Independent Study – providing focus and purpose

COMMUNICATION

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The paper describes a final year undergraduate degree module which has been running at the Nottingham Trent University for the past four years. The module, 'Independent Study', is a student-centred programme where students study topics from two of the three main branches of chemistry, inorganic, organic and physical. The manner in which the summative end of module, revealed paper examination is structured, compels extensive coverage of the subject matter. The module allows concurrent final year project work to be carried out away from the home university. This 'end of university' unit of the course guides students to independence in their future lifelong learning. The results currently obtained with the programme show an equivalent level of academic attainment to traditionally delivered modules. The outcomes of the programme since its inception and its refinement are discussed.

Introduction

In the academic year 1995/6 the final year of our cluster of degree courses was modularised. This provided the ideal opportunity to modify our degree programme to achieve educational objectives which we believed were desirable, and which additionally, would give greater flexibility for our students in the study arrangements available to them immediately prior to graduating. The educational objectives set out in our course documents and of particular relevance to our final year students were

- Promotion of the development of the student as an independent learner;
- Encouragement of the personal and intellectual development of the student.

In the modularised programme the majority of the finals examinations were completed by the end of the first semester (February) of the final year, and the entire second semester was available for project work and a new module. The project takes up 40 of the 60 available credits for a semester, and at that time a significant number of students carried out their projects in the United States or in Continental Europe and some in industry. Thus the adoption of a new 20 credit module of Independent Study would not only meet our primary objective of encouraging the development of the skills of independent learning, but would also meet the needs of students doing project work away from the university. A further objective of the module was that it should require the students to study a broad range of topics within (at least) two of the main sub-disciplines of chemistry.

Independent Study and Learning is not a new idea in Higher Education. Much has been written about it and its value (eg [1-4]). Knowles[1], in particular, is a major proponent of the techniques and strategies related to self-directed learning which are said to constitute the distinctive practice of andragogy (as opposed to pedagogy which is said to characterise the more teacher-directed approaches of conventional education). In self-directed learning the needs and activities of the learner take precedence over those of the teacher (whose role thus becomes one of a facilitator of learning). This is the style of learning in which we would wish our students to engage by the time they graduate. Whether Independent Study can be truly 'independent' is a moot point since, as Collins[4] has pointed out, the ideas underpinning self-directed learning have been readily translated (by their proponents) into techniques which seem to set out *"in formulaic terms, how it (ie self-directed learning) has to be done; directed self-directed learning... managing a pedagogic technique, usually in the form of a learning contract with a student client."*

The writing of independent study material[5] and examples for use in university chemistry teaching[6,7] have been described and excellent sources of such materials can be found[8,9]. These will all influence the design of new strategies for developing the skills of independent learning. In addition, the design of any new module must take into account the number and background of students involved. At the time this module was planned about 100 students were expected to take it, though this number has since fallen to about 70.

This paper describes how we designed a module structure and an assessment procedure to meet the three main objectives outlined above.

Methodology

Design of the syllabus

Independent study is encouraged by minimising contact with staff. It is therefore important to build carefully on students' existing knowledge and skills, and to provide guidance and support which will enable them both to study successfully and to recognise that they have developed useful new skills. Also we took the view that some traditional topics on the syllabus do not need to be covered in lectures but are particularly suited to independent exploration by final year students with a firm grounding in chemistry. The syllabus for the module was strongly influenced by our analysis of these topics and by the availability of relevant information in standard and specialist texts. We decided to base the syllabus on the three traditional sub-disciplines of physical, inorganic and organic chemistry. This has the advantage for students of being reassuringly familiar. For the staff, it means that the full teaching load of the module does not fall on a single individual. The syllabus is defined in terms of nine examination questions. These are devised by selecting three topics from within each sub-discipline and setting an essay question on each topic. Only three of these questions appear on the examination paper, one inorganic, one organic and one physical and the students have to answer two of them. Since the students do not know which three out of the nine questions will appear, the syllabus is effectively defined by a sub-set of six of the nine questions. Students are told that they are expected to write in excess of 1000 words for each answer.

