Doing Pedagogical Research in Engineering

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Doing Pedagogical Research in Engineering

George Brown and Sarah Edmunds

July 2011

About the authors

George Brown is a retired Professor of Higher Education from the University of Nottingham. As a young man he studied electrical engineering but switched to the study of psychology. His DPhil was on the use of video recordings in skills training. He taught psychology and subsequently became involved in research on teaching in higher education and in staff development. He was co-director of the Effective Engineering Education (E3) project. He has assisted many faculties in their re-development of courses and he has provided consultancies and workshops on pedagogical research, research supervision and aspects of teaching, learning and assessment in this country and abroad.

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Published by Engineering Centre for Excellence in Teaching and Learning (engCETL).

Photographs courtesy of Glenda McMahon, Engineering Subject Centre and engCETL.

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Acknowledgements

We thank Professor John Dickens and Dr Adam Crawford, Director and Manager of engCETL for encouraging us to write this book and for their suggestions and comments. Professor John Cowan is thanked for his perceptive comments on an earlier draft of some of the text. Glenda McMahon of the Engineering Subject Centre based at Loughborough University, is thanked for her contribution to the design and print of this publication. David Goldblatt for permission to use the photograph in Unit Six and CERN is thanked for granting permission to reprint the mind map in Unit Seven. Mohammed Abdulwahad, Dr Yussuf Ahmed, and Dr Fakhteh Soltani-Tafreshi are thanked for their contributions to the text. Last, but not least, we would like to thank colleagues and students who attended our workshops on pedagogical research and who, unknowingly, prompted us to write this book.

Foreword

We should like to thank George Brown and Sarah Edmunds for this book on pedagogical research which they wrote on behalf of the Engineering Subject Centre and engCETL. Its purposes are to help and encourage colleagues in faculties of engineering and industry to do research on the diverse forms of learning, assessment and teaching so that they and future generations of colleagues are better equipped to meet the challenges ahead in undergraduate education and the continuing professional development of engineers.

The first sections of the book deliberately engage with qualitative research. This form of research is the most neglected and least understood by engineers. These units are a powerful reminder that researching people is different from researching engineering components. People have thoughts, attitudes and feelings which influence the pedagogical processes. Components do not. Later sections of the book deal with the more familiar ground of qualitative research but even here there are differences between conventional research in engineering and researching people who are learning about engineering. The final section of the book deals with both the practical aspects of getting published and the deeper philosophical issues underlying research methods.

The contents of the book may look formidable. They are not. The authors have designed relatively brief units of study: many if these can each be read in a half hour. They write in a clear, sometimes humorous way, and they provide practical suggestions, activities which develop understanding of the research methods and, at the end of the book, brief discussions of the activities. The book may not yet be part of an open learning module but it does open the pathway to learning about pedagogical research in engineering.

Professor John Dickens
Director of engCETL and the Engineering Subject Centre

Dr Adam Crawford
Manager of engCETL and the Engineering Subject Centre

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Unit 1
Introduction to the book

The purposes of this book

This book is about pedagogical research in engineering. It has been written to help new lecturers in engineering who are about to embark upon some pedagogical research, perhaps as part of a PGCHE; and for more experienced academic engineers who wish to refresh and refine their approaches to pedagogical research. If you think pedagogical research is a soft option, think again. Pedagogical research will involve you in learning new methods of enquiry, different modes of reading and thinking and writing in different styles from those you are accustomed to. You will be examining, perhaps deeply, your assumptions about what constitutes good research. A further challenge will be that the objects of your study are not components which can be taken off the shelf, experimented upon and then put back. Often the objects of study in pedagogical research are students, their teachers and practising engineers who have their own motivations, perceptions, ways of thinking and degrees of willingness to participate in pedagogical research.

The structure of this book

The book is divided into four major sections. Each section is divided into units of study. Each unit of study contains guidelines, suggestions, and activities designed to encourage you to think. For your convenience, notes on the activities are provided. If you can, please resist the temptation of reading the notes before trying the activities. At the end of each unit there are suggestions for further reading. The full references for these suggestions are given in the bibliography at the end of the book. We have deliberately not included frequent references to the literature in the text of the units nor provided a detailed list of learning outcomes. We assume you know why you are reading this book and what your own learning outcomes are. You have an opportunity to explore these issues in Activities 2.3 and 2.4 in Unit 2. If you want an abundance of references and to be told what your learning outcomes should be, then you should read other books. Better still, though, read this book first. You will find the relatively small units enable you to use the occasional half hour or hour for study, and you can always pursue the activities and further reading when you have more time.

The content of this book

A quick glance at the contents list will show you that the main thrusts of the book are qualitative and quantitative research methods and methods of data analysis. In the final section we have included a section on the similarities and differences of qualitative and quantitative research; this digs into the underlying strata of the philosophical issues and assumptions of these methods. We have also included in that section, units on Ethics and Ethics Committees and writing research proposals. The ethics of pedagogical research is more complex than at first appears. Ethics committees are now, in effect, the gatekeepers of pedagogical research. Sometimes they close the gates unnecessarily against some methods of investigating pedagogical research problems. The discussion of these issues, it is hoped, will help you to navigate your research proposal through Ethics and Research Committees.

How to use this book

This book may be used in at least five ways. First, you may simply dip into it to explore an approach you are interested in. This way of reading will give you useful snippets of information, but it will not give you an overview of the whole field and you may miss an alternative approach which may be more fruitful. Second, you may read it from cover to cover. This will take most people no more than one or two evenings. We hope you will consider such time well spent, since you will learn of various methods that you can use. Third, you can read the book and as you do so try out the activities on your own or with small groups of colleagues. This will provide practice, reflection, and perhaps discussion of the issues involved, thereby deepening your understanding and developing your expertise in pedagogical research. Fourth, you can use parts of the text as the basis for peer group learning on different methods of pedagogical research. The notes and comments as well as the activities are of value for this purpose. Used in this way you will learn from your colleagues through discussion. The fifth way of using the text is for organising, and participating in, a systematic course on pedagogical research. This approach will give you and other participants time to try new approaches, to reflect on them and to bring back to the course your experiences and problems.

Finally, a word about terminology. There are various collective nouns to describe the people whose behaviour one is studying in pedagogical enquiries. Some experimental psychologists refer to them as 'subjects'; some qualitative researchers refer to them as 'objects'; some researchers in management and social work refer to them as 'clients' and some refer to them as 'respondents'. We prefer to use 'participants', although in discussing quantitative research we sometimes use the word 'respondents'. We leave you to judge why we made this choice.

Activity

Spend a moment thinking about the reasons for the choice of the terms 'participants' for pedagogical research methods. *Then* look at our reasons.

Further reading

At this stage we do not recommend any reading of more advanced texts or articles on pedagogical research. But if you need to read a quick overview then try the useful toolkit and bibliography devised by Sue Moron Garcia and Liz Willis (2009). The reference to their work is in the bibliography at the end of this book. If you really want to dive in at the deep end then access Morrego et al (2009). If you want to read a down-to-earth article on research methods from outside of engineering, try Liamputtong (2009).

Unit 2
Pedagogical research: an overview

What is pedagogy?

Broadly speaking, pedagogy is the study of teaching, learning, assessment of learning and courses, in different contexts and cultures. It embraces historical studies such as how methods of teaching engineering have changed, and contemporary studies such as learning in remote or simulated laboratories. It is a subset of educational research which is also concerned with issues of educational management, institutional goals and the wider political and social contexts. It draws on the research methods of the social sciences and psychology. As such it is an applied field of study rather than a distinctive academic discipline. In this respect, it is more like engineering and medicine than physics or biochemistry.

The term pedagogy sprung originally from 'pedagogues' who were usually Greeks who accompanied the sons of their Roman masters to school. Pedagogy became the study of methods of learning and its underlying principles. From Roman times, through the Middle Ages, the Renaissance and well into Victorian times, treatises on methods of learning and teaching were published and debated. These treatises were based on observation and wisdom gleaned from experience. Experimental research was not their forte. The control of variables, the use of hypothesis testing and statistical analyses were either not known or not considered appropriate. Pedagogy was closer to the study of rhetoric, whereas today it is closer to psychology and social psychological methods of investigation. However, in continental Europe pedagogy and its sub-speciality didactics, which is the study of teaching and learning in specific subjects, has long been established in teacher education and training. In the UK and USA 'pedagogy' became 'educational research'. Pedagogue and pedagogy almost became terms of abuse, with connotations of authoritarianism and narrow teachercentredness. All of this changed in the US, and subsequently in the UK, towards the end of the 20th century. Pedagogy became the new vogue. But the new pedagogy differed from the earlier forms of pedagogy with its emphasis on the use of qualitative and quantitative methods of enquiry.

The concept of' 'didactics' suffered (and still suffers) the same fate in the UK and USA. A didact is often perceived as someone who is rigid and more concerned with precise application of method than with what and how students learn. Yet in continental Europe, didactics is the special study of teaching and learning *within* a subject or field of study. Looking to the future, it may be that the 'didactics of engineering' becomes preferred to the 'pedagogy of engineering'. The first signs of this change of emphasis from pedagogy to didactics can be seen in the discussion paper by Hamilton (2009).

Why do pedagogy?

The importance of pedagogical research in engineering lies in the long-term goal of producing well-educated engineers and researchers in engineering. Without these, engineering as an industry in any country cannot easily survive in a global market. For, as indicated above, pedagogical research in engineering is primarily concerned with developing more effective methods of teaching, learning, assessment and course design for different aims and purposes in different contexts and in different cultures. What counted as a good engineering course in the 20th century may not necessarily be a good engineering course in the 21st century. What counts as a good engineering course in one university may not necessarily be a good engineering course in another where resources, materials, high technologies and the intellectual capabilities of the students may be limited. Fundamentally, the research issue is finding pedagogical approaches which are fit for purpose.

There is another cogent reason why academic engineers should do pedagogical research. There is already plenty of research, whether 'old' or 'new' pedagogy, which could improve learning, teaching and assessment in engineering. But such research is often not incorporated into practice, and may even be actively resisted by conservative colleagues who wish to avoid change. For change to occur the research has to be shown to be and perceived as sound and useful by practitioners working in the same field. In more technical language, the expertise has to be part of the 'community of practice' of engineers. That is why good quality research carried out and used by engineering teachers is so important. Such research is likely to be perceived as more relevant than research by pure educational researchers or researchers in another discipline.

What kinds of research?

Four overlapping areas of pedagogical research may be identified in engineering:

- Pedagogical research which focuses on practices which are relatively new to the engineering community such as problem-based learning (PBL) and remote laboratories.
- Pedagogical research which re-examines existing knowledge and creates new perspectives, such as on methods of assessing engineering competence.
- Pedagogical research which applies existing knowledge to a new practice such as the use of simulations in learning and thereby generates new knowledge and expertise
- Pedagogical research which seeks authoritative findings from which the practice of the researcher can be enhanced.

Often these areas are given labels such as pure research, scholarship, applied research and action research. These labels do not do justice to the subtleties and intricacies of these broad forms of research. Furthermore, 'research' itself is a contestable term. What counts as good research, good evidence or proof differs across disciplines and even within disciplines. Examples abound: what is regarded as proof in engineering differs from what is regarded as proof in pure mathematics; what counts as a good dissertation in music differs from what counts as a good project in ultra-sonics; what a qualitative researcher or a quantitative researcher would regard as good evidence differs; what the RAE panels consider good research may not be what industrialists regard as good research.

The important point here is not how the pedagogical research is labelled but how its methods can contribute to knowledge, understanding and practices of learning, teaching and assessment. It is to these issues that the next sections turn.

Box 2.1

An old story illustrates the difference between an engineer and a pure mathematician's approach to a problem….

An engineer and a pure mathematician were intense rivals in the courtship of a young woman, She favoured the engineer so she set this task. She would locate herself 40 paces from her suitors, and would choose the one who would start at 20 paces, then 10, then five, etc until he was touching her lips. "H'mph" said the pure mathematician. "That's an infinite series which never actually reaches 40." and walked away. The engineer carried out the task and when he was within 0.5 cm. of her lips said "For all practical purposes, I am close enough." They kissed passionately. The woman smiled triumphantly….
Who was the better engineer, the woman or the engineer?

Activities

2.1 In which do you have the strongest belief?

- Your personal experiences of teaching and assessment.
- What experienced engineering teachers advise you.
- What pedagogical researchers in engineering report.
- What other educationalists report.

Be honest! And think about the data and experiences which inform these judgements.

2.2 Research, for the purposes of the RAE (Research Assessment Exercise) was defined as 'original investigation undertaken to give knowledge and understanding'. In their formulations of pedagogic research, it is stated that:

'It is research which enhances theoretical and/or conceptual understanding of…….and then follows a list of pedagogical topics.'

- Is the first statement an adequate definition of research?
- Is the second statement an adequate definition of pedagogical research?

(See http://www.rae.ac.uk/pubs/2006/01/ for the full report.)

2.3 What are your arguments for and against you doing pedagogical research in engineering?

2.4 Generate a list of research topics based on 'learning outcome'. These might include historical, philosophical (analytical), philosophical (ethical), psychological and sociological issues (all part of pedagogy).

Further reading

Here are some suggestions for further reading of topics discussed in this unit. The full references are given in the bibliography.

