Undergraduate Learning in Science Project

Working Paper 2

The Research Project Study: Design and Methodology

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March 1996

The Undergraduate Learning in Science Project is currently funded within the University of Leeds by:

The Academic Development Fund
Department of Biochemistry & Molecular Biology
Department of Chemistry
Department of Earth Sciences
Department of Education
Department of Genetics.

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Further copies of this paper and others in the series are available from:

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School of Education
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United Kingdom

ISBN: 0-904-42173-2
March 1996

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Abstract

The Undergraduate Learning In Science Project (ULISP) started at the University of Leeds in September 1994. Project members include educational researchers, lecturing staff within various science departments and others with interests in teaching and learning at the undergraduate level. The aim of the Project is to inform understanding of science teaching and learning at the undergraduate level, through a variety of research activities.

The Research Project Study was a two year ULISP research investigation into final year undergraduates experiences during project work. The results of this research study are reported in ULISP working papers 2 to 8.

This paper describes the design and methodology of the research project study. A case is made for the action research design of the study, and the collection of data in the particular context of final year research projects. The methodological strengths and limitations of the study are discussed. Finally, the interview schedules used for data collection with both students and supervisors are presented and justified.

Acknowledgements

The authors would like to thank all of the many science lecturers and science students who have contributed to the work of the Undergraduate Learning in Science Project.

Groups in departments were coordinated by:

Prof. Joe Cann	Department of Earth Sciences
Dr. Alan Radford	Department of Genetics
Prof. Steve Scott	Department of Chemistry
Dr. Ed Wood	Department of Biochemistry & Molecular Biology

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1 Introduction

Most undergraduate science courses in the United Kingdom include a project of some kind during the final year. Although different institutions and departments organise project work differently, the majority involve students in undertaking original research work on novel problems, with a view to introducing undergraduate science students to the actual practice of scientific research.

In Working Paper 1 we described our particular interest in the ways in which students learn about the actual practice of science during undergraduate courses. For many students, the final year research project is the first time when actual scientific research is encountered; we therefore identified the final year project as an important teaching context for enculturing students into the culture of scientific research.

This interest in learning about the actual practice of science was developed during informal discussions and workshop activities involving the various participants in ULISP: science educators, lecturers from various science departments and others with an interest in teaching and learning at the undergraduate level. Three broad aims for the investigation of research projects in the undergraduate curriculum were identified:

- To characterise the various learning aims identified for undergraduate project work by departments, research project supervisors, and students.

- To characterise the nature of, and interactions between, the following aspects of undergraduate research projects:
  - the learning experienced by students;
  - the teaching/supervision approaches used by departmental staff;
  - the departmental administration of research projects; and
  - the departmental approach to the assessment of research projects.

- To evaluate research projects as teaching and learning activities on undergraduate courses, in terms of the learning aims identified.

The methodology used to address these questions is described later in this paper. Firstly, however, the design of the study is described.

2 Description of the study

The study focused upon the final year research projects of 12 students from the departments of biochemistry and molecular biology, chemistry, genetics and earth sciences at the University of Leeds. Each project was completed by one student working alone, though often within a group of other students or researchers. Data were collected from the students themselves, their supervisors, and the departments hosting the projects. [1]

A longitudinal design was used for data collection from students, each student being interviewed at the beginning of the project, at a point when work was well underway, and once the written report of the project was completed. Students were also visited informally while working on their projects. In addition, students were asked to keep a journal throughout the duration of their projects. Copies of the interview schedules used with students, and the information provided concerning the use of journals, can be found in appendix 1.

Project supervisors were interviewed once, when students' project reports had been completed and were in the process of being marked. The interview schedule administered to supervisors can be found in appendix 2. Further data about departmental policies and practices in administering and assessing research projects were collected through a workshop activity involving project supervisors from each department (see appendix 3).

Written data were also collected from departments relating to administrative procedures and the assessment of projects. In particular, departmental guidelines on the assessment of projects were collected, as was any written information produced for students about completing projects or project reports.

Table 1 summarises information about the sample used in the study:

Table 1: The sample used for the research project study

Department	*Number of projects*	*Number of supervisors covering these projects*
Biochemistry & Molecular Biology	3	3
Chemistry	2	1
Earth Sciences	4	4
Genetics	3	3

[1] A questionnaire survey of students (N~250) and supervisors (N~120) has recently been designed and will be administered in May 1996.

Of the above students, 7 were female and 5 were male. 10 supervisors were male, 1 was female. The sample was identified in order to span the participating departments. Examination performance was used by departments to select students across the ability spectrum for inclusion in the sample, though no attempt was made to reflect ability in a systematic way due to the small numbers involved.