Students decide for themselves which two branches of chemistry (defined by six questions) to study. An indication of their choice is obtained when they attend the appropriate tutorials, but in the examination they can choose any two of the three questions regardless of the programme of work they have followed. They may be influenced in their choice by the opportunity provided in the previous semester to specialise in two branches of chemistry, advanced inorganic, advanced organic or advanced physical, although there is no compulsion to study the same two areas here.

Nine questions, with their lead in references, which we have typically used in recent years are shown in Figure 1.

The module is assessed by a two hour closed book examination at the end of the module. This has two perceived advantages. First, the students taking this module were also involved in project work which is engrossing and intensive; it seemed unreasonable to impose assessed course work on students committed to project work. Second, it provided reassurance for sceptical staff that this new type of module would be rigorously assessed.

Student Support

Students are issued with guidance notes about the Independent Study module at the end of the first semester and given a briefing which spells out in fuller detail what is required of them and explains that the aims of the module are to develop the skills needed to

- find, read and assimilate information
- manage their time
- structure an answer
- write a coherent essay

They are informed that that their reading and study should be directed towards answering the questions after developing a thorough understanding of the topics. Attention is drawn to the lead references provided for each question. They are given the name of a member of staff who is responsible for each subject area and who can be consulted over the concepts involved. When the module was first introduced (but see later) students were told that staff would not however read specimen answers but this since been relaxed in the interests of improving student support.

They are reminded that a 20 credit module is intended to require about 130 hours of study time spread evenly over the semester, and that in a conventional module this would involve about 70 hours of student contact and 60 hours of directed and independent study. In this module they should therefore expect to devote about 20 hours of concentrated work to each of the six questions which defines their course.

In the first year of operation students were required to complete a study timetable detailing the time that they were spending on this module. Approximately five weeks into the module, two seminar/appointment slots are timetabled with staff (email provision for those away from the university). Students are instructed to attend one to show that they had constructed essay plans. They are warned that if they do not meet these requirements that are aimed at monitoring their progress, then their names will be reported to the Finals Examination Board and the external examiners, and this may be a factor when decisions have to be made about any performance compensation etc.

Outcomes

Examination results for the past four years are shown in Figure 2.

The pattern of results shows a steady shift towards the distribution which we regard as reasonable and by 1999 the average mark was 52% and comparable with our other modules delivered in the traditional way; this compares with 48% in the first year the module was offered. By 1998/99 the proportion of fail marks had dropped to an acceptable level, and most of the candidates were able to compensate within our rules by scoring higher marks in other modules. The proportion of first class marks is lower than we would like to see, but it is a common observation that it is harder to obtain a first class mark on an essay question than on a highly structured question.

Comparison between years is bound to be speculative because of changes in student background and quality. For instance, in the early years, in addition to those taking Chemistry, a significant number of Combined Studies in Science students were taking this module. The number of the latter has markedly decreased over the four year period which this module has been running. Another factor which contributes to variation between each cohort of students is the number who have undertaken industrial training prior to their final year; these students show a markedly more mature attitude to their studies on their return from industry. In spite of the real variation in student quality over the years, we believe that at least some of the change in observed mark distribution can be attributed to changes in the support given to students, which we introduced in the light of experience.

In 1995/6 some 3% of the students admitted after the examination that they had either attempted to question spot or had started their revision only two days before the examination. Typically these students scored zero or, at best, less than 10%. It is likely that a larger proportion made the same mistake without admitting it, and that this accounts for the unacceptably high failure rate.

Accordingly, in 1996/7, we placed greater emphasis on the need to develop a responsible attitude and an effective pattern of study. This appeared to have the desired effect on reducing

Figure 1: Examination questions with lead references *(Extract from student handout)*

INORGANIC

1. Discuss the types of inorganic chemical reactions that occur in a range of nonaqueous solvents, such as anhydrous ammonia, glacial acetic acid, conc. sulfuric acid, dinitrogen tetroxide and sulfur dioxide. Demonstrate how the use of such solvents has encouraged the development of inorganic chemistry.