On teaching in engineering and allied topics
Wankat and Oreovicz (1993)
Baillie and Moore (eds) (2004)
(http://www.engcetl.ac.uk/)

On teaching electronics
Entwistle (undated)

On pedagogy
For a very quick guide to pedagogical research in engineering go to http://www.engcetl.ac.uk/downloads/dissemination/infopack/guide_to_pedagogic_research or www.engsc.ac.uk.
Heywood (2005) provides a comprehensive view of research relevant to Engineering Education

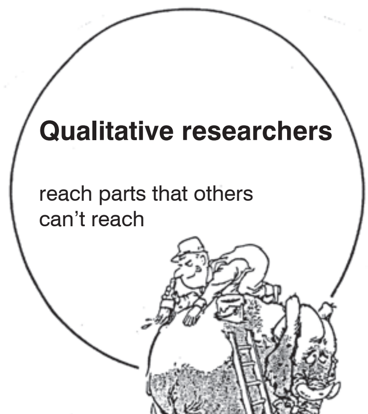
Svinicki (2010) reviews various theories and perspectives relevant to research in Engineering Education
Cowan (1998) provides a stimulating exploration of becoming an innovative teacher.
Broudy and Palmer (1965) provide a scholarly history of methods of teaching and learning.
Hamilton (2009) gives a contemporary view of pedagogy and didactics.
Stierer and Antonoiu (2004) claim that pedagogy in higher education is different from pedagogy in schools. But is it that different?
Stones (1979) provided an insightful, pioneering work on pedagogy in schools which has relevance to Higher Education.

On the nature of research and knowledge
The nature of research is considered by Brew (2001) and Ashwin and Trigwell (2004). A seminal work on the relationship between research and scholarship is Boyer (1990). Other texts on the same theme are Kreber (2001, 2008). The guidelines by the RAE (2008) give the official policy on research, including pedagogy. The nature of knowledge in different subjects (epistemology) is discussed perceptively by Becher and Trowler (2001).

P.S. Don't use reading as an excuse for not starting a pedagogical research project.

Section B
Qualitative Research

This section of the book considers the least familiar aspect of pedagogical research for engineers: qualitative research. We discuss qualitative research in this guide before quantitative research since qualitative research requires a different form of thinking from that required in engineering. Considering qualitative methods first will help you to see the more familiar quantitative methods in a different light. Qualitative and quantitative research do have similarities as well as differences and these are outlined in Unit 13. For the moment it is sufficient to note that qualitative research can capture insights that quantitative research often cannot and its assumptions and modus operandi are very different from those of standard research in engineering. Be prepared for emotional reactions as well as cognitive responses to some of the material in this section.



Unit 3
Open questions

Introduction

Qualitative research is concerned primarily with words and their meanings in different contexts whereas quantitative research is concerned primarily with numbers and their significance. The nuts and bolts of most qualitative research are open questions. These questions give the participants freedom to provide their own views, opinions and knowledge in interviews, group discussions, focus groups, or questionnaires. To avoid unnecessary repetition, we refer to these methods as *qualitative investigations*. In the case of qualitative, direct observation there is a difference. The observers note what they see, perhaps guided by open questions or the open questions spring from their observations and are then used in subsequent observations, interviews or focus groups.

Types of questions

The questions used in qualitative research may be roughly classified as:

- Spontaneous
- Guided
- Standardised
- Closed/Fixed

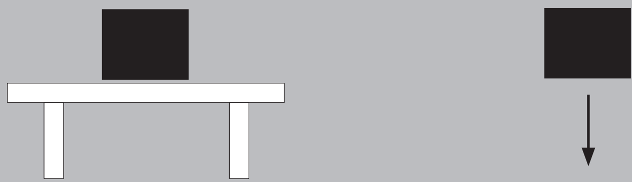
Spontaneous questions are those which spring to mind in informal conversations. Obviously they are not planned but such conversational questions should not be neglected. Often one can collect unexpected and valuable information from casual chats. The information may be useful in its own right or it may lead to the formulation of guided questions on a particular theme. Guided questions are deliberate steers but they are not leading questions. For example, a guided question might be “What are your views on coursework and examinations?" A leading question on the same topic might be "Do you actually prefer coursework to examinations?" Guided questions may be standardised questions which are asked of different individuals or groups. But one must be careful in the use of standardised questions when used in interviews. A slight difference in emphasis of a word can change the meaning of a standardised question. Try saying 'What do you think of examinations' a number of times with the emphasis on just one word each time: the meaning changes subtly.

Closed fixed response questions are normally the province of quantitative research but they do have their uses in qualitative investigations. Relatively simple closed questions can be used at the start, in the middle or at the end of a qualitative investigation to summarise or check views on a topic. If possible, biographical data should be obtained through closed questions (e.g. gender, age range, years of experience etc. as appropriate) so that data inputting and analyses are easier. Biographical data can be completed at the outset of an interview or focus group. Beware of asking for biographical data at the end of face-to-face events. Participants are likely to feel threatened (why is he / she asking me this now?) In questionnaires it is usually better to ask for biographical data at the end. This is because respondents usually want to deal with the content of the questionnaire first.

Why ask questions?

The obvious answer is to get information. But questions such as "How are you?" in interviews are more a form of greeting than a request for health information. One can classify questions as *social, biographical, knowledge-testing, knowledge-seeking, opinion-seeking or explorative*. As indicated, biographical data should be sought through closed fixed questions for ease of categorisation. Knowledge-testing in qualitative research usually follows a pattern of short answer questions. One might also include various forms of multiple-choice questions. These knowledge-testing questions can be used in most qualitative investigations. Knowledge-seeking questions can be useful for ascertaining the constructs or assumptions of participants, see Box 3.1 for an example. They can be based on a case, on a practical demonstration or on a broad field of study. Knowledge seeking questions can be used subtly in interviews or groups, see Box 3.2. The interviewer can appear to take a more submissive but curious role and allow the participant(s) to explain (even teach!) the interviewer.

Box 3.1. An example of exploring constructs (knowledge testing questions)



Researcher: "You all know Newton's third law: Every force has an equal and opposite reaction. Why does the box stay on the table?"

Various answers by participants

Researcher: "Now, when I drop the box (drops the box and catches it)……..How does Newton's Third Law apply?"

Various answers by participants.
Many could not use Newton's third law to explain why the box dropped.

(Based on a study by Bowden et al., 1992)

Box 3.2. Example of researcher as learner (knowledge seeking questions)

A researcher looked at the long list of sub-skills an assessor was required to use in assessing a student's competencies in engineering.

Researcher: (in a puzzled voice) This is a very long list. It must take a very long time to do each student.

Participant: (reassuringly) Och. No. It's easy. Yer think to yersel' 'Is he a guid student?' If he is, yer just tick most of the boxes.'

Opinion-seeking questions in qualitative research are used so the participants can air their views - for example - one might ask the broad question "How do you feel about the introductory course on tensor analysis?" Opinion-seeking questions can yield evidence of deeper, underlying attitudes which attitude inventories may not capture. *Exploratory* questions are questions which test the ground. They can provide you with an indication of the initial reactions of the participants in interviews or focus groups so you can then adjust your questions accordingly. These questions can, of course, also occur spontaneously when one is puzzled by a reply; they can be deliberate, guided questions or a standardised open question for use with several interviewees or groups.

Dimensions of questions
When preparing open questions for use in interviews, focus groups or questionnaires, it is advisable to consider the broad characteristics of questions. These are: -

open - closed recall - thought	for all qualitative investigations
encouraging - threatening clear - confused	particularly important in oral-based investigations

Like all dimensions, these are continuous variables although they are often categorised as dichotomous. Judgements along these dimensions are not absolute but relative to the background of the participants. What is a simple recall question to a final year student may be a thought question to a first year student. What may appear to be an open question to some tutors may be a closed question to other tutors; they already know the expected answer. This form of questioning is sometimes known as a *pseudo-open* question. What may be an encouraging question to some line-managers may be perceived as threatening to other line managers and so disrupt the remainder of the qualitative investigation. One has to be careful in the phrasing of questions to minimise threat. On rare occasions a threatening question can be useful for evoking strong responses which may tell you more than the participant realises. But for the most part, it is better to ask questions which feel safe enough for the participants to answer. Such questions should be intellectually challenging but not emotionally threatening.

The clear - confused dimension is concerned with the clarity of the question to the participants. This includes clarity of speech. Some interviewers mumble their questions or ask multiple questions so the participants are unsure which questions to answer. In questionnaires and face-to-face encounters, the questions have to be conceptually clear to the participants (they understand the question). Vague questions can produce vague answers. However, an occasional deliberate vague question can sometimes reveal interesting, unexpected and useful answers.

It is worth using the above dimensions to assess the quality of your open questions. You should also check the quality of questions with a few ‘critical friends’ or individuals of roughly the same background as the research participants. For interviews, it is worth recording a mini-interview with a colleague to check your delivery of the questions. As well as judging the overall characteristics of the questions, you must also check that the questions fit the objectives of the research. This is sometimes difficult in qualitative research since one is exploring people’s thoughts and feelings rather than testing specific hypotheses.

Planning your open questions

Obviously, ‘spontaneous’ questions are not planned but as you gain more knowledge of a topic and theme, the more likely you are able to ask good, spontaneous questions. Serendipity favours the prepared mind.

Guided questions are equally obviously deliberately planned. The easiest way to plan them is rather different from the approach of aims, objectives and expected outcomes. One begins by generating several open-ended questions. Let your mind do the work. This form of brainstorming may produce unexpected ideas and questions. The next step is to combine questions, if that is possible, and then select the questions that seem most important to ask. You are now ready to frame the open questions you are going to ask. These questions then give the purpose of the qualitative research questions to be addressed, in your qualitative research. This form of ‘reverse engineering’ is potentially useful if you are researching unfamiliar areas. Even if you think you are familiar with the topic, you will find this method can yield unexpected insights.

Sequencing the questions

In qualitative investigations, the sequence of questions is important. Usually, it is better to begin with open questions, which the participants can answer easily, and then proceed to more challenging or sensitive questions. In interviews and focus groups end with questions based on the discussion you have just had with the participants. This approach gives the participants confidence not only in themselves but in you, the researcher, and they leave the interview or focus group with a feeling of satisfaction. This approach is particularly important if you are going to interview the participants again.

As well as the broad, open questions you might use in your research, it is also important to think about possible follow up questions you might ask within the discussion of a broad question. A useful sequence is:

open question - participant's response - probing question - pause - prompting question.

Examples of probing questions for use in interviews and discussions are given in Box 3.3.

Box 3.3. Examples of probing questions for use in interviews and discussions

- Why did you do that?
- Do you still think that?
- Looking back, can you see any connections?
- Can you give me an example of that?
- So what made you change your mind?
- Could you provide more detail on that?
- You say it is an x, what kind of an x was it?
- Tell me a little more…
- So how do you see it now?
- So what seems to have stayed the same?
- So, what's different?
- What's so different now?
- What did you enjoy?
- What was difficult for you?
- Why did you feel that way?

Prompting questions give participants a range of choices such as 'Is it because it's boring? Too difficult? Too easy? Not relevant? You don't see the point of it? Any of these?'

One should use prompting questions sparingly in open interviews. Some purists think they should never be used. But, providing a broad range of choices are offered, they can be useful and they can stimulate the participants to think of other alternatives.

Further reading

On questions and questioning

Watts and Pedrosa (2006) provide a useful brief guide on questioning in higher education.

Brown and Atkins (1988) contains a chapter on small group teaching which discusses different types of questions, Wragg and Brown(2001) outline approaches to effective questioning in secondary school classrooms which can easily be transferred to asking and analysing questions used by tutors in undergraduate courses.

Dillon (1990) provides a review of questions used in different professions and alternatives to questions which can encourage participants to talk.

On constructivism
Examples of research on how students construct their scientific concepts are provided by:

Bowden and Green (2005)
Bowden et al (1992)
D'all'Alba (2000)
Driver et al (1994)
Laurillard (2002)
McDermott (1991)

Their methods could be adapted to research how well students understand concepts and principles in engineering.

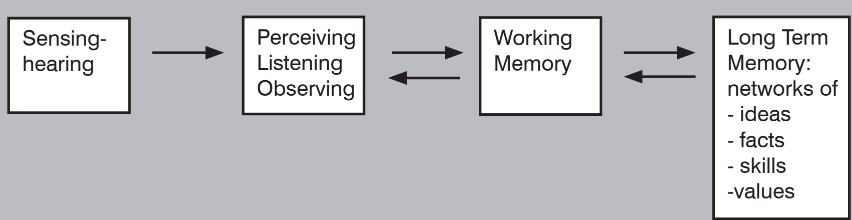
Troublesome knowledge
Meyer and Land (undated) discuss this notion. Their paper might prompt you to research the troublesome knowledge of your students.

Unit 4
Are you listening to them?

Hearing and listening

Listening in interviews and focus groups is an important but oft neglected skill. It is not enough to ask questions, one needs to listen *actively* to the answers – and *indicate* that one is listening. One needs to be aware of the distinction between hearing and listening. Hearing is, for most of us, part of our genetic inheritance. Listening is a skill we begin to learn as a child and continue to develop as an adult. (Top companies such as Ford and IBM run courses on active listening for their managers.) Active listening involves *cognitive* processing of what we hear. Box 4.1 describes the processes.

Box 4.1. Cognitive Processes of Listening



Perception is re-cognition (recognition). Listening is a form of perception. It is the active processing of the noises we hear. We interpret the sounds and these are stored temporarily in the working memory and then transferred into the long term memory. If they are not transferred within a few seconds, then they are lost. The long term memory stores the information in networks (schemata) or, rarely, creates a new network which is loosely associated with existing networks. The initial sounds trigger associations in the long term memory which then transfers these associations back to the working memory and from there to the perceptual mechanisms (ears + brain). That is how we listen to what we hear. Think of listening to music….