In this series of working papers, the comments of students and supervisors are treated anonymously.

3 Methodology

3.1 Methodological commitments

The design of this study is underpinned by two methodological commitments:

- a commitment to an *action research* approach, in which lecturing staff and educational researchers work collaboratively on investigating the practice of teaching and learning at the undergraduate level;
- a commitment to investigating student learning in *actual teaching contexts.*

3.1.1 Action research

Somekh (1995)[2] describes action research as:

> *'(...) rejecting the concept of a two-stage process in which research is carried out first by researchers and then in a separate second stage the knowledge generated from the research is applied by practitioners. Instead, the two processes of research and action are integrated.'*
> (p.340)

As described in working paper 1, this project emerged from a concern on the part of undergraduate science lecturers to improve their students' understanding of 'the actual practice of science'. Addressing this issue involves identifying what might be meant by 'the actual practice of science', the extent to which such meanings are shared by the various stake-holders in undergraduate science education, the contexts in which students get the opportunity to learn about the actual practice of science and the sorts of interactions that are involved in promoting learning in such contexts. The process of making the learning aims of teaching contexts explicit, and characterising the learning resulting from such teaching, is an important factor in producing improvements in practice. The validity of action research is evaluated through a constant cycle involving appraising the effectiveness of changes in practice, and communication of findings through formal and informal channels (Somekh, 1995). It is worth noting that this evaluation draws upon the practical usefulness of the research, rather than by reference to externally generated criteria.

We describe this project as an action research project because practitioners and educational researchers were jointly involved in identifying the research problems, designing and critiquing data collection instruments and analysis, and identifying findings. This was achieved through a series of workshops

[2] Somekh B (1995) *The contribution of action research to development in social endeavours: a position paper on action research methodology*
British Educational Research Journal 21 (3) 339-355

involving ULISP participants. The education researchers involved in the project organised these workshops, based on the priorities identified by the whole group. At different times during the project, workshops focused on data collection, data analysis, and identifying areas for further research (appendix 3). In addition, some workshops involved collecting data from participants on issues such as the perceived purposes of research projects in the undergraduate course. An illustration of the way in which this action research project was conducted can be found in section 3.3.4.

Each of the papers in this series has been made available for comment by ULISP participants. The content and style of the papers have been written with a number of possible users in mind. The main users are likely to be ULISP participants, whether science lecturers or science education researchers. An attempt has been made to produce as full an account of the project as possible for this audience, with summaries being used as appropriate for readers whose interests are more related to implications for practice than the research basis of findings. It is hoped that other science lecturers will find this approach to reporting the work useful and accessible. A further audience for the papers is the science education research community, and we have therefore made explicit the theoretical grounding of our work. Future publication plans include articles for the science education research community.

3.1.2 Contexts for data collection

So far, the Undergraduate Learning in Science Project has investigated the ways in which undergraduate scientists go through the process of 'becoming a scientist' in two curricular contexts, namely final year research projects and first and second year tutorials. These contexts were selected because their primary purpose was to teach about the actual practice of science (see working paper 1). Matthews (1994)[3] has argued that science education should include explicit teaching of the history and philosophy of science, in order to enhance understanding of particular scientific ideas, and documents a number of approaches to science teaching in which historical and/or philosophical subject matter is covered. But there is evidence that scientists hold different views of 'the nature of science' in general, the nature of science in their own disciplines, and the nature of science in their own work (Samarapungavan, 1992)[4]. Our interest is upon the ways in which undergraduates become encultured into their own disciplines and for this reason, our focus is upon documenting students' understandings of the actual practice of science within their own disciplines and in the context of their own investigative work.

A range of information and data was used to inform the study. Our perspective on teaching and learning science at the undergraduate level was

[3] Matthews M R (1994) *Science Teaching: The role of history and philosophy of science* (Routledge)

[4] Samarapungavan A (1992) *Scientists conceptions of science: a study of epistemic beliefs* Paper presented at the AERA Annual Meeting San Francisco April 1992

informed in part by published literature on science education, as cited in working paper 1.

As already mentioned, the bulk of the data for the research project study were collected around a longitudinal study of 12 research projects in which students were interviewed at the beginning of their projects, at a point when work was well underway, and at the end of the project when reports had been completed. These interviews were timed so that particular aspects of our research questions could be addressed at points when they were most likely to be on students' minds (see section 3.3.1). A longitudinal design was used so that we would be able to comment upon the interacting factors in research projects and their possible roles in promoting learning (Leach et al[5]). It was acknowledged that important events for project students might occur between interviews, and might subsequently be forgotten by students before the next interview. For this reason, students were asked to keep a diary for the duration of their projects, and these were passed to interviewers before interviews so that interesting issues could be followed up. A number of informal visits to project students were also made with the aim of identifying important happenings in the research projects, and to get a sense of the students' working environments. Each interview with a given student was carried out by the same researcher, two researchers covering the 12 project students. Interviews were carried out in a private office, and were tape recorded and transcribed in full. These transcripts comprised the data source for interviews with students. A number of early interviews were observed by another researcher, to ensure consistency of approach.

