Science Education Enhancement and Development

SEED

Working Paper Series

Using multimedia for providing feedback to students undertaking concurrent group project-based practicals

Graham Bradley and David Gaudie, March 1999

The SEED Programme, Faculty of Science, University of Plymouth.
Supported by the Higher Education Funding Council for England, through the Fund for the Development of Teaching and Learning.

AN INTRODUCTION TO SEED

The programme for Science Education Enhancement and Development ('SEED') is based in the Faculty of Science at the University of Plymouth. It is resourced principally by the Higher Education Funding Council for England through its Fund for the Development of Teaching and Learning. Additional support has been received from many areas of the University and particularly from Academic and Information Services.
SEED builds on the success of the University of Plymouth Science Faculty in the national Teaching Quality Assessment system where Plymouth achieved 'excellence' in Environmental Science, Geography, Geology and Oceanography.

SEED's overall aim is to develop, document and disseminate good practice in Science teaching and learning. The programme consists of a series of projects in areas such as lab-work, field-work, graduate teaching assistants and computer-aided learning, which are itemised inside the back cover. Most are based in the Science Faculty but some have been taken forward by staff in the University's School of Computing and in Educational Development Services (EDS). All the projects are linked to dissemination partners in other institutions who act as external advisors, ensure that SEED's outputs are capable of being used in other institutions and help to disseminate and embed SEED's end-products.

Anyone wanting further details on the SEED programme is welcome to contact Brian Chalkley or Andy Elmes at the address below. Contact details for the individual project leaders are available inside the back cover.

The SEED Programme

Faculty of Science
University of Plymouth
Drake Circus
Plymouth PL4 8AA
Tel: 01752 233530 or 01752 233053
Fax: 01752 233534 or 01752 233054

Programme Manager: Brian Chalkley
e-mail: bchalkley@plymouth.ac.uk

Programme Officer: Andrew Elmes
e-mail: aelmes@plymouth.ac.uk
http://www.science.plym.ac.uk/departments/seed/

UNIVERSITY OF PLYMOUTH

Science Education Enhancement and Development

SEED

Working Paper Series

Using multimedia for providing feedback to students undertaking concurrent group project-based practicals

Graham Bradley and David Gaudie, March 1999

The SEED Programme, Faculty of Science, University of Plymouth.
Supported by the Higher Education Funding Council for England, through the Fund for the Development of Teaching and Learning.

Using multimedia for providing feedback to students undertaking concurrent group project-based practicals

Graham Bradley and David Gaudie

Abstract

This paper reports on how the use of interactive multimedia has improved the effectiveness of the feedback processes during four separate but concurrent, small group, project-based microbiology practicals in a Stage 3 (final year) module. These concurrent practicals were originally introduced as an aid to the teaching and assessing of increased numbers of students in an educationally productive and yet time and cost-effective manner. This development was achieved by encouraging the production of enhanced word processed reports, oral presentations and student-shot and edited video clips, which are easily accessible to current and future cohorts using a laboratory-based PC. The group project-based practicals were enhanced as judged by staff observation and student questionnaires.

Context and purpose

It has been a criticism of many teaching and assessment practices that they do not promote independent, reflective or critical learning (Entwistle *et al.,* 1992) and that this is incompatible with modern academic aims. The achievement of such aims has been further complicated in recent years by increasing student numbers, and diminished amounts of student contact time, reduced funding and consequent capital and consumable equipment limitations.

In an effort to respond to these aims and developments, group project-based practicals were introduced several years ago into laboratory sessions of a Stage 3 (final year) Environmental Microbiology module on the Biology Undergraduate Scheme (BUS) at the University of Plymouth. These students may be following one of a range of degree programmes including Biological Sciences, Microbial and Cellular Biology, Marine Biology (with Microbiology) and Chemistry (with Microbiology). The BUS is a modular-based programme and the module reviewed in this paper is a single-semester, ten-credit module, although it is assessed in conjunction with a second-semester module in Marine Microbiology. The coursework accounts for 40% of the double module mark (60% examination) and this assessment is 10% of the double module mark. There are typically 20-25 students enrolled on this module and most have a background in microbiology, having undertaken one to four previous modules in the microbiology area. The module has nine hours of laboratory time and a three hour feedback session allotted for these project-based practicals, but also includes 12 lectures and two seminar sessions within the contact time.