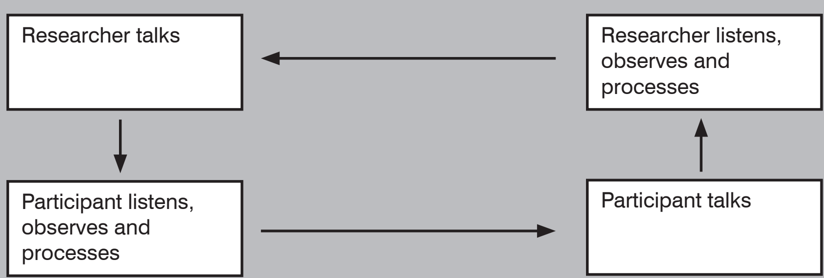
Listening involves attending to the meanings of what is said and not said. Hesitations, stumbles, silences and tone of voice convey added meaning to what is said in telephone interviews and face-to-face discussions. In telephone interviews, it is particularly important to indicate frequently to the participant that you are listening. In face to face discussions, the body language of the speakers convey extra meaning so one should observe participants (but don't stare at them!) and be aware that they are observing and, one hopes, listening to you. Note your impressions immediately after the discussion. The notes will prove useful when analysing the discussions.

Listening is a two way process

Listening is a two way process. The participant listens to you, observes you and processes the information. You listen, observe and process the information provided by the participant. A simple model of the two way process is shown in Box 4.2.

In telephone interviewing, it is important to convey you are listening by using fillers such as 'ha, ha, mm' etc. Silence in telephone interviewing can be disquieting. In face to face discussions, facial expressions, gestures, body position convey whether you can be trusted and whether you are listening. The arrangement of the seating, the nature of the furniture and even the location of the room convey meanings.

Box 4.2 Listening: a two way process



In a smooth conversation there is a steady flow of turn-taking. This flow and its cognitive processing can be disrupted if either the researcher or participant talks too slowly or too quickly or if neither researcher or participant listens to what the other says. You may know this from experience of tutorials with mildly depressed or manic students or students who talk but do not listen to each other (known as a collective monologue).

There are levels of listening

The different levels of listening levels are shown in Box 4.3. They are based on an account by Brown and Atkins (1988). Skim listening is the most passive form of listening, study listening the most intensive. Both have potential pitfalls. You may miss some significant points if you are skim listening. Rather than daydream or think about your next meal, it is better to ask oneself questions such as:

- Am I listening carefully enough?
- Why is he/she telling me this now?
- What does she/he mean?

Box 4.3. Levels of Listening

Skim listening	listening very casually
Survey listening	listening to obtain the outline
Sort listening	categorising the contents
Search listening	listening for particular content
Study listening	going beyond the content given to its significance

Study listening runs the risk of over-interpretation or getting sidetracked. Why did the student this morning say ‘Hi’ rather than ‘Good Morning’? Over-interpretation of body language is also a risk. Tightly crossed legs may be a sign of intense nervousness or of an intense desire to urinate. It is prudent to check some interpretations during the interview.

Kinds of listeners

Hargie and Dickson (2004) distinguished four types of listener. These are:

People orientated listeners
These are primarily concerned with the others feelings and comfort. Consequently they can go off task. But they are good helpers and they are worth seeking out when we need someone to listen to us.

Task orientated listeners
These are mainly concerned with getting on with the task. Consequently they neglect feelings and sensibility of others. In so doing they run the risk of their participants being uncooperative? They do not like discussing what they perceive as irrelevant information and indicate this verbally and in their body language.

Analytically orientated listeners

These enjoy dissecting all the information provided by participants whether personal or task based. They leave no stone unturned. Consequently, their interviews can be long and rambling and the data generated can be difficult to analyse. Their strength is they can obtain valuable insights and perspectives. Their weakness is they may go into too much detail and lose track of the main purpose of the interview.

Time orientated listeners

Their main concern is time constraints. Time is a precious commodity not to be wasted. They are more concerned with finishing an interview on time than the task of the interview. Consequently they rush, they may show signs of impatience and they are prone to jump to conclusions before they have all the information.

These types might better be considered as styles of listening since the context as well as the preferred mode can influence listening. Activity 4.1 gives you an opportunity to reflect upon what kind of listener you are typically. Ideally, a good interviewer has a balance of being person-oriented and task-oriented, analytical and time aware. Percentages cannot be ascribed to these features. One has to make a judgement on meeting the participant(s) but it is wise to bear in mind the core task of the discussion and your time constraints.

Barriers to listening

The path of effective listening is however strewn with barriers. The most notable of these can be deduced from the model of cognitive processes in Box 4.1. Sensing can be difficult if you are hard of hearing or there are loud external noises such as pneumatic drills at work. If the participant talks at length and rapidly, the working memory cannot cope. If you are distracted, you may not be able to retrieve the relevant information from your long term memory; you may not even register what the participant said.

Less immediately barriers to effective listening are individual biases and mental sets. One cannot eliminate entirely one's biases although one can reflect upon them and correct (but not over-correct), for them. Our perception and judgement is affected by our attitudes, values and previous experiences (ask any policeman). These create a mental set based on a stereotype, which leads us to take short cuts to conclusions without making the effort to find out if our conclusions are valid.

More obvious barriers to effective listening are non-verbal cues such as lack of eye contact, inappropriate facial expressions, monotone, interrupting the speaker, absence of head nods, behaviour such as yawning or frequent glances at one's watch. This list can be turned round to produce a list of what you can do to indicate you are listening and encourage the participant to talk. In addition, smile a little, respond to the facial expression of the participant to show you accept their views and feelings.

We should *not* leave this topic of barriers to listening without pointing out that sometimes one should not signal one is listening intently. In focus groups one might eavesdrop. Signals of intense listening could inhibit the discussion. At other times, one may want to convey that one does not want to listen. Hand gestures (stop there) and verbal tactics such as '*deferring*' - lets talk about that later; *referring* - 'maybe you should talk that over with the course tutor' or *rejecting* 'that's interesting but it's not an answer to the question, now tell me your answer to the question.' These tactics are sometimes a necessary preliminary to moving the discussion on. Such statements as 'So far you've said a lot about x, what about y?' are also useful.

Effective listening

A useful acronym for effective listening is PACIER, with its implications of revving up your listening skill, it stands for:

Perceive the other person's verbal and nonverbal communication
Attend carefully to gain maximum information
Comprehend and assimilate verbal messages
Interpret the meaning of the accompanying non-verbals
Evaluate what is being said and, where appropriate, empathise
Respond appropriately

And remember the advice: listen more, talk less

Activities

4.1 Time to reflect……
What kind of listening do you do typically? See paragraphs on Effective listening. What contexts change your typical approach to listening? If you can, discuss these questions with a few friends or colleagues. (We hope not mutually exclusive categories!)

4.2 Watch a couple of people having a conversation. Observe their non-verbal responses to each other whilst they are in the role of listener and talker. Note your observations at the time, if that is feasible, or soon afterwards. The following grid may be useful:

A talks	B listens
B talks	A listens

Who listened most? How did they show they were listening?

4.3 Eavesdrop a conversation (if that does not offend your moral sensibilities). Note the conversation at the time or soon afterwards. What were the main points of the conversation? Were there other matters you could infer such as motives?

4.4 With permission of the participants, video-record a brief discussion on an engineering topic. Watch the video-recording and note how the participants signal they are listening or want to talk, who interrupts who, who takes the discussion off the topic and how (if at all) does someone else bring the discussion back to the topic.

4.5 Think of a couple of people who, in your opinion, have a good and a poor telephone technique. How do they:

- open calls (a) when phoning you, and (b) when answering your call?
- establish rapport and reduce social distance (through humour, use of first name, personal conversations about family, holidays)?
- conduct the business side of the call?
- terminate calls?

Analyse your telephone manner carefully over the next ten calls you make and receive, and produce a list of your strengths and weaknesses. Ideally record these calls (with permission from the other person) for more detailed analysis. Use this information to refine your technique of telephone interviewing

Based on Hargie (2009, p256-7)

Further reading

Cognitive processing
Most introductory texts in psychology contain chapters on cognitive processing, e.g. Eysenck (2001), or Hayes (2000b). These will give you sufficient background to the general processes of cognition.
Texts entirely devoted to cognitive processing are Baddeley (2004) who focuses primarily on the processes involved in memory and Eysenck and Keane (2005) who also consider the processes of thinking.

On listening
Thorough reviews of research on listening and some practical suggestions are provided by:
Hargie and Dickson (2004)
Hargie (2009)

Telephone interviewing
Hargie, Dickson and Tourish (2004) provides a thorough review of the psychological aspects of telephone interviewing and provides some useful hints on telephone interviewing.
Representativeness of samples in telephone interviewing is discussed by Social Research Update8 (2004)
How to organise teams of telephone interviewers (but not how to be an effective telephone interviewer) is outlined by Frey and Oishi (1995)

Unit 5
Data collection and analysis: interviews and focus groups

Introduction

This substantial unit outlines the main methods of qualitative data collection. These are:

- Interviews
- Group Interviews
- Focus groups
- Qualitative Observation
- Questionnaires
- Case Studies

Qualitative interviews, group discussions and focus groups use open questions predominantly and some closed questions (a mixture of open and closed questions is often referred to as a semi-structured interview). Qualitative observations are considered in Unit 6. Less common methods of qualitative data collection are considered in Unit 7. Questionnaires are seldom based solely on open questions so we discuss questionnaires in Unit 8 in the section on quantitative data. Case studies may be qualitative or quantitative. They are discussed in Unit 11.

Interviews

Research interviews may be broadly defined as 'conversations with a purpose'. They are not interrogations. Their purpose is to obtain answers to the broad research questions. The interviews may be face to face, video-linked, online or by telephone. Skype is useful for video interviews but these are not easily recorded. Face to face interviews provide the richest data and, if possible, are the preferred *modus operandi*. Interviews based solely on a highly structured form requiring only box-ticking are uneconomical. One might as well distribute a structured questionnaire.

We have already discussed the core ingredient of qualitative research interviews: open-ended questions (Unit 3). Here we offer a few additional hints on interviews and alert you to some of the problems and pitfalls.

Hints on interviewing

The major hints on interviewing are closely linked with the discussions in Unit 3 on open questions and Unit 4 on listening. These hints are easy to understand, the hard bit is putting them into practice. Indeed, if you wish to become an effective research interviewer you may need practice with feedback as in Activity 3.1. Box 5.1 provides broad hints and warns of the pitfalls. Box 5.2 offers more detailed advice on the interviewing procedure.

Box 5.1. Hints and pitfalls of research interviewing

The following hints and pitfalls are common to all forms of interviewing, not just open-ended interviews.

Hints :-
- Be clear about the purposes of the interview.
- Know why you are asking the open questions you are asking.
- Ensure the interviewees are also clear of its purposes – if that is your intention…..
- Conduct the interview in a safe, quiet environment.
- The more open the interview, the more likely are people to go off the point……. but you might find unexpected information which could be useful….

Common pitfalls :-
- Interruptions and distractions such as mobile phones.
- Stage fright of the participant(s) or interviewer(s).
- Moving too fast from one question to the next.
- Asking delicate questions too early.
- Presenting one’s own perspective.
- Teaching.
- Counselling.
- Inaccurate recording.

Box 5.2. Hints on qualitative interviewing

1. **Greetings**. An important element is getting a good start with a friendly greeting, both verbal ("Hello, how are you?") and nonverbal (e.g. handshake). Hugging is not recommended.
2. **Ask permission to use an audio-recorder**. For most interviews it is better to get permission to record it – and make sure the recorder works. (See 'Recording the interview'.)
3. **Express interest**. Again, use both verbal cues and nonverbal cues (eye contact) Let the participant know that you are interested in what he/she is saying, and want him/her to continue talking.
4. **Feign ignorance**. Give verbal cues to let the informant know that he/she is not boring you with information you already know, and to open areas of conversation ("I have never heard of that before." ;"That's interesting, tell me more"). Look puzzled so the participant expands, clarifies or qualifies what he/she is saying.
5. **Avoid unnecessary repetition**. Do not go round a loop of the same questions. People get bored when they have to go over a story twice in the same conversation. Although we sometimes ask participants to repeat information ("Could you describe the problem to me again?"), it is good to avoid repeats if you can.
6. **Take turns**. Avoid letting the conversation becoming too one-sided.
7. **Use their vocabulary in your questions**. By using terms the participant has used, you are indirectly telling the participant that you are learning from the conversation and you are interested in learning from him or her.
8. **Restating and incorporating**. Restating (or reflecting back) occasionally what the participant says often encourages him or her to say more, particularly if you use the same terms as the participant.
9. **The final question**. Often it is useful to ask a summary question or ask for a rating at the last part of an interview (" So if you had to make a judgement on a 6 point scale where 6 is very good etc, then how would you rate…") (Purists may disagree. They might argue that ratings smuggle in spurious forms of measurement)
10. **Farewells**. Thank the participant. Look pleased, maybe shake the participant's hand. Often a farewell prompts a participant to say more so you collect more information. Some interviewers put their digital recorders in their pockets without switching them off to catch this extra information. Others think this is unethical. Whatever you do, make a note of the farewell as soon after the interview as possible.

Ethnography and ethnographic interviews

Ethnography (the modern word for anthropology) is particularly concerned with understanding people's perceptions, experiences, lives and worlds. Ethnographers make field notes of their observations of people, the conversations they hear and their own discussions with the participants. They examine the signs and symbols (known as artefacts) such as notice boards, memoranda, age of equipment, where people sit at lunch breaks and who with. They often use the data they have collected to tease out a model (more like a mind map than a predictive model) of their findings. More information on ethnographic observation is given in Unit 6.

Ethnographic interviews are the most fluid of interviews. They are mostly in the control of the participant with occasional prompts from the researcher. The researcher encourages the participants to talk about themselves, their feelings, their inner conflicts, their ideas and their recollections of past experiences. The researcher tries to get beyond the official rhetoric to the 'real' practice, to the values and the taken for granted assumptions of the participant(s). These conversations are sometimes described as 'untold stories' or 'narratives'. They often reveal information, insights and perspectives which other forms of research do not.