Project supervisors were also interviewed. It was only deemed necessary to conduct one interview with supervisors in addressing our research questions (see section 3.3.3). Interviews were carried out in private, and audio-taped in full. Each project supervisor was interviewed by the researcher who had interviewed the project student. Some interviews were observed by another researcher. Again, the data source for these interviews were the full transcripts of the interviews.

Some aspects of our research questions related to departmental procedures and policies, particularly in the area of project assessment. Written departmental procedures relating to research projects were collected, and some workshop time was allocated to discussing the procedures followed in particular departments (see sections 3.3.4 and 3.3.6).

It is recognised that written or espoused policies on project administration and assessment may differ from actual practice. For this reason, a number of different data sources were used in addressing several aspects of our research questions, as described in the next section.

[5] Leach J, Driver R, Millar R and Scott P (1995) *Progression in Learning about 'the Nature of Science': Issues of Conceptualisation and Methodology* Chapter 5 in *Progression in Learning* ed. Mark Hughes BERA Dialogues 11 (Multilingual Matters Ltd) ISBN 1-85359-309-5

3.2 Sources of data used to address each of the research questions

The first research question relates to the learning aims identified for projects. A number of questions were written into interview schedules in order to characterise the various learning aims identified for undergraduate project work by supervisors and students. Also, written information about the aims of project work was collected from departments and lecturers reported their departments' policies as well as their personal views at workshops.

The second research question of the study involved characterising the nature of, and interactions between, the following aspects of undergraduate research projects:

- the learning experienced by students;
- the teaching/supervision approaches used by departmental staff;
- the departmental administration of research projects; and
- the departmental approach to the assessment of research projects.

Information from interviews, workshops and departmental policies was used to make this characterisation.

The final research question involves evaluating projects as teaching and learning experiences for students. Research projects were evaluated as teaching and learning activities on undergraduate courses by ULISP members in terms of the learning aims identified above, and the perspective on teaching and learning described in working paper 1. To this extent, all data sources and literature on science education were drawn upon in making these evaluations.

3.3 The design of the data collection instruments

Data collection instruments were used in this study to address the first two research questions. The evaluation identified for the final research question can only be started once the first two research questions have been addressed, and no specific data were collected in the context of this question.

3.3.1 Interview schedules for use with project students

Some aspects of the research questions were deemed more appropriate to address with students at the beginning, the middle, or the end of their research projects. Three interview schedules were therefore prepared, with differences in focus, and administered at different times in the projects.

It was anticipated that students' views about a number of aspects of research project work might change as their projects progressed, and questions on these issues were therefore included in the first and third interview, or all three interviews. For example, students were asked about their views of ideal project supervision in each interview, as the role of the supervisor might be different at different points in the project. In other cases, it was felt that there were good reasons to assume that students' views might remain

fairly constant and that questions could be included in only one of the interview schedules. For example, it was not felt necessary to ask students about the process of project allocation after the first interview.

In each interview, a number of general questions were included to give the interviewer a feel for the context of the project. For example, questions on the scientific context of the project were included at various points, as were questions about the environments in which students were working and the relationships between project work and other commitments. In particular, the second interview related to the details of particular research projects.

Students' views of the aims of projects in the undergraduate course were probed in interview I sections A-D, and in interview III section A. Students overwhelmingly identified the aim of undergraduate projects as introducing them to 'real' scientific research in interview I, and for this reason question A2 was phrased in these specific terms in interview III.

Students' views about the ideal supervision of projects were probed in interview I section B, interview II section D, and interview III section C. Their views about project assessment were probed at the outset of projects (interview I section B), and once project reports were in the process of marking (interview III section C). Views about the process of allocating students to projects were probed in interview I section B.

A major focus of the interviews with students was upon their enculturation into the world of scientific research within their disciplines. In order to characterise this process, interview questions were designed which related to students' prior expectations about what completing a research project might involve (interview I sections A, C, D and E) and their views about what was actually involved having completed the project (interview III sections A and D). Also, interview II addressed the nature of research activities actually being undertaken as part of the project (sections B, C and D). These questions also allowed us to probe students' views about a number of key aspects of their disciplines as identified in working paper 1, such as the purposes of various activities performed in their disciplines, the nature and structure of disciplinary knowledge, the methods through which enquiries are carried out within the discipline and the social dimensions of the discipline.