2. The concept of acids and bases has widespread use in inorganic chemistry. Discuss how a consideration of non-aqueous solvents, such as anhydrous ammonia, glacial acetic acid, conc. sulfuric acid, dinitrogen tetroxide and sulfur dioxide, has refined the acid-base concept and rationalised the wide range of chemical reactions known.

3. Non-aqueous solvents, such as anhydrous ammonia, glacial acetic acid, conc. sulfuric acid, dinitrogen tetroxide and sufur dioxide, provide a medium for many synthetic reactions in inorganic and organic chemistry. Discuss the properties of these solvents that make such synthetic developments possible.

References

Introduction to Modern Inorganic Chemistry, MacKay and MacKay, Intertext.
Non-Aqueous Solvents (Studies in Modern Chemistry), T.C. Waddington, Nelson (1969)

ORGANIC

1. Discuss the formation, stereochemistry and reactions of cyclic monosaccharides, and methods by which they may be further converted to *C*-glycosides. A discussion of degradative studies leading to structure determination is not expected in your answer.

2. Discuss the formation, stereochemistry and reactions of cyclic monosaccharides, and methods by which they may be further converted to *O*-glycosides. A discussion of degradative studies leading to structure determination is not expected in your answer.

3. Discuss the formation, stereochemistry and reactions of cyclic monosaccharides, and methods by which they may be further converted to *N*-glycosides. A discussion of degradative studies leading to structure determination is not expected in your answer.

   (Note: In your account you should be able to give acyclic and cyclic forms of D-glyceraldehyde, D-ribose, D-mannose, D-glucose and D-fructose, using Fischer, Haworth and other appropriate representations).

References

Organic Chemistry, 4th Edition, McMurry, pp, 1010–1033,1050
Organic Chemistry, Carey, pp. 1002–1042
Organic Chemistry, 5th Edition, Solomons, pp. 997–1022
Natural Products, Their Chemistry and Biological Significance, Mann, Davidson, Hobbs, Banthorpe & Harbourne, pp 26–41, 67–118

PHYSICAL

1. Osmometry, light scattering, viscometry and gel permeation chromatography are techniques which may be used to determine the molecular weight of polymers in solution. Describe in detail the experimental procedures used and discuss the relative advantages and disadvantages of their use in molecular weight determination.

2. Discuss the mechanism and kinetics of free radical addition polymerisation including reference to the usual physicochemical parameters.

3. Give accounts of the structures, properties and uses of:

   a) copolymers;

   b) elastomers

illustrating your answer with examples wherever appropriate.

References

General Physical Chemistry texts such as those by P W Atkins, G Barrow, Laidler & Meiser and W J Moore etc. contain chapters/ sections on macromolecules/polymers which feature molecular weight determination and kinetics of polymerisation.

General texts on Material science such as:
The Structure and Properties of Materials (Moffatt et al) The Boots & Clifton libraries.
Materials Science (Anderson & Leaver). The Boots Library contains material relevant to structure and properties of polymers.