The methods used are open questions with occasional interactions such as '*Tell me more about that*' and probing questions such as '*You mentioned earlier that you didn't like using CBD* ***(Computer Based Design)*** *packages at first and preferred blueprints. What changed your mind?*'

Practice is needed to become a skilled ethnographic interviewer. Feedback from a 'critical friend' and self-feedback based on an audio-recording of one's interview are useful, as indicated in Activity 3.1. It is worth analysing how some television interviewers (such as Mark Lawson but not John Humphreys) draw out stories from their guests although these situations are somewhat contrived. The interviewee often knows the questions likely to be asked. They are usually very articulate and sometimes seek to present themselves in a favourable light. The TV interviews also reveal some of the risks of ethnographic interviewing. If impression management is uppermost in the participant's mind then he/she will massage his/her messages. The task of the ethnographic interviewer is to get beyond the layers of deliberate impression management to the inner 'truths'. To avoid deliberate impression management, some ethnographic interviewers do not divulge the questions beforehand so the comments made by the participants spring from their unconscious thoughts. Others prefer to give a broad outline of the questions before the interview so the interviewee has time to reflect. It is worth noting that not all participants are articulate or forthcoming so one has to adjust one's vocabulary to theirs and be patient if they are slow in their responses. In general, to be an effective ethnographic interviewer, one has to be clear in one's intentions and appear interested, curious and empathetic.

Group interviews and focus groups

In group interviews, the researcher interacts with each individual in the group and occasionally checks the level of consensus in the group. In a focus group, the researcher encourages participants to interact. Usually a group interview or focus group is a mixture of mostly open questions and some closed questions. The role of the researcher in a group interview is primarily to ask questions, listen and note (and preferably record) the individual answers. The role of the researcher in a focus group is primarily to ask questions, listen to individuals *and the group(s)* (and preferably record) what is said.

Political parties and some large organisations use focus groups of thirty or more to capture, ostensibly, a wide spectrum of opinions. The size of these groups begs questions about the validity of their claims. Even if the focus group of thirty meets for two hours, the air time for each participant is at best four minutes and that figure does not allow for the organisation of activities and the facilitator's comments. For research purposes the composition of a focus group of four to eight is preferable. Beyond eight it is difficult to obtain active engagement, take notes, or record the discussions and it is difficult to transcribe these recordings. The larger the focus group, the more likely it is to induce fatigue and repetition. Figure 5.2 shows the difference between a group interview and a focus group.

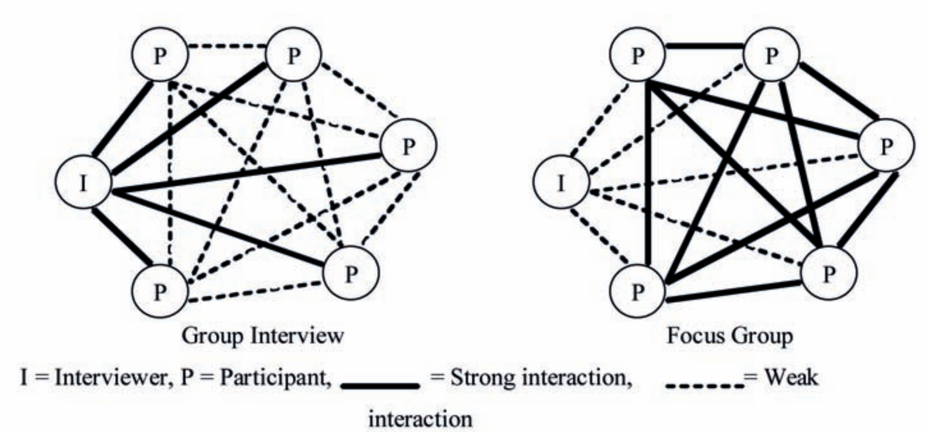


Figure 5.2. Differences between Group Interview and Focus Group

The composition of a focus group is, ideally, determined by the purpose of the research. Hence the group may be homogenous (e.g. all bright students), heterogeneous (from different engineering departments), well established (have worked together on an in-depth project), experts or novices (experienced teachers, new lecturers). One may have an idea of who one wants in a sample but in practice, one gets who volunteers to participate. So it is important to provide a brief profile of the focus group when writing up the research so the reader can judge the typicality of the sample.

Focus groups are usually face-to-face events although it is possible to organise video linked focus groups if one wants to involve participants from different geographical areas. We have not yet seen reports of such focus groups. Focus groups are more challenging for the researcher than group interviews. Indeed some focus groups lapse into group interviews because the researcher does not have the expertise to stimulate interaction between group members and relies heavily on 'question-answer' techniques used in engineering tutorials.

Useful methods of stimulating interaction in focus groups

The key to success in stimulating interaction is to design discussion activities. A useful initial tool is *free association*. In Activity 5.1 you are invited to use it. It can be adapted for use in many research topics. *Brainstorming* is also useful in qualitative research. Brainstorming consists of choosing a topic relevant to the research question and inviting participants to say whatever springs to mind regardless of its value. These are noted by the researcher or a member of the focus group. The list is then categorised by the group usually on the basis of their importance.

A more structured approach is *card sorting* in which the group are given cards which contain suggestions or opinions. The task of the group is to sort these cards into piles of agree or disagree or prioritise them. The precise nature of the task depends on the purpose of the focus group and the research. Sometimes 'wildcards' are included. These are blank cards on which the participants can write additional views. *Open questions* may be used for discussion by the whole group or in pairs or threes and then in the whole group. The responses may then be noted on a flip chart, categorised, and opinion sought on their value. '*Is anything missing?*' is a good question at this point. A useful open question is "*What do you think others outside this group might think?*" Post-it notes and flipchart sheets may be used and you can pose the most open question of all: "*What open questions would you ask about this topic?*"

Pitfalls of focus groups

Focus groups can yield rich information for use in their own right, as a preliminary to a larger scale research, or as in-depth exploration of themes which emerged from a large scale survey. But they are open to manipulation by an unscrupulous facilitator and they are not appropriate for dealing with highly sensitive issues. Trust between participants and between participants and the facilitator is vital to their success. Self-disclosure is not always forthcoming in focus groups. Dominant participants (power talkers) can sway the expressed views of a group. If the power talker takes a particular view then others are likely to agree even if they disagree (and sometimes say so after the focus group).

A procedure for running a focus group

Box 5.3 outlines a procedure you might use initially. Then adapt a procedure which you are comfortable with – and which yields results.

Recording interviews and focus groups

It is better to record the interview or focus group than rely solely on notes but do take a few notes and explain that they are just an *aide-memoire*. Some researchers prefer to explain informally their note-taking to participants with statements such as "*This is just to jog my memory*". Taking detailed notes can be threatening and distracting for the participant(s). They are often curious about what you are writing. You can also suffer from lapses in attention whilst taking notes in a long interview or focus group. And if you rely solely on notes, you have no opportunity to review what you or the participants said or how you or they said it "*That's what my supervisor said to do*" may have different meanings according the tone of voice of the speaker. Again, try putting the emphasis on different words and listen to how it changes the meaning of the sentence.

Use a digital recorder rather than an analogue recorder so you can transfer the recording of the interview to a Mac or PC, relay them to other people and, if necessary edit the recordings for dissemination or training purposes. You can then transcribe it more easily and, if you are lucky enough to have a secretary, you can give him or her the recording on a memory stick or email a zip file. Recordings of focus groups require careful positioning of the microphone and checking the sound. It is useful to ask participants in a focus group to say their names and a few sentences so their voices are readily identifiable on the recorder. If you can't record the interview or focus group: be warned. Notes may be quicker than transcribing the interview but they are not as reliable as verbatim transcripts and you lose the 'voices' and often the language used by the participants. If you are interviewing someone who needs an interpreter or someone whose English is stilted, then it is important that you use a recorder so you can listen over and over again to the recording.

Box 5.3. A structure for a focus group

There are several ways of running a focus group. The following are guidelines - not rigid rules of procedure:

1. Opening
   Establish rapport with the group and between the group members.
   Use an open-ended question or instruction which can be responded to briefly.
   Don't ask for information which might divide the group.
   Provide some information about yourself.
   Don't ask for detailed demographical information- that can be supplied on a response sheet.
   An example of a approach is:
   'Tell us who you are, which department you are in, and what research topic you are doing'.

2. **Introductory statements and questions**
   State briefly the purposes of the meeting.
   Use an open-ended question, brainstorm or free association on the topic.
   'When you hear the words 'qualitative research', what springs to mind. Write your first thoughts, whatever they are, on the 'stickies' provided.'
   Discuss the 'thoughts' with a few colleagues'.

3. **Transition**
   Use the responses to the introductory question to summarise and, perhaps to probe a little deeper into the views expressed.
   'OK. So you have different ideas about qualitative research. Do you think these are related to your views on what counts as 'good' research? So what is good research?'

4. **Key questions**
   These are the broad questions for the focus group to explore. They should be prepared beforehand, open questions, and open to modification in the light of the responses of the participants.
   Allow about 15 -20 minutes for discussion of each key question.
   Use about 3-5 key questions.
   Use probing and prompting questions and explore any inconsistencies or minority views.
   Summarise and check with participants before moving to the next key question.
   Be aware that summarising can prompt other thoughts and views which may be worth listening to. Examples of summaries key questions are:
   'The next important question for us to explore is:
   'What is the value to a researcher/teacher of knowing about qualitative research?'
   The range of views seem to be……?

Box 5.3. continued

How does this relate to the relative merits of quantitative and qualitative research?'
'What about being able to do qualitative research rather than just knowing about it?'

5. **Ending the focus group**
   There are various ways:
   a. Use 'all things considered questions'
      'Of all the things we have discussed, which two are the most important for you?'
      'Say one sentence which summarises your view the value of qualitative research.'
   b. Summarise the ideas and suggestions
      Alternatively, or in addition, summarise the ideas and suggestions which have been explored. Then ask the participants what they would add to the summary.
      Allow about five minutes for the summary.
   c. A final question
      Use a simple binary or rating question such as:
      Would you use some qualitative research methods in your own current research.?
      Yes or No?
      Would you use some qualitative research in your future research? Yes, Maybe,
      No, don't know
      'If you had to rate the potential value of qualitative research for you on a 6 point scale, how would you rate it?
      6 = almost ideal 5 = very good but not perfect, 4 = good, 3 = OK,
      2 = Poor, 1 = Very poor.'
      Each participant should answer the final question asked at the end of the focus group meeting.
6. **Say 'Thank you'**
   Thank the participants for their time and views

If you want to do a detailed analysis of the nonverbal cues of the participant then you will need to video-record the interview. This approach will require you to arrange the seating so that the participant is clearly in view. If you want to record both you and the participant then you probably need two video cameras and a technician to switch from one camera to the other or to use a split screen. Whatever video method you use, do check the sound as well as the picture before the interview. It is better to check beforehand than swear afterwards. Swearing afterwards may be cathartic but it will not bring back the interview.

Transcribing qualitative data

Before starting your data analysis, it's a good idea to listen to the audio-recording or watch the video and make detailed notes including any significant events and juicy quotations. You must also have decided which form of qualitative analysis you are going to use. The more sophisticated the method of data analysis you are going to use, the longer the time required for transcription.

If you are simply collecting written responses to open questions then these responses can be cut and pasted so you have all the responses to the same question together. However, the responses obtained are not always answers to the questions asked so in your subsequent data analysis you will have to identify the underlying themes and these might appear in responses to different questions. Word documents of open-ended responses are easier to work with than spreadsheets.

Do code each questionnaire or each speaker in an interview or focus group so you can easily track the responses and report them. If you have coded the participants, you can also track if a particular participant has recurring themes (hobby horses!).

There are basically three approaches for interviews. You can just transcribe the words. This is the easiest approach and it can be done by you or someone else. But you do lose some of the meanings. You can transcribe the words and the hesitations (um, ers,), stumbles, mis-pronunciations and pauses (para-linguistic cues). This requires a little more skill and patience but the transcript then gives you more information. For example, transcripts of short lectures by new lecturers often contain several hesitancies in the early stages of the lecture which give clues to thoroughness of preparation, confidence, and fluency. Transcripts of participants' responses which contain hesitations and stumbles can provide clues on uncertainty of opinion or even possible cover-ups of genuine opinions

If you audio-record the interview, then allow approximately 5 x n for the transcription (where n is the number of minutes of the interview or focus group) by an experienced typist. If you are using complex techniques of linguistics or conversational analysis, allow at least 10 x n. If you video-record the interview to explore the non-verbal plus paralinguistic cues (ums, ers etc.) then allow at least 20 x n. The information obtained from this approach is rich and complex but you will have to look at the video-recordings several times.

Analysing the qualitative data

If you opt for fine-grained analyses based on theoretical perspectives such as discourse analysis, conversational analysis, grounded theory, narrative analysis or Interpretative Phenomenological Analysis, you will have to master these methods of transcript analysis or obtain help from an expert. It is not proposed to enter into the complexities of these fine-grained methods of qualitative data analysis. For that you are referred to Robson (2002), or Bryman and Burgess (1994) or other texts cited at the end of this unit. Instead, the focus here is on a general method which underpins most qualitative data analysis regardless of theoretical perspective: thematic analysis. This can be used with data collected through open questions, interviews, or focus groups A simpler form of this method based on hypotheses is sometimes described as framework analysis (Ritchie and Spencer, 1994). Box 5.4 outlines a useful approach.

Box 5.4. Analysing your qualitative data

The first step is to read carefully the transcripts and note the tiny themes which occur in the responses (first order coding). These will not necessarily fit the themes or guided questions which you thought might be in the data collected. The unexpected can and does occur.