An additional interest related to the extent to which students' views of the nature of science in more general terms were influenced by the experience of completing an undergraduate project, and an identical set of questions was included in interview I section F and interview III section B.

Each interview schedule was piloted before use. Complete copies of the interview schedules used with project students can be found in appendix 1.

3.3.2 Log books for use with project students

The purpose of the log books was to provide students with a means of recording important events in their projects between interviews, that might

otherwise not be raised in interviews. It was therefore necessary to encourage students to use their log books flexibly to record whatever they felt to be important. Students were encouraged to make at least one entry into their log books per week, so as to maximise the likelihood of important events being recorded. In practice, the frequency and depth of comments in log books varied considerably between students, and for individual students at different stages of the projects.

Log books were read by interviewers prior to interviews, and interesting points were raised in interviews. As such, data from the log books is incorporated into interview transcripts. Although quotations from log books are used in subsequent working papers for illustrative purposes, no formal analysis of the texts was performed.

A copy of the information provided for students about the use of log books can be found in appendix 1.

3.3.3 Interview schedule for use with project supervisors

The interview schedule used with project supervisors incorporated questions relating to all aspects of the first two research questions of the study. The supervisors interviewed during the study had all supervised projects before, and most were experienced supervisors. As we were not interested in supervisors' learning about the process of supervision through the projects, a longitudinal design was not necessary; data were collected through one interview only.

Supervisors' views about the learning aims of research projects were probed in section A of the interview schedule, which involved questions about the contribution of research projects to undergraduate courses, and the essential requirements of a project for it to make such a contribution.

Views about the nature of, and interactions between student learning, supervision approaches, departmental administration and assessment of projects were probed in a number of different ways. The notion of enculturation is central to our perspective on teaching and learning science. We were therefore interested to probe supervisors' views about the contribution of particular projects to broader research programmes, and question A3 therefore focused on how particular projects had arisen as areas of enquiry. Questions in section B focused on the student's experience of the project, including the nature of findings, the students' strengths and weaknesses, and comparing the student's approach to the project with that which might be taken by a more experienced scientist. Question C5 asked supervisors explicitly about the image of 'being a scientist' that they would wish students to have at the end of the project. Supervisors' views of ideal project supervision, and their own approach to the supervision of the particular project in question, were probed in section C of the interview. Also, supervisors were asked about the criteria that were to be used in assessing the student's performance on the project. Supervisors' accounts of

the departmental administration of projects were probed in questions A2 and A3.
Each interview schedule was piloted before use. A full copy of the interview schedule used with project supervisors can be found in appendix 2.

3.3.4 Workshop activities for use with project supervisors

A number of sessions were designed to allow for data collection from lecturers. In particular, data were collected about lecturers' views of the 'enquiry skills' needed by undergraduate scientists, and appropriate teaching contexts through which such skills might be developed. At the December 1994 workshop, groups of lecturers were presented with four examples of teaching activities used in particular departments for developing enquiry skills, namely a tutorial activity on data analysis in the context of glycolysis, an activity to model the geology of an area based on data analysis and interpretation, a research project to trace the evolutionary lines of species of bacteria through the use of a database of gene sequences, and a lecture course on the fundamentals of physical chemistry. These activities had been identified during informal conversations with various lecturers at the planning stage of the project. Small groups of lecturers were asked to identify the 'enquiry skills' that could be taught through each activity, and how such enquiry skills might be incorporated into a teaching programme.

Each group prepared an overhead transparency of their decisions, which was presented to the remaining participants. Educational researchers took field notes on these presentations, and the transparencies were also collected. Following the workshop activity, these notes and transparencies were then analysed, and all enquiry skills raised by groups were recorded. In addition, educational researchers added enquiry skills mentioned in research literature not noted by the ULISP group. All the enquiry skills were then grouped into similar skill areas, and this list was presented back to ULISP participants at the March 1995 workshop. Again, small groups of ULISP participants read through the list, adding and amending as felt appropriate. These modified lists were discussed, collected by educational researchers, and form the basis of the lists reported in these working papers.

Students' responses from the interviews were presented to lecturers during workshops in order for collaborative work on devising coding schemes to take place, and to provide feedback on practice. For example, at the January workshop ULISP participants were presented with anonymous extracts from transcripts of where students talked about the supervision process. Working in small groups, commonly-occurring features in students' responses were noted and reported. Again, overhead transparencies from the small groups and field notes from presentations were used as a data source. Educational researchers also presented their initial attempts at analysis to supervisors for comment and critique.

A full description of all workshop activities carried out to date can be found in appendix 3.