Small group work seemed to offer a good method of helping to overcome the laboratory session constraints whilst providing active learning for the students and the support of their peers (Garvin *et al.,* 1995). As well as the "hard" scientific knowledge, numeracy, problem solving/analytical ability and reporting skills which were developed in the module, this approach was intended to help to develop the "soft" skills which employers have identified as those they would appreciate in recent graduates and which these Stage 3 students therefore need to have if they are to obtain employment within the coming year. These include: team co-operation, leadership and initiative, interpersonal skills, self-management, high-level communication skills, organisation and planning, adaptability and work culture awareness. The art of teaching in small groups is not in itself either easy or time-saving (Brown, 1997). The Stage 3 students here will already have had some experiences of group work including advice on learning how to work in groups, factors affecting group working, chairing a group meeting, monitoring teamwork skills and assessment of group work (Northedge, 1990).

Concurrent, group, project-based practicals are laboratory experiments which run over several sessions and as such they are essentially small projects. The students work as small groups within the module cohort and, most importantly, each group only performs one project during the module. There may be three or four project-based practicals running concurrently depending on the total student numbers within the module. This approach has now been used for several years as 3 x 3 hour laboratory sessions. It helps to deal with the increasing number of students now entering Stage 3, makes best use of the reduced amount of overall practical time within this module, helps overcome equipment limitations and satisfies the need to make practicals more cost effective. The project-based practicals also develop and change with each year they are used. They are designed as on-going investigations, as real research projects would be, and each successive year cohort is given the report, references and other information from the previous year so that they can develop the project further by identifying problems, formulating a hypothesis, designing and performing the investigation, analysing the data and forming conclusions. The successful use of concurrent project-practicals in this module as an aid to the teaching and assessing of large student numbers in an educationally productive and yet time-and cost-effective manner has been described (Bradley *et al.,* 1995).

It is essential, if the students are to acquire the theoretical knowledge provided each practical when they do not actually perform it, that there is efficient information exchange between the groups. The main problems previously encountered, as judged by student questionnaires and staff observation, were in the feedback of information horizontally between groups in the same year cohort and vertically between subsequent years. This current development attempts to address these problems especially by the use of multimedia techniques.

"Multimedia" can refer to a computer-based system that may combine several components of text, sound, still images, full-motion video, animation and graphics (Velleman & Moore, 1996). The main disadvantage of video, in its traditional technological forms, is that it is passive but the incorporation of new multimedia instructional methods should make it a more effective teaching/learning aid (Moore, 1993). Interactivity with read-write software rather than the read-only version has been shown to be more effective in computer-assisted learning (Inglis *et al.,* 1995). Multimedia, computer-based training (CBT) has also been shown to enhance the teaching and learning experience in a variety of situations (Vidal & Iskander, 1997; Kallinowski *et al.,* 1997). The most obvious strength of video as an aid to learning is that it can take students outside of the laboratory, a most desirable advantage in a module where field sampling is required and student availability is often constrained by the modular degree timetable. Through correct editing, especially if this is performed by the students themselves, it can also concentrate the attention on past events and on important points.

Programme of work

The concurrent project-practicals were run essentially as they had been for the past three years. The number of students in each group varied from four to five. A new title was introduced for this year and thus four project-practicals were run concurrently. These involved aspects of Environmental Microbiology using locally available resources;

1. Biodegradation of polyurethane in soils.
2. Bacteroides fragilis group bacteria in marine environmental samples.
3. Survey of apple phylloplane yeasts and moulds.
4. Fungal growth in four compost types.

Allocation to groups was based on students' preferences and then by drawing lots if groups were uneven in numbers. The three available laboratory sessions are essentially:

1. an initial explanatory, organisational session including assessment criteria generation
2. a sample processing session
3. a final further investigation/results/problem-solving session.

Additional laboratory time is often required outside these timetabled sessions for sampling and sub-culturing. Group organisational skills are certainly required here. Lack of effort by some group members is a common problem which could result in poor group scores for staff-marked components. This can be overcome, to some extent, by the use a staff imposed "yellow and red card" system following any complaints by other group members. This ultimately results in a zero score for this assessment for the particular student making a limited contribution to the group product. Discussion of the progress of these project-practicals can be made in the available seminar sessions if the students so decide. Technical assistance is available, as always, for the preparation of materials but the students must request these in advance using an order form.