The next step is to collapse the tiny themes into broader themes (second order coding) and then into broad themes (third order coding). Some people who are used to doing literary criticism skip first order coding, move quickly to identifying themes and then, perhaps, do some first order coding. Their argument is that a compilation of bits does not make a whole: the whole is greater than the sum of the parts.

At this point you have a choice of pathway. You can:

- List the themes and give examples of quotations to illustrate the theme. These might include positive and negative responses.
- List the themes and count the number of times the theme is mentioned.
- Produce a hierarchy or flowchart of the themes in the data and describe their relationships
- Produce a map of the themes and describe their relationships.

The last two methods can lead to a ‘theory’ emerging from the data.

Whichever approach you use, we suggest you check your thematic analysis with another person(s). You can ask them to read your categories and transcripts to see if they agree with your categories. This is an arduous task. Or you can give them your broad themes and examples from the transcripts to check if they categorise the examples as you did. This approach will provide you with an estimate of the validity of your themes and the reliability of your categorisation. If you use this method and feel inclined, you can use a correlation to measure the degree of agreement between your analysis and theirs. If you are a purist you might want to argue that the data analysis is your personal phenomenological standpoint so agreement with others is not necessary.

We have not found any good examples of qualitative data analysis in pedagogical research in engineering but the research article by Li and Seale (2007) on learning how to do qualitative research as a PhD student is worth a look. Useful hints on doing qualitative data analysis in pedagogical research in engineering can easily be extracted.

There are computer programmes available for analysing qualitative data (see Further Reading), but these can be cumbersome to use. A computer-based approach is not always sensitive to perspectives and nuances expressed in the responses to open-ended questionnaires and interviews. For small samples, it is easier to analyse by reading, categorising, checking and re-categorising if necessary. Be wary of having too many categories or themes in the final analyses.

How many?

A frequently asked question in qualitative and quantitative research is' How many should I sample?' (We also discuss samples in quantitative research in Units 8 and 9.) For qualitative research, the counsel of perfection is known as 'saturation': keep taking samples until you get no additional information (Kvale,1996). We prefer a more pragmatic approach. First consider the related questions in Box 5.5 then make a guesstimate.

As a rule of thumb, we suggest that a dozen interviews of 30 to 45 minutes is sufficient, if you are using thematic analysis. Three focus groups or group interviews of four to eight participants, possibly representative of different groups, (e.g. line managers, tutors, students) of about one hour to ninety minutes may be sufficient. for focus groups, group interviews and ethnographic interviews – depending on the topic and how many questions you use.

Box 5.5. Questions to ask when deciding your qualitative sample

How much time have you got?
Bear in mind that qualitative data analysis is time consuming.

What is the research question?
Can it be simplified? Is it feasible in the time you have? If not, can you change it?

Is the qualitative research the only method you are going to use?
Mixed methods of quantitative and qualitative research yield a more rounded study which is often easier to get published. But a pure qualitative study can be very illuminating. If you opt for mixed methods, you will still need to do time estimates for design, data collection, data analysis and writing.

What is the expected unit of time of the interview or focus group?
The longer the time, the more analysis required.

What method of qualitative analysis are you going to use?
The more complex the method of analysis, the longer it will take you.

What funding and other resources do you have?
If you have no help from a secretary or assistant, it will take you longer.

Do you intend to publish the research?
Where? If it is a project for PGCHE then it can be regarded as a training exercise so do what is feasible and discuss the limitations in the final chapter. The number of credits for the project should provide a guide for you. If the research is for a doctorate, remember you have only about 6,000 hours in which to complete all of it and do all the other things you have to do to meet the requirements of doctoral study. If you intend to publish the article in a journal, look at the back numbers of the journal to check the sample sizes reported and if they publish research related to your research question and methods.

Activities

5.1 *This activity is best done as a group exercise but it can be done as a private study exercise. The instructions here are for an individual exercise.*
Read the first word and immediately write whatever comes to mind. Do not censor any thoughts no matter how private, rude or irrelevant. (An aside: the prompt word 'sex' sometimes immediately evokes 'tonight'.) Write for about two minutes, longer if you wish.
Repeat the procedure with the next word and so on. Then put away your scribbles for a few hours. Then read the notes and identify the ideas or themes which they contain.

The Words are:
Science Arts Qualitative Quantitative Renaissance God

5.2 Prepare and run a focus group for about thirty minutes. Choose only two or three broad questions on the topic chosen. Record the focus group's discussion and soon afterwards listen to the recording and make notes of your first impressions. If you have time, transcribe the recording and analyse the themes which emerge.

5.3 *The purpose of this activity is to give you some practice in thematic analysis. It is best done as a group activity but it can be done in private study.*
Try analysing the following transcripts of five minute explanations given by two new lecturers in engineering. For each transcript: read the transcript and scribble in the right hand margin any thought you have whilst reading it. Then read it again and write in the left hand margin the theme of each paragraph. This may be expressed as a question or a summary statement. List the themes in order of appearance. Write a comment on the structure, clarity and likely interest of the explanations to first year students, based on your initial notes and the themes identified.

The Transcripts

Transcript One
Well, um, we'll get, er, down to earth now literally and do a bit of soil mechanics for you.

I don't know how many of you are walkers but next time you find yourself walking across Dartmoor and you fall waist deep in slimy muck and bog what I'm going to tell you will be of no consolation whatsoever.

But I want to ask the question what is quicksand and try to answer it in a very short time.

Before we can discuss what a quicksand is we've got to look briefly at the structure of a soil. The first thing about the soil structure is that unlike most materials that we use in engineering it's not a solid structure, it's made up of particles. These particles in size will depend on the type of soil we're talking about, whether it's a sand or a clay, but all soils, even the most dense clays, have small what we call voids in between the soil particles. These voids may be full of air, gas, water vapour or water, if the soil is saturated they will be completely full of water.

The soil structure is important because it leads us on to how soil gets its strength, what's the strength of a soil. If you do this (demonstrates on a diagram), if you put a weight on top of that soil structure there, it's not going to crush the particles that's not how it's going to fail, what will happen is the particles will slide over each other and slip, and so the strength of a soil is entirely dependent on its shear strength. It's not the strength of the individual rock particles that make up the soil, it's the strength of the friction between the particles.

Now, when we load a soil we put on the total load here (demonstrates on diagram), and the reactions inside the soil give us forces, we call them inter-particle forces, between the particles and if the voids have only air in them the forces between the particles take this entire load that we're putting on. If, however, there's water in the voids the water will take some of the load because you can't compress water, the water will react outwards so you've also got a pressure which is built up in this water which acts outwards in this manner here (shows).

So, we've got that overall strength, and if you'll forgive me for resorting to some Greek symbols for a minute, we've got the overall strength which we normally call sigma and we've got these two components which make it up. That strength there is made up of an inter-particle strength sigma dash and the pressure in the water.

Now, coming back to what I said when I started, the strength of a soil is its shear strength. These particles are going to slip and the friction between them is going to stop them slipping. From you're A level Physics or your O level Physics you should know that friction depends on the force between two surfaces so that the strength of the soil is entirely dependent upon this factor here, that is the inter-particle force, that's what's creating the friction between the particles and giving the soil strength.

So this represents the effective strength of the soil and if we take that and rearrange it slightly we get that there (shows simple formula). It now becomes apparent that for any given load here the strength of the soil whether it's going to fail or not depends on this whole pressure, the water pressure. If this water pressure increases enough we can get a situation where the effective stress is zero, the soil has no strength, it won't take any load at all. This situation occurs naturally when you get a, say a slight dip and the soil is totally saturated with water everywhere and because of the gradient the water wants to flow like this into the dip. This water flowing upwards increases the pressure in here, there's a buoyancy due to this water coming down, as in the sea you tend to float, the water's pushing upwards and the soil particles increasing this and if you get enough flow down this increases until the effective stress is zero and that's when the soil becomes a quicksand.

So we end up with the conclusion that a quicksand is not a type of soil, it's a state of soil, any sand can be a quicksand, it just has to be in the right conditions where the flow and the pore size are such that the flow will create a zero effective stress giving us a quicksand.

Transcript Two
The computer control of cold rolling

My subject is the computer control of cold rolling, and this is a research project that we are involved in.

The reason that we are looking at this problem is it is a problem on shape control, is that rolled products, things like washing machines, car bodies, freezers, are made out of, the steel surface can have distortions I, it, (er) which make it unsuitable for making these products.

So it is important that you should control something called strip shape, so that the products that you make out of the strip are (er) suitable for (er) mass manufactured goods.

The project involves the computer control of cold rolling mills, the mill itself is something that looks just like a big mangle, strip enters at something like forty thou and it goes out at something like thirty thousandths of an inch, er and the mill is reversible so that it keeps being rolled until the strip is sufficiently reduced in thickness to something like that you can make a car body out of or washing machine. The problem is that when you roll the strip you also, apart from reducing the strip in thickness you cause internal stresses to be held inside the strip, and these stresses aren't apparent while you're actually rolling it because there is very high tensions in these mills which stretch the strip so that it looks flat while its in the mill, but unfortunately, when you take the coil of strip out of the mill and cut it up into sections and put it on a flat surface, then you can see imperfections, you can see that in some cases it's only a small imperfection, perhaps it is necessary to look at the strip at a certain angle, and then you can see that it's got these undulations in it. So the problem is to roll the strip, so that it doesn't have any internal stresses and that's called shape control. It's only been in the last twenty years shape measuring devices and shape control has come in because the techniques weren't available for actually measuring these internal stresses.

Now measuring instruments are available, it is possible to form a close-loop system, that is to say it is possible to measure the strip shape to put that into a computer which then decides how to change the control system which affects the position of the rolls, so that eventually you get the right shape to the strip.

The computer forms part of the control loop and the design problem, the problem that the students are going to look at is the specification of the components in the shape control loop and the measurement problems that's to say that you don't actually, when you try and measure what the shape of the material is, because you are trying to measure something which is hidden really, it's not, you can't measure it by say a contact instrument, you can't actually put an instrument on the strip, you have to measure it by magnetic devices, electrical devices, you actually get a lot of noise on the measurements.

That's summarised the two main problems really that the student's looking at:

1. specification of the components in the shape of the control loop and
2. reducing the problems of the noise that is contained in the measurements.

Further reading

This unit of study provides you with sufficient guidance to use and analyse interviews and focus groups in your pedagogical research. The references given here provide more extended advice and justification of the methods of qualitative research although their focus is not on pedagogical research in higher education. As far as we know, this is the first book devoted to doing both qualitative and quantitative pedagogical research in an area of higher education although Reid (2003) does consider the use of quantitative pedagogical research in the physical sciences.

Interviewing and focus groups

Chapters on interviewing and focus groups can be found in
Basit (2010)
Bell (2005)
Cohen et al (2000)
Denscombe (2003)
Opie (2004)
Barbour (2005) article on the use of focus groups in medicine contains ideas which can easily be transferred to pedagogical research in engineering.
The text by Kvale (1996) details the theories and justifications of qualitative interviewing.

Overviews of qualitative research
The website http://www.psy.dmu.ac.uk/michael/qual_reflexivity.htm provides a good brief overview of how to do qualitative research.

Myers (2003) al provides a broad view of qualitative research with links to other websites

'Social Research Update' contains bite-sizes of suggestions on research methods.

Texts on qualitative research
Basit (2010) provides a lively text on all the major methods of qualitative research in educational contexts.

Bryman (2008) provides a good overview of qualitative and quantitative methods.

Bryman and Burgess (1994) contain chapters on qualitative research including a chapter on framework analysis, which is essentially thematic analysis based on guided questions (Ritchie and Spencer, 1994).

Dey (1995) discusses how computers can be used to analyse qualitative data.

Gibbs (2002) explains, in detail nVIVO.
Hayes (2000a) explains clearly qualitative and quantitative research methods.

Robson (2002a) contains a useful chapter on the analysis of qualitative data.

Shank (2002) and Braun and Clarke (2006) give a good overview of the different methods of thematic analysis.

Smith and Osborn (2003) describe IPA (Interpretative Phenomenological Analysis)

Warren and Karner (1995) is a substantial, lively text on qualitative research and analysis.

An annotated bibliography of qualitative methods and software is available at http://onlineqda.hud.ac.uk/resources.php#N

A free qualitative software package for analysing transcripts can be downloaded from http://www.pressure.to/qda/

If you are still wanting to read about qualitative research rather than do it, try:

Denzin and Lincoln (2005)

Miles and Huberman (1994).

Richardson (1996)

They will keep you occupied for a few months.

Unit 6
Qualitative observation

Qualitative observation

Look, listen and note are the keynotes of qualitative observation although touching, even tasting and smelling, can be part of qualitative observation. Whereas quantitative analysis has pre-determined categories in the form of checklists, rating schedules and interaction analyses (See Unit 10), in qualitative data, the categories emerge from the data and are reported and analysed linguistically rather than pre-determined and analysed statistically. Qualitative observations may be free flowing or semi-structured and may include the immediate thoughts, questions and feelings of the observer as well as what he or she observes The categories in qualitative observation are loosely determined by the open or guided questions in the mind of the observer, his or her knowledge, what he or she observes and what the participants do and say.

The roles of observers

The observer may take four roles: independent observer, observer-participant, participant-observer and participant-covert observer.

The independent observers watch but do not participate but their presence does have an effect upon the participants. Usually this effect is short-lived. But, it is prudent to observe from an unobtrusive position and allow time for the participants to get used to your presence - so you become part of the furniture. Similar remarks apply to the use of video cameras and audio recordings. But beware, videos and audio recordings may edit out significant events (cameras are not all seeing). However, if you are primarily interested in observing practical skills then close up camera work is essential and if you are interested in detailed analyses of discussions then recordings are invaluable. Independent observation is particularly useful for short-term observations such as practical sessions, problem solving tutorials and problem based learning seminars. For these observations, use a timing device and write a note of what is occurring in each unit of time or at the point of change in activity.