3.3.5 Informal visits to students

Students were visited by interviewers in the laboratories/departments in which they were working. These visits were made at an early stage in projects, in order for interviewers to get a sense of the environments in which work was being conducted, the techniques involved and so on. Field notes were kept from such visits, and were drawn upon in interpreting aspects of interview transcripts as appropriate.

3.3.6 Information collected from participating departments

Written information was collected from departments about research projects where available. In particular, information sheets for students and project supervisors about the assessment of projects were collected, as were lists of the actual projects offered to students. Again, there was some variation between departments in the amount of detail included in such documents.

3.4 Approach to data analysis

The aim of data analysis in the research project study was to provide a characterisation of various stake holders' views about the aims of research projects and the various factors that promote learning during projects. An ideographic approach to analysis was used in that all data were analysed with a commitment to reflecting the content of students', lecturers' and departments' views about various issues in the terms in which the views were stated, rather than evaluating particular viewpoints in terms of some normative position (Driver and Erickson, 1983)[6]. Different approaches to data analysis were used, according to the nature of the data.

Interview data in the form of full transcripts were analysed on a question by question basis in order to characterise the range of students' responses across the sample. Responses were read by an educational researcher, and a note was made of commonly occurring features. For a number of parts of the interviews, analysis was performed on students' responses to groups of similar questions, and in all cases an attempt has been made to characterise students' responses across the whole interview rather than within specific questions. The process of reading responses and identifying commonly occurring features was also carried out by participants at a ULISP workshop, and additional features were incorporated into the list. A coding scheme was then produced incorporating all points on this list of features, the coding scheme was reapplied to the data and amended as necessary. This process of re-allocation and amendment involved all three educational researchers. Final drafts of coding schemes were discussed in workshops where possible, and circulated to interested ULISP participants for comments. Coding categories are illustrated by the use of typical extracts of transcript in subsequent working papers.

[6] Driver R and Erickson G (1983) *Theories-in-action: Some theoretical and empirical issues in the study of students' conceptual frameworks in science* Studies in Science Education 10 37-60

Data from log books were analysed by the interviewer associated with that project, and informal judgments were made as to important aspects of students' experiences on projects which would not come up in response to questions on the interview schedules. These issues were then probed at interview.

In addition, a number of case studies of particular research projects have been prepared (see list of working papers in appendix 4). These serve the function of illustrating students' progress during research projects, and the sorts of factors that influence this progress. By 'progress' we include changes in students' views of the purposes of research projects in the curriculum, the nature of ideal project supervision, administration and assessment, the nature of scientific enquiry in the context of a project within a specific discipline, and the nature of science at a more general level. Data from student interviews, supervisor interviews, informal visits and log books have been drawn upon in preparing such case studies.

The purpose of data analysis from the workshops was to characterise ULISP participants' views on particular issues, to reflect this characterisation back to the participants and to amend the characterisation in the light of participants' comments. All points raised by ULISP participants were therefore recorded, and an attempt was made to group similar issues. Educational researchers included points raised in research literature but not raised during workshops at this stage. Such characterisations were then reflected back to workshop participants for discussion and feedback, and were amended accordingly.

4 Methodological critique of the study

As a methodology, action research has the advantage of allowing practitioners to understand their practice better, and to make changes to their practice as they wish to. As action research focuses upon the particular concerns of a group of practitioners, samples are constructed in a pragmatic way: there is no sense in which the sample used in this study can be taken to represent the population of undergraduate science students in the U.K., for example. On the other hand, the sample used does allow for insights to be made by lecturers in the participating departments about the students that they tend to encounter. In order to generate detailed insights into the nature of learning in particular contexts, sample sizes are necessarily small. In the case of this study, for example, the number of projects observed represents a small fraction of the total number of projects undertaken in each participating department. These case studies have been undertaken in order to identify a range of factors likely to be relevant to undergraduate learning through research projects, though at this stage it is not possible to quantify the likely prevalence of such factors across all projects within a department. Findings from the case studies have been used to design written surveys for administration across a more representative sample of students and supervisors (working paper 7).

Action research is pragmatic in its purposes: the primary aim is to improve practitioners' understandings of their own work in particular contexts rather than to generate broadly applicable findings. To this extent, it could be argued that findings from studies such as this one are of no use outside the limited contexts in which they were generated. We would certainly urge caution in the application of findings described in this series of papers to different contexts. Having said that, we imagine that the way we have characterised features relevant to learning in undergraduate project work may be of interest and stimulate reflection among science lecturers in other Science Departments in the University of Leeds and other Higher Education Institutions.