This year, in order to facilitate effectiveness of the feedback processes, several developments were encouraged and several improvements of previous techniques were used:

1. The production of enhanced word processed reports in which all of the group members were to have an input,
2. Oral presentations which utilised multimedia video clips which had been shot a and edited by the students during the project-practicals,
3. The production of a database of these video clips which are easily accessible to current and future cohorts using a dedicated laboratory based PC. A selection of these were also to be made available over the Internet from the module website.
4. A member of each student group was allocated the role of "facilitator" and moved between the groups encouraging information exchange whilst the projects were progressing.
5. A dedicated post-graduate demonstrator was used who was familiar with the projects in use and with the computer software used to generate the multimedia presentations.

Student Assessment

Assessment was achieved collaboratively by a combination of a staff-marked group report and a self/peer assessment of individual performance. The use of this type of assessment again allows for learning by interaction. Indeed, the assessment process is thought to maximise the amount learnt and has been shown to work in a number of contextual situations in this University (Bradley, 1990) and to promote skills capability (Falchikov, 1988). The skills learnt here are among those most desired in graduates by a wide range of employers. The mark of a true professional is often seen as the ability to criticise ones own performance and those of ones peers. Stage three students, as more mature and experienced individuals, are probably more comfortable and reliable in this type of assessment and for many of them this is not their first experience of self/peer assessment. The validity of the assessment is improved when the criteria for assessment are developed and understood by the assessors, in this case the students (Cowan, 1988). The weighting of these assessment components and the criteria for the self/peer assessment are therefore decided upon by student negotiation during the initial session. This session must be carefully managed by the tutor. Criteria have to be distilled down to those which the students can understand, can usefully be applied by the students and are useful to the tutor for assessment purposes. With appropriate handling of the group discussion these criteria should be four or five of those attributes listed above as employer-identified skills. It is important to emphasise in these sessions that the mark will be used although it may be modified, if necessary, if intra-group discrimination is not applied or if unwarranted, excessively high marks are reported.

Evaluation

As with previous years, student feedback was sought regarding the success of the project-practical approach to this Stage 3 module. In order to obtain an evaluation of the effectiveness of the changes introduced this year, questions were added to the questionnaire used in previous years so as not to invalidate the data regarding project-practicals from earlier groups. These questionnaires were circulated with the results of the collaborative assessment.

Outcomes

The concurrent project-based practicals were all once again successfully completed in the time allocated and the written and oral reports were presented by the students to the other groups who had not followed the same practical. The group reports were all word-processed and generally well produced and referenced. These will be available for future years of students to utilise and to plan their extensions to the project-based practicals. The oral presentations were around 30 minutes in length and again generally of a reasonable quality with all group members taking part. All of the groups took advantage of the ability to use multimedia video which appeared to give a new dimension to the presentations and added zest. The students had access to a portable video camera and a 200MHz Pentium PC with 4Gb SCSI hard drive, a MiroDC30 video capture card and associated editing software with which they had the option of producing and adding video clips to their presentation. The entire video collection is also available for future cohorts.

Whilst it may be true that shooting and editing good on-location video is skilled and time-consuming and that poor video can be extremely annoying to watch, the concept that the learners themselves shoot and edit the video circumvents this problem to some degree. The majority of students did not need advice on using the video camera since they have previous experience. It was important to stress the need to keep clips short so that they can easily be edited on the computer. The students were told to think carefully about each sequence before filming so that they would find the editing process more straightforward. The clips can be further edited for use externally or by further cohorts if necessary. A major problem was that the software used was not easy to come to grips with and the images produced can require large amounts of disc space. Nevertheless, since length, smoothness of motion and size of window are all easily observable effects, this stimulated the production of "reasonable" clips and on one occasion further, rehearsed, reshooting of scenes was observed. A selection of the video clips will shortly be available on-line (module website) and some screen-shots from all four project-practicals are attached on disc (.bmp files). It is hoped that these will stimulate the new cohort and produce even better project-practicals next year and in subsequent years.