Observer-participants predominantly observe and participate occasionally. The participants are aware of the researcher's role. These sessions can be recorded with the approval of the participants and the effects of the participation of the observer studied. Participant-observers predominantly participate and observe occasionally. It is a moot point whether participants should be informed of the role of the participant-observer and whether the discussion should be recorded. If you are investigating the decision-making processes in a Board of Examiners you would be lucky to find a Board willing to agree to participation in your research (or an Ethics Committee). For this research you may need to be a participant-covert observer.

Covert observation may be described as people watching in naturalistic settings. The observations may be of one session or over extended periods of time. Field notes are essential. During the observations it may be unwise to be seen taking detailed notes but field notes, including themes, and your reflections, including the questions raised by the observations, should be made as soon after the observations as possible.

Ethnographic observation

As indicated in Unit 5, covert observation is the core method of data collection in ethnography. It goes beyond the obviously visible to its significances. Ethnographic observers note artefacts of expressed values and taken for granted assumptions. Basically all that may be seen or heard in a department, engineering company or organisation. The artefacts might include the layout of a learning space and its effects upon behaviour, the office furniture and layout, the age of equipment, personalised objects d'art, notice boards, posters, the way people talk to each other and what about, behaviour patterns, taboos, jokes, frequently used metaphors, jargon, signs and symbols of status and power and unwritten rules and procedures. Values are examined as the 'expressed values' in mission statements, documents and official gatherings and matched against 'values in actions' as expressed in conversations and actions.

Ethnography may be used to explore the broad assumptions underlying how a department works or for a relatively narrow explorations of a topic. For example in some departments of engineering there may be a tacit assumption that a high level of undergraduate mathematics is necessary for all engineers; that plagiarism is best controlled by severe penalties; or that today's research students should be supervised in exactly the same way as the supervisors were supervised when they were research students. Ethnography can be used in pedagogical research in engineering to explore sensitive areas, but it does raise ethical issues (these are discussed in Section D of this book). It can be used to deepen personal understanding by 'taking the role of the other'. For example, John Cowan, a civil engineer, when he became director of OU, Scotland took on the role of a first year OU Social Science student and reported his thoughts and feelings of being a student (Cowan, personal communication). Donald Woods (1994) became a student of PBL classes in chemical engineering to experience what it was like to be a student and to observe the interactions of students and tutors. Simon Sinclair (1997) in 'Making Doctors' reports his study of returning to medical school as an undergraduate. Of course, these studies are not exact 'roles of the other' since the researchers bring to the roles their own experience and skills. But the studies do reveal interesting insights into what it is like to be a student. Similar studies in engineering could focus on being a disabled student, a mature student, or a part time student but one needs time, motivation and expertise for such studies.

Box 6.1. An ethnographic study

A young doctoral student was invited by a large engineering company to explore the thoughts and feelings of shop floor workers of managers and the policy of the company. She joined the company as a six month work placement student. She did not reveal her core task. She worked in various sections of the factories, read various documents of the company and did the usual observations which ethnographers do. From her detailed field notes, she was able to identify there were huge gaps between what shop floor workers thought of managers and company policy and what the managers thought the shop floor workers thought of management and policy. She also discovered that the departments in the factory were also distrustful of each other and less co-operative than they appeared. She revealed there was not one culture in the factory but a series of sub-cultures. Shop floor workers pointed to the discrepancies between company policy on transparency, ease of communication with managers and equity of privileges such as car parking and dining facilities. Her findings were debated hotly by senior managers and eventually led to some changes in policy, privileges and management styles.

The company asked for her PhD to remain confidential for five years – even though all the details were anonymised.

Clearly ethnographic observation can be subversive - but it is useful. It can turn an organisation for learning into a learning organisation - providing the organisation wants to change - and it can provide deep insights into how organisations and groups work. But it is a challenging, time-consuming iterative form of research in which initial observations and analyses have to be tested against further observations and analyses until a clear picture emerges.

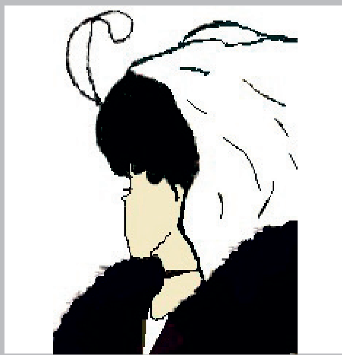
The observables?

What you observe is determined only in part by what there is to observe. Put simply, the more you know, the more you see. For example in Kings College Chapel, Cambridge in the top of the stained glass windows one can see beautiful patterns and colours. A historian sees in these patterns the signs and symbols of the Tudor dynasty: a less knowledgeable visitor might not. An experienced designer can read a blue print and mentally picture a 3D model, whereas a first year student unfamiliar with blueprints and elevations may see only a puzzling set of lines. An experienced observer of groups sees subtle interactions which a naïve observer misses. A radiologist sees more in an X-ray radiograph than an engineer. In all these cases, experts perceive more than novices. The implication here is that observation, as a research tool, has to be learnt. Now try the light-hearted activities below. Then read the notes on activities.

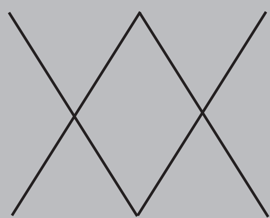
These illustrations give you clues to the process of observation and to the common pitfalls. These processes and caveats are summarised in Boxes 6.2, 6.3 and 6.4.

Activities

6.1. Glance quickly at these pictures below and jot down what you see



6.2. Jot down the different things you can see in the diagram.



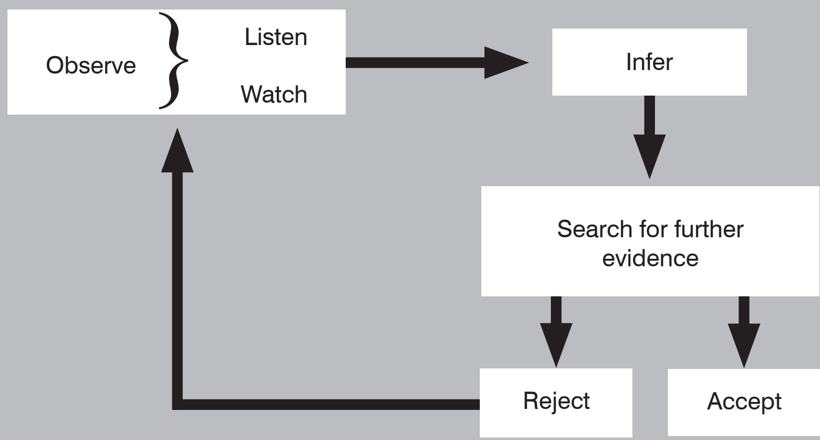
6.3. Glance at these and say aloud what you see

Godisnowhere

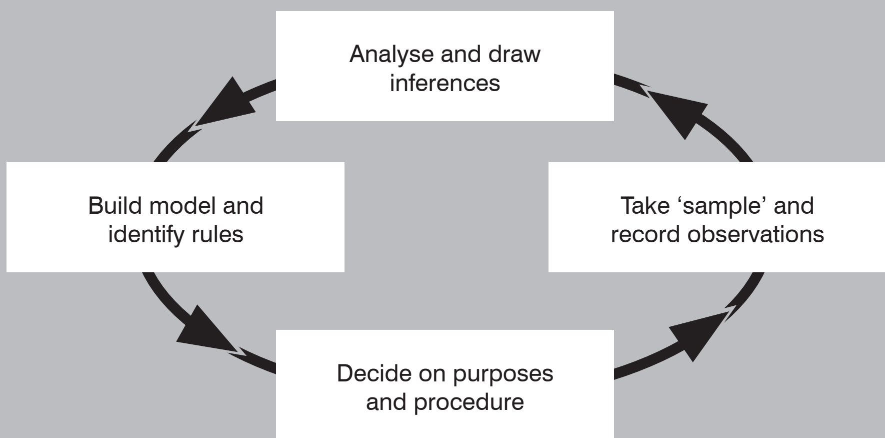
Newswipe

6.4. Look at this picture and note your very first thoughts

6.2. Process of Qualitative Observation



Box 6.3. Procedure for building model based on observations



Box 6.4. What one observes

What you observe and infer is a function of:

You, the observer:
- Your attitudes, values and beliefs
- What is salient in your thinking
- Your purposes in observing
- Perhaps, the traditions of your subject

↔

The observable:
- Its meaning to you

Boxes 6.2, 6.3 and 6.4 will help you to understand the processes of observation but one needs to be aware of common pitfalls of:

- Accepting the first inference too quickly.
- Not searching for evidence that tests the inference.
- Not being aware of one's attitudes, values and prejudices.
- Assuming that what you observe is all there is to see.

In summary, observation is a cognitive process, it is more than sensing the obvious, what you observe is a function of what there is to observe and its meaning to you. It is determined in part by what is potentially observable and in part by the observer, the observers' purposes in observing, their attitudes, values and beliefs and what is salient in their thinking. Qualitative observation is a powerful tool and rather more than just looking at phenomena. It is looking *into* phenomena.

Uses of qualitative observation

Qualitative observation can be used as a preparation to more structured, quantitative observations based on checklists or ratings; as further evidence, to exemplify and illustrate qualitative observations, and as a method in its own right. It can be used to analyse tasks, for mapping practical procedures, matching claims against actions, for studying interaction in groups, students' reactions in lectures and how students perform in laboratory work. For example, the method might be used to study students' practical skills and compare the findings with the grades of reports in their laboratory notebooks or laboratory sheets. Such a study might reveal that laboratory notebooks are not necessarily a useful measure of practical engineering skills.

How many and how often?

We are often asked 'how many should we sample and how often?' (How long is a piece of string?) Box 5.5 in Unit 5 indicated the questions you need to ask yourself about sample size. The number of observations is also dependent upon resources, feasibility and the research problem. If you are interested in changes in observable behaviour then obviously a minimum of two observations is required. Two or three observations are also useful for normal observations since only one observation may not be typical. If you are doing ethnographic research think in terms of hours, even days or weeks. If you are interested in consistency or standards of behaviour (competence) of the participants, the usual recommendation is 7-9 observation sessions (Norcini and Burch, 2007) but this is rarely achievable in qualitative observation and their recommendation is based on quantitative observation (See Unit 10).

Rigorous qualitative research can be challenging so we suggest you practise qualitative observation based on video-recordings, preferably with a co-researcher and compare your observations. When you feel confident about doing qualitative observation, do at least two observations per sample, if that is possible. In the research report or paper, state the number of observations made, discuss the limitations of the study and counsel caution in generalizing results. Qualitative researchers rarely report reliability measures.

Further reading

On perception

For background knowledge of perception see:
Hayes (2000b) or Eysenck and Keane (2005) or most standard introductions to psychology.

On qualitative observation

http://www.gsociology.icaap.org/methods/qual.htm contains links to sites which consider qualitative observation.

Basit (2010) contains a chapter on different types of observational research.

Lofland et al (2008) provide a comprehensive view of qualitative observation in different social settings but does not consider directly higher education.

Coolican (2009) contains a good chapter on qualitative and quantitative observation. It is also a useful text on experimental design, methods of research and statistical analyses.

On ethnographic research

We have not discovered any published pedagogical research in engineering based on ethnography. Some texts which used ethnographic methods, sometimes unknowingly, which may be of general interest to readers are:

Dennis, Henriques and Slaughter (1969) on 'Coal is Our Life' which describes the work, thoughts and feelings of coal miners in the late sixties.

Fox (2005) on 'Watching the English" provides a light hearted, amusing account of customs and patterns of the behaviour of the English.

Hammersley and Atkinson (2003) is a serious read on the nature of ethnography.

Jackson and Marsden (1986) describe the reactions to grammar school education of working class pupils and their parents.

Woods (1986) reviews some major ethnographic researches in schools.

Unit 7
Other methods of qualitative research

Introduction

This unit outlines some alternative methods of qualitative research. These are sometimes neglected in pedagogical research but they can yield interesting, insightful information. The alternative methods considered are mind maps, self-talk, narratives, studying leaderless groups and documentary analysis. As usual, all of these methods can be used in their own right or as a preliminary to a larger empirical study.

Mind maps

The term ‘mind maps’ is used generically to cover ‘mind maps’, ‘cognitive maps’ and ‘spider diagrams’. The differences between these approaches in practice are marginal. All may be used to plot perceived linkages between topics and subtopics or the structure of a procedure or argument. All might include brief notes on relationships and all are based on the methods of free association and mapping. The maps may be generated by individuals or groups and subsequently refined. The maps are of course unlikely to be accurate representatives of cognitive networks stored in the long term memory. Nevertheless they do provide a representation of the perceived relationships between topics. Put another way, the structure of a mind map is dependent on the topic being explored and the explorer. Some topics yield simple hierarchies such as relative velocity leading to vectors to vector analysis to vector mechanics. Other topics might produce complex hierarchies or concatenated networks (basically connections) or a mixture.

Mind maps may be used in thinking and planning a research submission or research project or as a research method in its own right. Used as a method, it can be used to compare the different constructions of a topic by experts and novices, to compare changes in knowledge from before and after an intervention, or simply to ascertain the initial mental constructs of students entering an engineering course or going on a work placement. In all of these forms of research, it is important that the researchers and participants have had some practice in creating mind maps. Box 7.1 offers some guidance on constructing a mind map. Figure 7.1 shows a simple mind map and Figure 7.2 shows a rather colourful mind map of engineering, its uses and relationships to other fields. Figure 7.3 shows the 'mind map' which Sir Tim Berners-Lee sent in a memo to his boss at CERN, Mike Randall, which led to the foundation of the Web and revolutionised computer-based communication.