5 Appendices

5.1 Appendix 1: interview schedules used with project students and information on the completion of log books

5.1.1 Interview I: Administered at the beginning of projects

A Details concerning the research project and the student:

A1 Tell me about your project, bearing in mind that I am not a specialist.
A2 Is your research project related to other work in the department?
A3 In your view what is the main aim of your project?
A4 Have you ever worked as a scientist outside of university?
A5 What do you hope to be doing after you have completed your degree?

B Project management in departments

B1 Was this project your first choice when you were deciding which project to do?
B2 What was your motivation for including this project in your choices?
B3 Are you satisfied with your project allocation?
B4 What in your view would be ideal supervision of the project?
B5 What can you tell me about how your project work is assessed?
B6 Do you feel adequately prepared to begin a research project?

C Students preconceptions about the nature of research project work

C1 Could you describe for me the kind of activities you feel that you will be involved in over the period of your research project?
C2 Which aspects of the research project do you think that you will enjoy the most?
C3 What do you think would be the best/worst possible outcome of your project.

D The purpose of research projects in the undergraduate course

D1 Why do you think that research projects are part of the undergraduate course?
D2 In your view who will be interested in the results of your project?

E Research Projects as 'real' science

E1 Do you think that your project will give you an insight into the work of a professional scientist?
E2 In what respects will your project work and the work of a professional scientist differ?
E3 How will you try to ensure that your project follows good scientific practice?

F Student's views of the nature of science in general

F1 How do scientists decide which questions to investigate? (i.e. what is the purpose of the scientific enterprise?)
F2 What is the purpose of scientific experimentation?

F3 How can good scientific work be distinguished from bad scientific work?

F4 Why do you think that some scientific work stands the test of time whilst other scientific work is forgotten?

F5 How are conflicts of ideas resolved in the scientific community?

5.1.2 Interview II: Administered once project work was well underway

A) What stage are you at on your project?
Ensure that this is understood in terms of the discussion about the project aims from the first interview. There may also be points from the visit which are relevant here. Follow up any new technical aspects of the project.

B) What technical difficulties have you experienced in your project? How have these problems been tackled? To what extent has the solution to these problems been within your control? To what extent have these problems impeded your progress on the project?

C) Could you describe some of the intellectual challenges that you have been faced with in your project?
E.g. thinking: the use of evidence, data interpretation, redesign of protocols, interpretation of reading, anomalies, planning of what to do next...

How have you tried to solve these problems?
Probe this in some detail - evidence of student epistemology. Use of terms such as theory, analysis, model, expected result...

D) Apart from these technical and intellectual challenges, what else has had an important impact on your progress in this project - for good or bad?
Illness/absenteeism; other university work (e.g. useful lectures, work load on other courses); interactions with other workers (personality clashes); supervision (next question)

E) How is the supervision going?
Positive points, negative points.

F) Follow up any points raised from the personal journal which have not been covered already.

G) What are your overall feelings about the project? What parts are you enjoying? What aspects do you not enjoy? Do you have any worries about the project? E.g. finishing on time, assessment...

H) Any points from the first interview which need clarifying?
E.g. work experience, a copy of the initial 'proposal'...

I) Concluding remarks
Continue to use the diary (return it to the student). Suitable period in which to do the final interview (i.e. after the assessment but not in the middle of final exams...). Does the student have any questions about the study?

5.1.3 Interview III: : Administered once project reports had been completed

A The research project as an introduction to the world of the research scientist

A1) I am interested in what you were actually doing during the hours that you worked on your project. What different things did you find yourself doing?
Expected factors: reading, library work, making notes in work book, writing up, doing practical work, analysing the results, planning, laboratory meetings, discussions with people in the laboratory.... - apply a hierarchical focusing strategy here.
- What proportion of the time did you spend on each of these?
- If we consider your project as a single timeline from start to finish when did you find yourself doing these things? *(Use a notepad here?).*
- hours of work per week / working at weekends?

A2) Do you feel that your project has included all aspects of scientific research work or has something been missing?

A3) What were the main findings of your project?
- use examples from the student's project as a 'hook'
- How do you know these things?
- How did you ensure that your project followed scientific practice?

A4) How important are your findings?
- Who has valued your results?
- Does your work fit in with other work - either in this department or elsewhere?
- how novel are your results?
- how have you tried to acquire a 'broader picture' of the place of your project in science?
- how has your ability to control the direction of the project changed?
- If you had an extra six months what would be your research questions?

B The student's explicitly stated views about what scientific research is in general.

B1) How do scientists decide which questions to investigate?

B2) Why do scientists do experiments?

B3) How can good scientific work be distinguished from bad scientific work?

B4) Why do you think that some scientific work stands the test of time whilst other scientific work is forgotten?

B5) How are conflicts of ideas resolved in the scientific community?