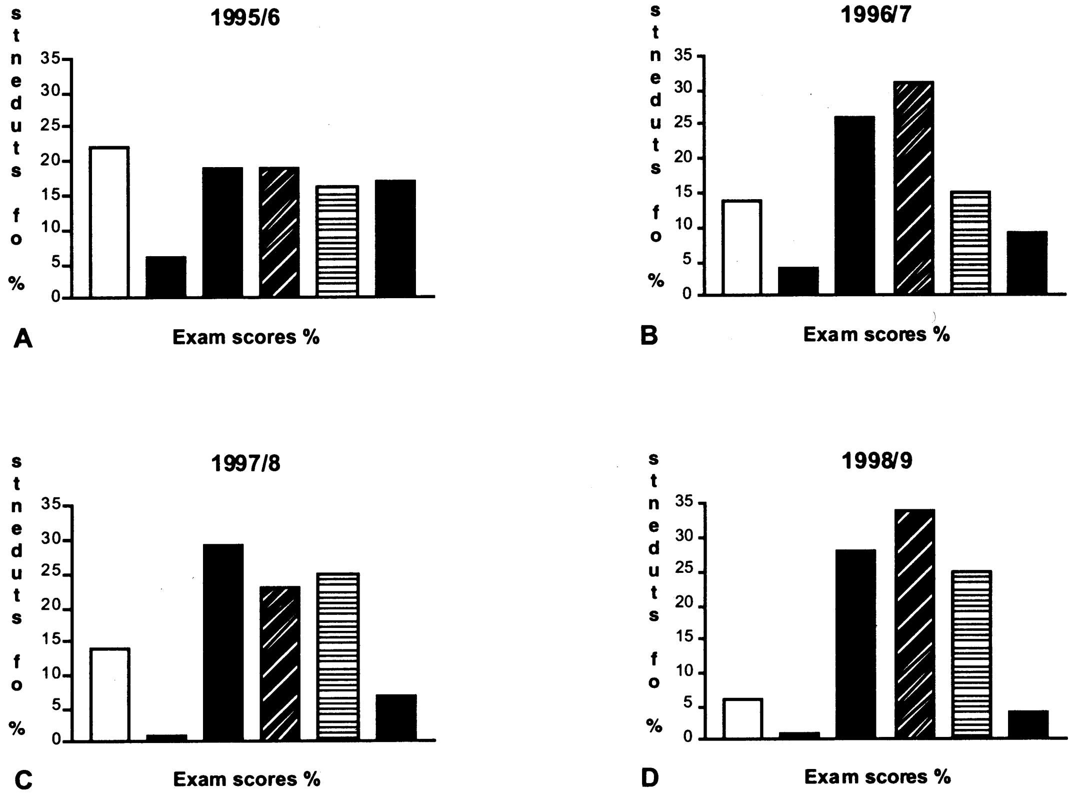
Specialist Polymer texts such as:
Textbook of Polymer Science. T W Billmeyer
Macromolecules: Structure and Properties, H G Elias
Introduction to Macromolecular Science, P Munk are available from The Boots library.

the failure rate, but the combined number of first and upper second class marks was disappointing. We noted that only about 50% of the students had completed their study timetables and attended the mid-semester seminar, suggesting that they failed to recognise that these features of the course were intended to help them to develop effective study patterns.

Further efforts to encourage the students in 1997/8 may have brought about the satisfactory increase in the proportion of upper second class marks. However the proportion of fail marks was too high, and called for a more significant revision of the available support. We decided to abandon the use of study timetables since lack of use made these ineffective, but we retained the seminars/appointments as a key point of contact with staff. Instead of refusing to read model answers, we recognised that this would also provide valuable support for the weaker students, and so we required those students whose performance had been very weak in the February Finals Examinations to submit these two weeks prior to the summer examination. This special treatment of weak students was not a precedent since these students are not allowed to carry out their projects away from the university. We noted with satisfaction that failures were reduced to 6% from 14% the previous academic year, and students moved back in numbers to the lower second class band.

The distribution of students between inorganic chemistry,

Figure 2: The examination performance for the past four years



Student numbers: A 94, B 91, C 69 and D 67.

organic chemistry and physical chemistry has tended to remain roughly constant (with physical chemistry slightly lower) over the four years of operation of the module. Over the years the average mark for the organic and physical chemistry questions are both about 50%, with inorganic chemistry being slightly higher at around 55%. We do not feel that this is significant.

Discussion

The Staff Perspective

The appointment of a single staff member for each subject area might at first sight appear a large individual burden. In practice during the first two years during which the module ran, given the spread of students and topics, it meant that the individual staff member was in theory responsible for no more than 60 students, up to 30% of whom were away from the university undertaking their projects and being in touch with the lecturer by email. In the latter two years the average number of students studying any sub-division has fallen to about 45. Despite our best encouragement, not all of our students take advantage of the tutorial sessions. Additionally students tend to pose similar questions and thus even email replies tend to be less onerous than one might imagine. Thus the overall teaching load is indeed somewhat reduced compared with the typical load of a conventional module.