Box 7.1. Constructing a mind map

1.

a) Free associate (brainstorm) a list of ideas, facts, whatever comes to mind and then look at ways of linking and casting out those that are random or irrelevant. Be careful at this point. What may appear random or unrelated might be pivotal.

Or

b) If you are predominantly a visualiser, write the topic in the middle of the page, free associate and draw your rough map of the perceived relationships.

2. Then look carefully at your list or rough map, tidy it and produce a first draft of the mind map. At this stage you might, if you wish, label the strings or show the direction of the connections.

3. Now produce the final version of the mind map. Some people use colour to highlight strong and weak connections. Sometimes additional ideas and connections ideas come to you at this stage. So if you are dissatisfied with your mind map, then do another version.

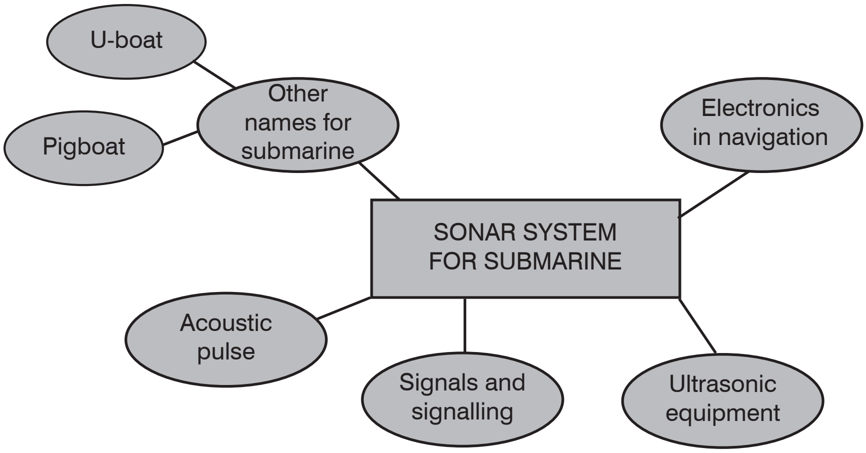
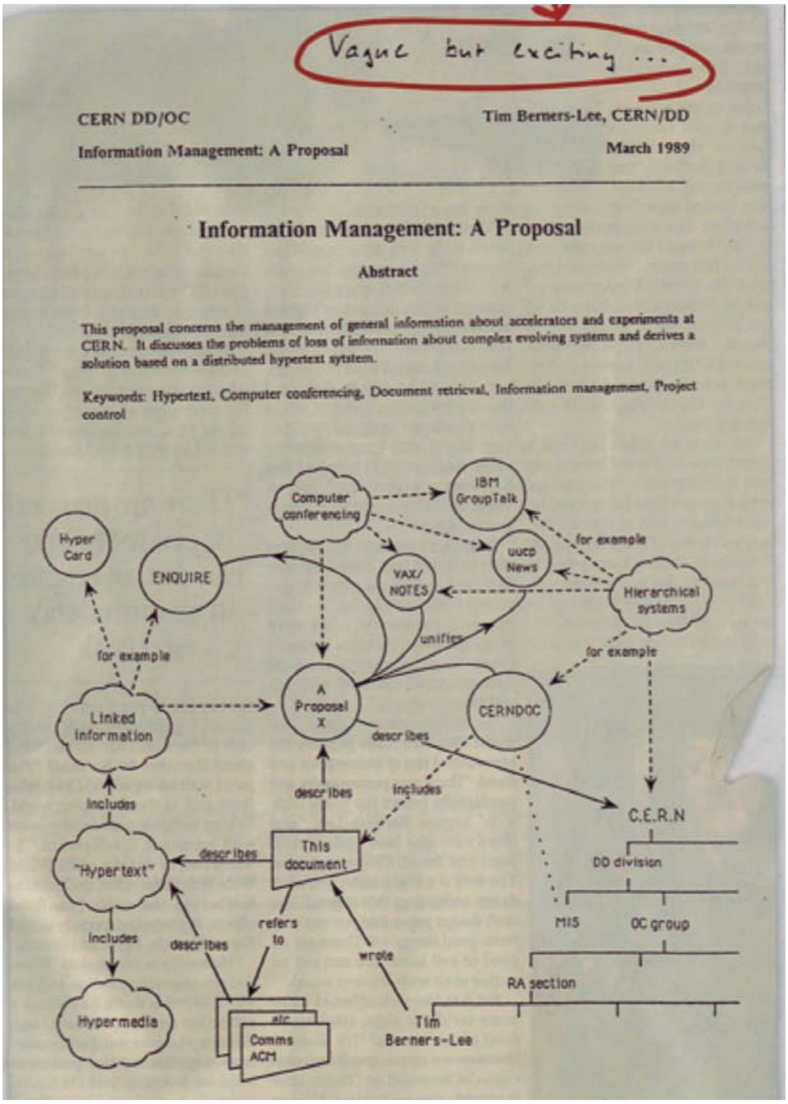


Figure 7.1. A simple mind map which can be extended
from http://library.sun.ac.za/eng/help/Infolit2002/mindmap4.html
[accessed 24 January 2010]

Figure 7.2. A mind map showing the uses of engineering
from http://www.mindmapart.com/engineering-mind-map-joan-clews/
[accessed 24 January 2010]

There are plenty of computer programmes on the web which supposedly will help you to produce mind or cognitive maps. But computer programmes can be constricting and training in generating mind maps is necessary for the outcomes to be useful in research – or in learning, note taking, and revision. With a little ingenuity, one can also use standard drawing packages to create mind maps. However, be warned, some engineering students, particularly those who think linearly, have difficulties in generating mind maps.

There is no standard method of analysing mind maps. But one can establish a set of criteria on which to judge the mind map. One can match a participant's mind map to a master template and intuitively assign a mark. One can count the number of nodes and strings (connections), or better still, the relevant (or accurate) nodes and strings. If these methods are used it is advisable to use double blind marking.



Vague but exciting ...

CERN DD/OC — Tim Berners-Lee, CERN/DD

Information Management: A Proposal — March 1989

Information Management: A Proposal

Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext sytstem.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control

Figure 7.3. Berners-Lee's mind map that led to the foundation of the Web
(*Note his boss's' comment at the head of the page*)
http://info.cern.ch/Proposal.htmlaccessed [accessed 24 Jan 2010]

Self-talk

Self-talk includes asking questions, giving oneself instructions and reporting what one is doing or thinking. The approach is used in therapy and sports coaching. In pedagogical research, self-talk recorded on an audio-recorder can provide a rich source of data on the processes of writing, reading a difficult text, problem solving, design and human-computer interaction. Two approaches are possible. The participant says whatever springs to mind when performing a task. This might include swearing, day dreams or fantasies as well as relevant thoughts and justification of actions. This approach reveals feelings as well as actions. In the second approach the participant reports what he or she is doing without explaining why or reporting their stream of consciousness. Either of these approaches can be used. For example, one could compare the frustrations and processes of problem solving of stronger and weaker students. There are plenty of areas in engineering where some students have academic difficulties. (For example, in stress analysis, thermodynamics and tensor analysis.) Talk-aloud, a form of self-talk, has been used for formative evaluation of CAL materials in mathematics by engineering students (Cowan, 1998) and in facilitating problem solving (Cowan, 1977). Self-talk would be useful for diagnosing these difficulties or comparing problem solving strategies in these topics. Self-talk can also be used as a training device and its effect judged or measured. For example, King (1992) trained a group of students to use self-talk questions (but not aloud!) in note taking in lectures such as '*How is it related to the previous topic?*' or '*What is the main idea?*' One week later their recall was superior to that of the untrained group.

Narratives

It is said that every person has a novel inside them. That may not be true. But it is certainly true that every person has untold stories of their experiences and observations. These are sometimes referred to as 'journeys'. These narratives are the basis of Oral History and can be a useful tool in pedagogical research in engineering. Narratives could be used to explore the experiences of students, lecturer's experiences or engineers working in industry. After identifying clearly the area one wishes to investigate, all one needs is some experience of open-ended interviews (See Units 3 and 5), a good quality digital recorder, a quiet place and a few well chosen questions; then let the participant talk. The data then needs to be transcribed and analysed using thematic analysis. The analysis is much more time consuming than the data collection. You can, if you wish, attach your analysis to a specific theoretical framework (see Sikes and Gale, 2006). We do not recommend complex theoretical frameworks in the early stages of doing pedagogical research.

Studying 'leaderless' groups

Leaderless groups are groups without an official leader, although a leader or leaders usually emerge from the group. Armed with an audio-recorder, or a camcorder if the group is media savvy, the group record their discussions. These discussions may be centred on a research problem or a group project. They may be based on one single session or a series of sessions and so track changes in the group's approaches. The method can be used to explore effective and less effective team work in design projects. It may be used, without the researcher being present, to allow participants to discuss a theme; for group problem solving or preparation; or for a group presentation. In all of these the recordings can be used to analyse the different roles which the participants take in group work and teamwork. Psychologists usually refer to this form of study as group dynamics although it has little in common with either dynamics in applied mathematics or groups in pure mathematics. Group dynamics, in the social psychological sense, is more to do with studying who says what to whom, when and to what effect. It can lead to the identification of the roles and characteristics of the leaders, blockers, playboys (and playgirls), free riders or social isolates in a group or a team. Analysis may lead to other ways of characterising individuals in groups or teams. The data can be analysed using thematic analysis. If you wish to do quantitative analyses, see Unit 10 on quantitative observation.

Documentary analysis

Documentary analysis is a portmanteau term for any methods of analysing official reports, reports of practices, historic texts, diaries and, of course, research papers. For managerial purposes one reads (or doesn't!) official documents for the implications for the department, the faculty and oneself. For research purposes, one reads official documents for their relevance to one's research, for shifts in emphasis and to ascertain whether the recommendations are based on sound evidence. At a deeper level, one reads critically to probe the underlying assumptions, and perhaps, ideologies of a document. Last but not least, one reads contemporary reports and documents to familiarise oneself with the fashionable jargon for one's own research applications., This jargon may be conceptually weak but it does have eye-appeal for referees. Such words as inclusivity, sustainability, embedding, sustainable development, accessibility, employability, diversity, impact, excellence, transparency and many others are current in pedagogy. 'Graduateness' is definitely out.

There is no set method of documentary analysis. The method depends partly on the purpose of the analysis and the nature of the document.

Analyses of diaries requires a different approach from analyses of official documents although in both, one searches for hidden implications, assumptions, inconsistencies and evidence of external validity. For the analysis of official documents one matches these against the official, avowed purposes of the document.

> Senior engineering academics will be familiar with the direct and inverse laws of documentary analysis. As you rise through the hierarchy the number of document you are expected to read increases proportionally. At the same rate, the amount of time available for this task decreases proportionally.

All of the above alternative methods have rich potential in pedagogical research in engineering. But like all forms of research, they require careful planning, and organisation and analysis. Unlike much research in engineering concerned with materials and processes, these methods do require the researcher to provide clear, well understood briefings of the experimental objects: the human participants.

Activities

7.1 Spend about twenty minutes producing a mind map of the key features of your discipline (e.g. mechanical engineering, civil, materials etc). Ask a PhD student, a first year engineering undergraduate and, if possible, a first year Arts student to do the same. Compare the mind maps and think about how you might asses them.

7.2 Ask a couple of students, preferably one who is accomplished and one who is not, to talk into a digital recorder as they are trying to solve the same problem. Transcribe their talk and compare their approaches. Explore if you can map the 'moves' made by each student.

7.3 Ask an older colleague and a recent graduate (separately) to reminisce about how engineering was taught when they were undergraduates. Audio-record each interview. Compare their accounts. Consider how you might verify their accounts.

7.4 Give a digital recorder to a small group of students (n<6) who are working on a project, or reflecting on how they worked together or who have just moved into a new learning space. Ask them to record a half hour discussion. At the beginning of the recording they should state their names and check the recorder is working. Listen to the recording and note the main patterns of interaction and roles. Or, if you have time, do a transcription and identify the major patterns and roles.

7.5 Read the brief report of the Royal Academy of Engineering on 'Pioneering Engineering Education' (http://www.raeng.org.uk/news/publications/list/reports/Pioneering_engineering_education.pdf.) What do you think of it? What's missing from it? Invite a few colleagues to read it and compare your views.

Further reading

On mind maps

Basque and Lavoie (2006) review major trends in the use of group mind mapping.

Buzan and Buzan (1996) are strong advocates of mind mapping (See also http://www.imindmap.com/).

Novak and Gowin (1984) is useful on how to construct and analyse mind maps.

Speller (2008) gives a succinct overview of mind maps.

Zampetakis *et al* (2007) argue the case for the use of mind mapping to develop and measure creativity.

Examples of mind maps can be found at http://www.mindmapart.com

Free mind map software is available on the web.
(e.g. http://freemind.sourceforge.net/wiki/index.php/Download)

On narratives and accounts
Basit (2010) has a useful chapter on documentary analysis.

Cohen *et al* (2006) contains useful suggestions on self-talk and documentary analysis in their chapters on Accounts and Historical Research.

Moyer (1999) provides an overview of methods of doing oral history which contain useful ideas for narrative research in pedagogical research.

Ramsden *et al* (1993) provide accounts of students' conceptions of speed, distance and time.