The collaborative (staff/peer/self) assessment was carried out successfully with comparable results (mean mark = 69.6%, SD = 5.9) to the previous three years of concurrent project-based practicals (Table 1) indicating a reliable assessment. Each criterion appeared to have been applied in a valid manner by the students. The project-based practicals were, as they had been previously, well received by the students when judged by the questionnaire (Figure 1) 47.1% thought that they were better than other group practicals they had experienced. Most importantly, the number of students obtaining useful information from the feedback sessions went up from 52.3% in previous years to 88.2% with 17.6% instead of 0% claiming this provided a lot of information. That this could be attributed to the use of multimedia was given further support by the fact that the majority of students claimed that this enhanced the feedback experience, that they had indeed used the video technology and that they had gained a new set of transferable skills during this process. Additionally they had become aware of the need for a coherent approach, from pointing the camera to completing the editing process. One group took an alternative format using a series of captured still images to illustrate their project-practical. A drawback which has been levelled at the use of computers is that it can sometimes limit student-student interactions however, this small-group production approach appears to get around this problem.

It was unclear whether the use of a student "group facilitator" to move between groups and exchange information had any influence on the proceedings. One student volunteer from each group was allocated this role. They did perform this task, some with more enthusiasm than others, but any direct effect was not readily apparent.

There are some important disadvantages with the new multimedia feedback of approach. Technical problems include the unpredictable and unusual nature of some of the requirements which are often needed at short notice. There is a demand for "out of class" work space and technical support. Timed access to technical help could be possible but this may stifle certain developments. Considerable outlay is required for the provision of a video camera and multimedia computer hardware and software. A shared system makes access less than easy and creates unnecessary constraints on the development of new skills. Additionally the inherent difficulty of biological material and a number of groups using the camera, make it essential to have a dedicated system. The software chosen needs to be easy to use by the students or sufficient training needs to be provided; this takes up valuable time. Indeed, this approach is very time consuming in terms of student, tutor and technician time, but the benefits are potentially worth this investment. Some reappraisal of the role of the tutor is required. It is often difficult to stand back and guide from a distance when promoting this student-active, independent learning. The degree of apparent lack of control can sometimes be unsettling! Indeed this is not an easy way out, as facilitator the tutor must act as negotiator, counsellor, manager and, since large amounts of paper and files are generated, as secretary.

The original project-based practicals have certainly helped to deal with the increase in number of students in Stage 3, maximised the reduced amount of overall practical time within the module, helped overcome equipment limitations and the need to make practicals more cost effective. It is hoped that the multimedia improvements have further helped this process and also helped to generate confident, articulate graduates with good teamwork and leadership skills thereby making them more acceptable to employers.

Further developments

Looking ahead the student "group facilitator" role must be extended and/or monitored more effectively in future years. Enhancing the videoclips by the incorporation of narration and sound will also be a major priority. This will make the presentations "multimedia" in the true sense of the term. This has been difficult so far due mainly to the user-unfriendliness of the software. It would also be helpful to have a means of returning the images to videotape format once edited; this is not possible at present. Recent advances in computer technology and digital cameras should make developments of this kind easier and enhance the student experience. The place of the tutor in this type of teaching needs to be carefully considered, especially with the difficulties some tutors sometimes find in "taking a back seat". The use of the material generated by these project-based practicals outside this module has still to be accomplished, although its availability on the module website will help. There may be some, as yet unseen, more long-term, subliminal effects associated with the use of video and these may need to be carefully monitored.

Multimedia video does not appear to be a replacement for a traditional report, although visual evidence of previous years seems to put students at ease and stimulates group thought and suggestions since this, unlike a report, can be viewed as a group. It is not easy to take notes from a repeatedly moving image whose subject is often non-linear, but it is an ideal addition. It is hoped that the students will be more confident about how they will approach videoing the projects in future years, after they have viewed the current efforts. It was not clear from the questionnaire precisely which transferable skills had been improved and it may be helpful to try and establish this. At the very least these should be evidenced, in curriculum vitae or personal portfolios, for use in employment applications.

Hints list for multimedia use in practicals

Do:

- Have a dedicated (i.e. accessible) battery-powered video camera.
- Use a different video tape for each group.
- Have a top range PC with large hard disc capacity.
- Keep a track of all clips and files produced.
- Obtain good editing software.
- Have a knowledgeable demonstrator with time to disseminate video, image capture and editing information.
- Organise the feedback session in a suitably equipped venue with more than enough time.
- Retain your sense of humour!

Don't:

Disregard any of the above.

References.

Bradley, G. (1990). But will it work? Collaborative assessment in context. Polyteach, 7: 6-7.