B6) In what way have your experiences on the project influenced your understanding of what scientists do?
- *probe by using the student's as described in B1-B5.*
- *what are the key things that you have learnt about being a scientist through doing this project?*

C Supervision and Assessment

C1) In what ways have your views about ideal supervision changed during the period of the project? Why have they changed?

C2) Has the role of those involved in your supervision been clear to you during the project?

C3) How would you describe your personal relationship with those people who have been involved with your supervision?
- i.e. Approachable? Encouraging? Supportive?

C4) What strengths and weaknesses did you show on your project?
- what were the most difficult aspects of this project for you?
- how did you react to working in an unfamiliar environment?
- how did your performance change over the period of the project?

C5) What do you know about the criteria which are used to assess your project?
- write up
- summative assessment of project performance

C6) How did you go about preparing the final write-up?
- did you know what to include? *(especially if limited 'results')*
- did the process of writing up change your view of the project?

C7) How did the assessment of your project influence what you did on the project?

C8) I appreciate that you do not know your final mark yet but do you feel that your project (has been/will be) fairly assessed?

C9) How would you assess your own project?

- what mark would you give your project?

D General Issues

D1) Now that you have completed the project what are your overall feelings about it?
- do you feel that it has been successful? Why?
- how has your motivation towards the project changed over the year?
- what surprised you about project work?
- what disappointed you about project work?
- how has your module work influenced your work on this project?
- would you have preferred a project that was more likely to get results or was more exploratory or 'risky'? *(as appropriate)*
- Have you been pushed to work to your maximum ability on this project?

D2) What advice would you give to a third year student who was about to begin a research project?
- what do you feel could have been done earlier in the undergraduate course to make you better prepared?

D3) *(If relevant)* Did your experiences in industry influence your approach to project work?

D4) Have your experiences on the project influenced your choice of future career?
- what is your intended career now?

D5) Are there any questions that you feel I should ask your supervisor?

5.1.4 Information on the completion of log books

Each student was given a journal at the end of the first interview, in the form of a board-bound A5 lined booklet. The following instructions were printed on the first two pages of the booklet, and were talked through at the end of the interview:

> Research Project Study - Using Your Journal
>
> What is the Journal?
>
> The aim of this Journal is to encourage each participating student to keep a regular record of their thoughts, feelings and ideas about their research project.
>
> The Journal will help you to reflect on your progress whilst providing valuable data for the Research Project Study.
>
> All entries will be treated as confidential and will remain anonymous.
>
> The Journal is **NOT** part of the project assessment in your department, and will only be consulted as part of the Research Project Study.
>
> What should I write?
>
> Anything that relates to your research project.
>
> This could include reflections on how well you are doing, problems, successes, insights into how to do good project work, 'blind alleys' you may have followed, or even comments about the Research Project Study.
>
> How much should I write?
>
> As much as you wish.
>
> We would suggest an entry every week as the minimum.
>
> A few comments after each project session would be ideal.

5.2 Appendix 2: interview schedule used with project supervisors

A The Research Project as part of the undergraduate course

A1) What do research projects contribute to the undergraduate course?
Expected factors: develop general skills, scientific skills, understanding of the research process, understanding of scientific concepts, preparation for future career...

A2) What are the essential requirements of a project for it to be suitable as an undergraduate research project?
- How are projects allocated to students in your department?

A3) How did this particular project come about?
- where did the *idea* come from?
- is it related to other work in the department/field?
- in hindsight how would you evaluate this project in terms of its suitability as an undergraduate research project

B The student's experience on the research project

B1) What strengths/weaknesses did the student show during this project?
- what were the most difficult aspects of this project for the student?
- how did they react to working in an unfamiliar environment?
- how did the student's performance change over the period of the project?

B2) In general what can research projects tell students about the work of a scientist? (cf. question A1)
- do you feel that the student has gained an understanding of what it is like to be a scientist through working on this project?
- what image of a scientist do you have in answering this question?

B3) What are the main findings of this project?
- are these findings important? To whom?
- do you feel that the student has a feeling for the significance of these findings?

B4) We have discussed the extent to which the research project has given the student a sense of being a scientist (B2). We have also discussed the sense that the student has of their scientific findings having a significance in the scientific world (B3). We could describe these as aspects of the student's 'broader view' of their project. What methods have you found are effective in fostering the student's sense of this 'broader view'?

B5) How would you have approached the project if you had been doing it?
- what would you see as characterising good scientific practice for this project?

- What aspects of the student's work would you say were good scientific practice and which were not?
- what have you got that they haven't?
- (*perhaps use an example from the student's project)*

C The role of the supervisor

C1) How have you supervised this project?
- what has been your role as supervisor during this project?
- what factors influenced your supervision style for this student?
- what other approaches have you found effective with other students?

