the old newspapers, which were previously used as wrappers for many things. Similarly the easy availability of plastic containers has brought down the demands for the metallic utensils. Since plastic things are much cheaper even the poor can now afford these items.

Possibility of moulding plastic in any shape has given a boost to toy industries. One can now see a large number of toys made up of plastics. Its easy availability has made many parents to buy and throw when not required. One can also see a variation in the household items. Large-scale manufacture of plastics made it possible to make things attractive leading to an increase in the sale of products. The furniture and decorative items made of plastics are affordable and durable. Restaurants and offices have made use of this aspect to a great extent to make their jobs simple and attractive.

**Environmental effects**

The over use of plastics has resulted into the spoiling of the environment. Plastic items are nowadays thrown in large numbers. Indiscriminate use of plastic has resulted into spoiling of the environment. Many countries are now facing the problem

of disposing the plastic wastes. It should be possible to show the picture of humps created by dumping plastic wastes. The concept of biodegradability should be discussed and the attempts to make biodegradable plastic must be mentioned. Issues concerning the recycling of plastic must also be presented so that the learner gets the clear idea of some of the ways of controlling the environmental degradation. Awareness for the limited use of plastics, avoiding its use where unnecessary should be created through this discussion.

**Assignments**

Following assignments could be given to the students.

1. Conducting a survey of use of different plastics in 10 homes in the locality.
2. Survey to find out average plastic waste in each house in the town.
3. Library search for the development of processes of making different plastics.
4. Interview of a person in the plastic industry.
5. Cuttings of newspaper reports concerning production, use, economics, etc.

**Assessment**

In order to assess the understanding of the topic a leaner can be asked to do the following

1. Prepare a brief summary on the concept of polymerisation.
2. Argue for and against the use of plastics.
3. Plan a social awareness campaign for recycling of plastic wastes.
4. Identify monomers in different plastics.
5. Suggest ways to modify the properties of existing plastic material.