Bradley, G., Gaudie, D. & Wilson, N.G. (1995). Linked project-based practicals for teaching and assessing large numbers of Stage 3 students. SGM Education Symposium, University of Bath.

Brown, S. (1997). The art of teaching in small groups 2. New Academic, 6 (1): 3-6.

Cowan, J. (1988). Struggling with student self-assessment. In; Boud, D. J. (Ed) Developing student autonomy in learning. Kogan Page. pp192-210.

Entwistle, N.J., Thompson, S. & Tait, H. (1992). Guidelines for promoting effective learning in higher education. Edinburgh, Centre for Research on Learning and Instruction, University of Edinburgh.

Falchikov, N. (1988). Self and peer assessment of a group project designed to promote the skills of capability. Programmed learning and educational technology, 25(4), 327-339.

Garvin, J.W., Butcher, A.C., Stefani, L.A.J., Tariq, V.N., Lewis, M.H.R., Blumson, N.L., Govier & Hill, J.A. (1995). Group projects for first-year university students: an evaluation. Assessment & Evaluation in Higher Education, 20 (3): 273-288.

Kallinowski, F., Mehrabi, A., Gluckstein, C., Benner, A., Lindinger, M., Hashemi, B., Leven, F.J & Herfarth, C. (1997). Computer-based training: A new method of surgical education. Chirurg, 68 (4): 433-438.

Inglis, T.J.J., Fu, B. & Kwokchan, L. (1995). Teaching microbiology with Hypertext - first steps towards a virtual textbook. Medical Education, 29 (6): 393-396.

Moore, D.S. (1993). The place of video in new styles of teaching and learning statistics. American Statistician, 47 (3): 172-175.

Northedge, A. (1990). Good Study Guide. Open University.

Velleman, P.F. & Moore, D.S. (1996). Multimedia for teaching statistics: promises and pitfalls. American Statistician, 50 (3): 217-225.

Vidal, O. D. & Iskander, (1997). Multimedia modules for electromagnetics education. Computer Applications in Engineering Education, 5 (4); 257-267.

Acknowledgements.

Thanks to the Science Education Enhancement and Development (SEED) and its programme co-ordinators at the University of Plymouth.

Mrs Jo Carter for technical help and advice.
Miss Laura Biggs for demonstration skills and suggestions and image editing.

Table 1. Mean percentage marks (SD) obtained for three years (1995-1997) using collaborative assessment of concurrent microbiology project-practicals and for one year (1998) using improved feedback methods.

Year	Individual (peer/self)	Report (staff)	Final (by negotiation)	Previous non-concurrent
1995	76.3	61.3	68.7 (3.2)	71.6 (3.2)
1996	90.0	53	63.2 (4.6)	
1997	79.1	54	64.7 (4.2)	
1998	76.0	58.5	69.6 (5.9)	

Figure 1. Student questionnaires obtained after performing concurrent microbiology project-practicals; a) before feedback improvements 1995-97, b) after feedback improvements 1998.

a)

In relation to other **group practicals,** how would you rate these project-practicals?

Better 11   Same 9   Worse 0

How much useful information did you obtain about the **other groups**' project-practicals (e.g. do you know what they investigated, what methods they used etc..)?

A lot 0   Some 11   Very little 10

PLEASE make any other relevant comments about this approach...

b)

In relation to other **group practicals,** how would you rate these project-practicals?

Better 8   Same 6   Worse 3

How much useful information did you obtain about the other groups' project-practicals (e.g. do you know what they investigated, what methods they used etc..)?

A lot 3   Some 12   Very little 2

How did the availability of the video camera and software contribute to the feedback from the other groups?

Enhance 14   No effect 3   Diminish 0

Did you personally use either the video camera or the editing software?

Yes 13   No 4

If YES, did using the video camera and software give you any new transferable skills?

Yes 10   No 3

Stills from the polyurethane study;

Plating cut for polyurethane degrading microbes.

Identifying isolates

Inoculating polyurethane prior to burial.

NOTES

NOTES

THE SEED PROJECTS

Project 1: A web based bibliographic database on Science teaching and learning, designed to support the information requirements of the SEED Projects.
Nigel May, Science Faculty Team Co-ordinator,
Tel: 01752 - 232318, E-mail: nmay@plymouth.ac.uk.