We accept that marking this type of examination requires a little more time than normal. Markers had to be aware that, whereas an essay set in a conventional exam is almost invariably based on a common set of lecture notes, students in this module could well, despite lead references, consult a wide variety of sources. With this in mind, the examination scripts are all read through by the examiners and then either arranged in a pecking order of essay quality or a list drawn up of the main points made by students in their essays. They are then read through a second time and assigned a mark, either based on what the examiner reasonably expects in content for a given degree classification band dependent on subject area, or on the number of relevant points made by the student (guideline 80% of major points mentioned = 10/10). For example in the first two questions in physical chemistry (see figure 1) 50% of the marks would be awarded for description and 50% for critical analysis and derivations. In coming to a final mark, moderation of the 'raw mark' takes into account structure and coherence of the written account. Quality control is maintained through some sampling by a second examiner and the essays are available for scrutiny by the external examiners. With all of the students answering the same question in a particular subject area, a greater comparability between students is achieved. The differences in approach by different examiners might be criticised on the grounds that students in the different branches of chemistry are not receiving uniformity in treatment. However, there is no reason for supposing that this is any less equitable than in any other examination with multiple marking.

We are satisfied that the strategy of defining the syllabus by three examination questions from each sub discipline encourages a suitably broad study of the area, even though only one of the topics is actually examined.

The Student Perspective

At the end of all modules all students receive an end-of-module questionnaire which poses nine specific questions about the module. These relate to its organisation, students' background for it, development of new skills, help from staff, resources, clarity of assessment procedures, the Internet as a source of information, relationship to other modules, and the extent to which the aims of the module are met. Responses from the Independent Study Module have been very positive with the scores rarely falling below the upper quartile in overall satisfaction in all nine areas. In addition the questionnaires allow for individual comments. Many positive comments were received for this module, and some of these provided encouraging evidence that the students were indeed developing their ability to study independently. A number of negative comments have also been received, and these can usefully be divided into those which highlight difficulties which the module is designed to introduce and those which suggest ways in which student support can be improved. Some illustrative comments are included in Figure 3.

The positive responses stand by themselves as evidence that at least some students recognise the benefits of this module. The negative comments require more serious analysis. "Lack of books" will probably always be perceived as a problem, particularly with current restrictions on library budgets, but our view is that students ought to own at least one standard text for each of the sub disciplines which they are studying, and that this should provide a basic background. Students away from the university are less able to rely on friends and peers who may own different standard texts, and this would put them at some disadvantage. Our only solution to this problem is to encourage better use of the available tutorial support. Most of the other negative comments reveal that the students find it difficult to develop some of the key aspects of independent study. A particularly disappointing comment was "parrot fashion learning" which clearly shows that some students have failed to understand the nature and purpose of the module, and have not appreciated that good answers to the given questions are unlikely to result from the uncritical commitment of facts to memory. We are addressing this issue by using the tutorials to discuss approaches to essay writing – not simply learning by heart an essay that they have written, but fixing in their minds how they will structure it and the concepts and ideas they will wish to put forward. For example, we remind them that, in organic chemistry, the heart of the subject lies in principals and mechanisms rather than in a cursory acquaintance with a host of reactions.

General Conclusion

We are pleased that this module has met with the approval of our external examiners, who welcome the breath of fresh air that it has brought to the degree programme. We feel that this approval confirms our view that the module is rigorous and at the same time introduces an important new dimension to the learning experience of our students.

Figure 3: Illustrative student comments on the module

Those in bold were made by over 50% of respondents

Positive comments (general)

"working by yourself", "relieved exam stress", "knowing the questions for the exam", "freedom to do it as and when", "interesting research on the net", "easier to learn material for the exam", "I learnt a lot about the subject", "flexible to fit round the project", "references given", "holding tutorials made you do the work", "no lectures"

Positive comments (relating to independence)

"Making my own plan for the subject studied", "Working independently. Not being treated like I was back at school anymore", "Left to do own research and revision", "Control over own time and work". Numerous other comments contained the word 'independent'.

Negative comments

"lack of books in the library (particularly overseas)", "quantity of information", "shortening the material to a 1000 word essay", "not enough help", "difficult to work during the project", "having lecturer who wasn't available all the time", "lack of information about structuring essays", "lack of confidence in my essays", "parrot fashion learning"

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