C2) How has the student reacted to this supervision?
- have the students reactions changed over the project period?

C3) What criteria have you used in assessing the performance of the student on this project?
- the write-up/report
- summative assessment of performance over whole period of the project
- are these criteria standardised/written down for your department?

C4) Clearly supervision is a sensitive balance between guidance and independence involving the establishment of a personal relationship with the student. What do you feel were the successes and failures of this project in terms of its supervision?
- *What is your evaluation of your performance as a supervisor on this project?*

C5) What image of 'being a scientist' would you wish the student to have at the end of the project?

D General

D1) Did the project go as you had expected it to?
- did the direction of the project change?
- did it achieve as much as you had expected?
- did your expectations of the student change as the project proceeded?

D2) Roughly how many research project students have you supervised before?
- how many do you do each year?

D3) What issues concerning this research project do you feel we have not covered in this interview?

5.3 Appendix 3: Workshop activities undertaken during ULISP

December 1994 workshop I

Feedback on progress.
Activity on the enquiry skills required of undergraduate science students, and appropriate contexts for developing these.
Presentation from lecturers from two departments on their tutorial programmes to promote enquiry skills.
Presentation from educational researchers on students' views of the nature of science and their relevance to undergraduate teaching in science.
Administrative matters.

January 1995 workshop II

Feedback on progress.
Activity for ULISP participants to reflect on their own views of the nature of science.
Activity to consider students' responses about supervision, and to derive a coding scheme for this aspect of the interviews.
Administrative matters.

March 1995 workshop III

Activity: feedback on initial working document on data analysis from the first interview with students.
Activity: feedback on the characterisation of enquiry skills produced following the December 1994 workshop.
Discussion: future lines of work and funding.
Feedback on progress.

June 1995 workshop IV

Presentation and feedback: a perspective on teaching and learning science (draft of working paper 1).
Activity: generation of a coding scheme on students' views of how conflicts of ideas are resolved in science.
Discussion: future lines of work and funding.
Administrative matters.

September 1995 workshop V

Discussion about the **action research** methodology used by ULISP.
Activity: working through the precirculated document which gave a summary of findings arising from Working Paper 3 - an analysis of supervisor interviews.

Discussion about how findings from Working Paper 3 could be used as a basis for workshop activities with lecturers within each participating department.
Administrative matters.

January 1996 workshop VI

Activity using sections of transcriptions taken from interviews with undergraduate project students (working paper 4)
Discussion and activity about 'skills for scientists' - what these are and how we might include them in the undergraduate curriculum.
The design of the survey of undergraduate project students and supervisors - discussion of methodology and activity covering questionnaire content.

5.4 Appendix 4: ULISP Working Papers

As part of the dissemination of research findings to ULISP participants and others interested in teaching and learning of undergraduate science, a series of working papers has been prepared. Details of these are given below.

1 A perspective on undergraduate teaching and learning in the sciences

This paper sets out the perspective which participants in the Undergraduate Learning in Science Project have developed towards the broad range of issues associated with undergraduate teaching and learning in the sciences. The paper draws upon discussions within ULISP and is informed by the studies that ULISP participants have been involved in.

2 The Research Project Study: Design and Methodology

Focusing on the Research Project Study this paper gives an account of the design of the study. It also includes the reasons for designing the study in this way and the limitations and strengths of the data obtained.

3 Final year projects in undergraduate science courses

This paper gives an account of the role of projects and how they have been implemented in departments as discussed in the interviews with supervisors. The paper covers the suitability of projects for undergraduate work, the allocation of projects to students, supervision of students and assessment of projects.

4 Undergraduate science research projects: The student experience

This paper focuses on students' views and experiences of projects. Using interview data and entries in personal diaries a variety of issues are addressed from the student's perspective.

5 Undergraduate research projects and students' views of the nature of science

This working paper focuses on the students' views of science and science research as discussed in the interviews.. What themes are evident in the students understanding of science? In our sample of students how do views of these themes develop in time? For particular students how do their views of science develop through the research project?

6 Case studies of science students doing undergraduate research projects

Several detailed case studies from the Research Project Study are used to highlight particular features concerning research projects in the undergraduate curriculum. These can be used as a teaching resource for use in tutorials with second year students.

7 A survey of students' and supervisors' experiences of research projects in undergraduate science courses

Following from the 12 case studies reported in working papers 2 to 6 a survey was designed and administered to students (N~250) and supervisors (N~120) at the University of Leeds. Results and conclusions from this questionnaire survey are presented in this paper.

8 Implications and messages arising from the Research Project Study

This paper reflects on all of the work described above. It attempts to summarise the salient features and draw some implications of these findings for undergraduate teaching in the sciences.