Project 2: An investigation of the potential development of Curriculum Support Teams.
Nigel May, Science Faculty Team Co-ordinator,
Tel: 01752 - 232318, E-mail: nmay@plymouth.ac.uk.

Project 3a: A handbook on field teaching in the Sciences.
Colin Williams, Geological Sciences,
Tel: 01752 - 233103, E-mail: c1williams@plymouth.ac.uk.

Project 3b: Field discovery days.
Colin Williams et al., Geological Sciences,
Tel: 01752 - 233103, E-mail: c1williams@plymouth.ac.uk.

Project 4: Fieldwork issues and developments.
Les Ternan, Geographical Sciences,
Tel: 01752 - 233060, E-mail: jternan@plymouth.ac.uk
and Andy Elmes, SEED Programme,
Tel: 01752 - 233532, E-mail: aelmes@plymouth.ac.uk.

Project 5: A handbook on laboratory teaching.
Les Jervis, Biological Sciences,
Tel: 01752 - 232929, E-mail: ljervis@plymouth.ac.uk.

Project 6: Peer assisted learning strategies (Supplemental Instruction) (P.A.L.S (S.I.).
Stuart Johnston, Educational Development Services,
Tel: 01752 - 233317.

Project 7: Development of a framework for the training and management of graduate teaching assistants.
Rhona Sharpe, Educational Development Services,
Tel: 01752 - 232346, E-mail: rsharpe@plymouth.ac.uk.

Project 8: Development of a computer-aided learning package for environmental organic chemistry.
Steve Rowland, Environmental Sciences.
Tel: 01752 - 233013, E-mail: srowland@plymouth.ac.uk.

Project 9: Environmental issues in the Mediterranean: a case study of the Maltese Islands.
John Stainfield, Geographical Sciences,
Tel: 01752 - 233069 - E-mail: jstainfield@plymouth.ac.uk.

Project 10: Computer based assessment in science: a review of good practice.
Dan Charman, Geographical Sciences,
Tel: 01752 - 233058, E-mail: dcharman@plymouth.ac.uk
and Andy Elmes, SEED Programme,
Tel: 01752 - 233532, E-mail: aelmes@plymouth.ac.uk.

Project 11: CAL and basic Science.
Neil Witt, Institute of Marine Studies,
Tel: 01752 - 232417, E-mail: nwitt@plymouth.ac.uk.

Project 12: A handbook on employer-links in Science.
Stuart Lane, Biological Sciences, Tel: 01752 - 232908,
E-mail: slane@plymouth.ac.uk and Mandy Burns,
Learning and Research Support Services,
Tel: 01752 - 232255, E-mail: mburns@plymouth.ac.uk.

Project 13: Using multimedia for providing feedback to students undertaking concurrent project-based practicals.
Graham Bradley, Biological Sciences,
Tel: 01752 232934, E-mail: gbradley@plymouth.ac.uk and
David Gaudie, Biological Sciences,
Tel: 01752 - 232945, E-mail: dgaudie@plymouth.ac.uk.

Project 14: An environmental data base for projects in environmental impact assessment (EIA) and conservation.
Andrew Williams, Geographical Sciences,
Tel: 01752 - 233059, E-mail: awilliams@plymouth.ac.uk.

Project 15: Webkit - a toolkit to produce interactive web pages in support of CAL.
Kevin Rowley, School of Computing,
Tel: 01752 - 232621, E-mail: krowley@plymouth.ac.uk.

Project 16: Qualifications update in applied Science for industry (QUSI).
Mike Lister, Cornwall College,
Tel: 01209 - 712911, E-mail: m.lister@cornwall.ac.uk.

Project 17: Baseline assessment of competencies and skills for Science and Computing.
Dave Croot, Geographical Sciences,
Tel: 01752 - 233070, E-mail: dcroot@plymouth.ac.uk and
Stanley Oldfield, School of Computing,
Tel: 01752 - 232552, E-mail: soldfield@plymouth.ac.uk.

The SEED Programme

Faculty of Science
University of Plymouth
Drake Circus
Plymouth PL4 8AA

Tel: 01752 233530
Fax: 01752 233534

Programme Manager: Brian Chalkley
e-mail: bchalkley@plymouth.ac.uk

Programme Officer: Andrew Elmes
e-mail: aelmes@plymouth.ac.uk

http://www.science.plym.ac.uk/departments/seed/