Sikes and Gale (2006) is a brief, well-written introduction to theories underlying narrative approaches which provides useful hyperlinks.

http://www.smith.edu/engin-eep/papers/big_picture.pdf provides reports based on narratives of engineering educators

Pawley (2009) at:
http://ratings.asee.org/publications/jee/PAPERS/display.cfm?pdf=1042.pdf reports engineers' conceptions of engineering obtained from narrative research.

Examples of students' narratives may be found at http://www.smith.edu/engin-eep/papers/big_picture.pdf

Section C
Quantitative Research

This section of the book considers the more familiar ground of quantitative research but there are differences between quantitative research in engineering and in engineering pedagogy (See Unit 13). Quantitative research in pedagogy may be characterised as the use of predominantly closed questions or statements with fixed alternatives, careful attention to sampling design and the use of statistics to test hypotheses. The fundamental process involved is mapping personal and social characteristics on to numbers and then manipulating the numbers statistically. The major instruments of data collection are structured questionnaires. These can be used in interviews, in-house, postal, email and online surveys. Important considerations in these surveys are the design, the sample and the methods of data analysis.

This section explores all of these issues. Units 8, 9 and 10 consider questionnaires and other methods used in surveys and outlines some relevant research. Units 11 provides a brief overview of statistics and experimental design.

All of these units are concerned with empirical research in pedagogy.
In this guide we do not consider conceptual research in engineering pedagogy. This form of research attempts to re-describe pedagogical processes in mathematical or engineering terminology. For example, in recent research at Loughborough, concepts from systems engineering have been be applied to lectures, student learning and feedback (Abdulwahoud, 2008a); game theory has been used to model costs and payoffs in experiential learning (Abdulwahoud et al, 2008b) and Kolb's learning cycle modelled mathematically (Abdulwahoud et al, 2008 c).

These approaches can be powerful; they can make hitherto unrecognized connections and thereby deepen understanding of the processes involved and they have a strong appeal to engineers who are used to thinking in terms of equations, matrices and vectors. They deserve a book of their own.

Unit 8
Questions, questionnaires and surveys

Introduction

Questionnaires can be used in interviews, emails, online or be paper-based. They are the most widely used method in pedagogical research in engineering and possibly the most ill-used. Contrary to popular belief, they require careful attention to design and detail. One can put together a questionnaire in an afternoon and use it the following morning. But, you would be lucky if such an approach yielded worthwhile publishable results.

This unit offers suggestions which will help you to improve your design of questions, questionnaires and surveys. It outlines the characteristics of different forms of closed questions and points to the pitfalls to avoid when using questionnaires and surveys.

Closed questions are questions or statements to which there are only a fixed choice of alternatives to respond to, although occasionally a researcher includes 'other' or 'none of these' in the alternatives to check the prescribed alternatives are complete. Closed questions usually require little writing - only ticks or crosses - but they do require careful reading and usually some thought. They simplify the process of counting and measuring and therefore are amenable to statistical analysis. The questionnaires may be concerned with the views of participants or their knowledge; they might include learning inventories, personality tests, attitude scales and tests of achievement. Unit 9 contains suggestions on these uses.

All of these uses are self-administered reports by the individuals (as indeed paper and pencil psychological tests are). It is assumed that their responses are an accurate report of self-knowledge, knowledge, opinions or attitudes. Cheating cannot be eliminated entirely in questionnaires and false presentation of self is possible. Usually one has to trust the responses of the participants although it is possible to check the consistency of responses by asking similar questions in different parts of a questionnaire or by searching for further evidence.

Questionnaires consist predominantly of sets of closed questions. Surveys refer to the process of data collection from the sets of respondents, the sample. The terms ‘questionnaire’ and ‘survey’ are sometimes confused or used interchangeably. Technically speaking, questionnaires are the sets of questions used to elicit information. Surveys refers to the processes of data collection from the sets of respondents. These components interact and design faults in either component result in low, perhaps useless, output.

Design of questions

Closed questions in the questionnaire need to be expressed in a language familiar to the respondents, unambiguous to the respondents and capable of being answered by them. In addition, it is often useful to ask them to give their honest opinion or state clearly to them that there are no right or wrong answers. Indicate the responses will be confidential to you, the researcher, or, if you do not need their name or number, do not ask for them. Some pitfalls to avoid in questions are given in Box 8.1.

Box 8.1. Pitfalls – avoid them

Don't use leading questions
Most engineering students are in favour of course work. Do you agree?

Don't use double negatives
It is not true that MCQ cannot test problem-solving skills

Don't use loaded words in questions
Do you believe in the value of intended learning outcomes?

Don't use double barrelled questions
The Head of Department is a good academic but not a good manager?

Don't use long-winded questions
Do you agree or not agree with the statements that engineers are usually more inclined to favour quantitative methods than qualitative methods of research in pedagogical aspects of engineering?

Don't use questions which are difficult to answer accurately
How many individual students have you seen privately in the past semester?

Some of you may think these pitfalls are so obvious that you will avoid them. Be careful: you might not.

Check the clarity of your questions with a person unfamiliar with your research topic and do consider whether your question is really necessary. Strictly speaking each question in a questionnaire should be based upon or directly relevant to a hypothesis you are testing. In quantitative research, if you do not know what you are looking for, you probably won't find it.

Design of questionnaires

Identify the research problem

The usual advice embarking on research is pertinent here:
'First, identify the research problem and questions'.

But how does one do this? Probably the best approach is to read and think around the topic, free associate, structure the questions or statements, and talk to colleagues or others familiar with the field. Then formulate the research problem and the research questions you wish to explore. Then formulate the hypotheses you wish to test. As usual, think before you begin your design.

What are your priorities?
At this point, you will need to stand back and ask again what are your priorities in designing the questionnaire and survey: make sure your questionnaires look (and are) professional. This will help you to get a good response rate.

What typography?
The typographical design, the use of friendly but formal fonts (Arial, Palatino Linotype, Times New Roman) and adequate spacing are all features which can influence response rates. If you are not confident about typographical design, consult someone who is adept at desktop publishing. As a rule of thumb, in small scale questionnaires, no more than 4 sides of A4 printed in 11 or 12 point font is preferable. More than this can produce questionnaire fatigue and, consequently, careless responses.

What structure and layout?
Don't mix up the different formats of items. This approach can confuse and generate irritation. So divide the questionnaire into different sections, and use the same format in each section. Layout the questions neatly so they are easy to read. Use bold and italics as well as normal type and do not overfill a page or use very small font sizes. Use a simple method of numbering which is easy for respondents to follow and which will help in coding responses. The 'marking' system and the questions structure should be clear to the respondent and for coding purposes.

Avoid too many 'skip' questions
As far as possible design the questionnaire with very few branches of the type 'If you answered 'No' to this question go immediately to question 21, if you answered 'Yes' go to question 8'. If there are several branches, some respondents take the easy option of skipping questions.

Consider the order of questions
It is better to ask easy or non-threatening questions in the earlier sections, then ask more sensitive questions, and end with questions which are relatively easy for the respondent to answer, a thanks and where to send the questionnaire to.

Create a meaningful title and introduction
Make sure the questionnaire has a meaningful title and a short persuasive introduction. Put the date on the questionnaire and file so you can track various versions.

Biographical data
Decide whether to ask for biographical data at the beginning or the end of the questionnaire and how much to ask for. Self-disclosure in a questionnaire is much more comfortable when one knows what one is being asked about (whereas a request for biographical information at the end of a confidential interview can be seen as threatening).

The biographical data can be used intuitively to make judgements of the typicality of the sample (civil engineering students, female line managers, English engineering students etc); to estimate statistically the representativeness of the group compared with the population from which the group was sampled; to generate hypotheses about the group and to offer generalisations. In much of small scale pedagogical research only tentative generalisations are possible. In large scale surveys, generalisations are based on sophisticated statistical methods. (see 'Further reading').

The biographical data can provide hypotheses such as male and female engineering undergraduates differ significantly in their views of the value of work experience: – they probably don't (Ahmed, 2009). If the biographical data will not be used for testing hypotheses, it is superfluous. If the biographical data is needed to track changes, as in pre-test-intervention-post test studies then it is important. But one can get tangled in legal and ethical issues. One solution to these issues is to provide a covering note and include a disclaimer such as:

'Please supply us with your name or registration number. It will help us in our research

Name:

Registration number (if known):

Please tick the box if you do not wish to disclose the above [ ]

Many thanks

Avoid the 'just in case' trap
Avoid asking several questions which are not directly relevant to the research problem but would be 'nice to know'. Often this leads to a lengthy questionnaire and probably a low response rate, too much data to analyse and too many hypotheses to test. For example, if you have 30 questions which each require statistical analyses by gender, age, experience, subject differences and qualifications then you have a minimum of 150 tables of data to analyse and select from for interpretation. Many of these will

probably yield non-significant, perhaps, valueless results. Inexperienced users of questionnaires are strong on data collection, weak on meaningful data analysis.

Using other people's questionnaires
If you wish to use or adapt someone else's questionnaire then do ask permission: preferably, before administering the questionnaire. Check the reliability and validity of the questionnaire and if it will provide answers to your research questionnaires. If it does not: change your research questions or the questionnaire items.

Further hints are given in Box 8.2.

Box 8.2. Some hints on questionnaire design

- State purpose
- Assure confidentiality
- Ask for biographical data at the end of the questionnaire
- Use a questionnaire package – but make sure your questionnaire fits its parameters
- Keep the questions simple and user friendly. (3 sides of A4 plus a cover?)
- Provide unambiguous instructions for each section of the questionnaire.
- Target the right people - at the right time.
- Do a pre-pilot to eliminate ambiguities and to estimate completion time.
- Do a pilot to check statistical analyses.
- Ask yourself: Do I really need to ask this question?
- The more complicated the questionnaire, the lower the response rate.
- Prepare reminders at the same time as the distribution of the questionnaire.
- Use some open ended questions - but remember they take longer to analyse and students often skip them.
- Estimate times for piloting, distributing, collecting, reminders, analyses.
- Allow for slippage.
- Use brief e-mail questionnaires when feasible.

Closed question formats and coding

There are several ways of formatting and coding closed questions. A closed question may be direct such as:

How important is a knowledge of mathematics to a practising production engineer? (Please ring the word(s) closest to your view)

Important	Very important
Fairly unimportant	Fairly important
Unimportant	Very unimportant

Or indirect such as:
An advanced knowledge of mathematics is important to a practising production engineer. (Please indicate your view)

Agree Strongly agree Disagree Strongly disagree

Notice the question has subtly changed.

If you use numbers instead of words, it is better to give the meaning of each item on a scale (known as anchoring statements) to minimise differences in interpretation In both examples an even number of choices were provided. Even numbers of items force a choice and do permit collapsing of data for statistical analysis but do not provide a midpoint for those who are genuinely uncertain. For small samples it is better to use an even number of items so the data can be collapsed into fewer categories for statistical analysis, if necessary. The number of points on a scale are typically 5 or 6.

Nine or 10 points (with anchoring statements) can be used when measuring change. However measuring change is not without difficulties (See Unit 11). Whether you use words or numbers, the responses have to be coded. It is usually better to use a separate column on the spreadsheet for each possible choice. For items missed by a respondent, it is customary to use the code '9'. For further advice consult a questionnaire designer and/or read the texts recommended in 'Further Reading'.

Some other examples of formatting
a) Numerical scales

Please circle the number that is closest to your view.
1 2 3 4 5 6

It is better to anchor 1 as the lowest point on the scale so that higher numbers indicate greater values. Avoid the use of negative numbers on a scale, they can wreak havoc with calculations. Visual analogue scales can be used instead but even with the aid of an optical reader this method is cumbersome and lends a spurious accuracy to the data.

b) Bi-polar scales

Supervisor should choose	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	Student should choose

This line manager was:

Friendly ______________________________ Unfriendly
Boring ______________________________ Interesting
Helpful ______________________________ Unhelpful

Bi-polar scales, such as these, need not have anchoring statements. Spaces between boxes should be equal. If you reverse the scale as in Boring- Interesting, remember to reverse the codes. Linear scales are not necessarily independent. A line manager who is friendly is likely to be helpful. Advanced statistical techniques such as factor analysis, item analysis and cluster analysis can tease out relationships between the data and profiles of the participants (See 'Further reading' and Unit 11).

c) Ranked response
Indicate the relative importance of the following statements by ranking them number 1-4, where 1 is the most important:

[ ] Friendliness of supervisor
[ ] Helpfulness of supervisor
[ ] Knowledge of supervisor
[ ] Industrial contacts of supervisor

Ranked responses look appealing but if possible avoid them they can be troublesome to code, analyse and interpret. If you are interested in the group's *ranked* responses it is better to use a Likert type scale for each item (e.g. a number scale 1-6), pool the results and calculate the mean and standard deviation of each item. Do not ask for ranking of more than seven items. The process is tedious for participants and rarely done carefully.

d) Usually applies
Please tick the box that usually applies (tick one box only)
[ ]
[ ]
[ ]

Respondents sometimes tick more than one box so you have to cast out all their responses to the item. You need a separate code for each choice (0,1) for each variable and another code such as 9 for non-responses.

e) All apply
Tick all boxes that apply.
[ ]
[ ]
[ ]
[ ]

When coding responses to this type of question you will need a cell for each box and use the code 0,1. If the respondent does not tick a box, then use '9' in the cell for each box. You will need to think about how you will summarise the information.

f) Frequency of use

Very often	Often	Occasionally	Never
4	3	2	1
[ ]	[ ]	[ ]	[ ]

You do not have to use numbers in the questions, boxes are clearer, but you will need numbers for your coding, each point on the scale represents a number.

g) Intensity of feeling

Strongly Dislike	Dislike	Dislike slightly	Like slightly	Like	Like strongly
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

h) Degree of agreement

Disagree strongly	Disagree	Disagree slightly	Agree slightly	Agree	Agree strongly
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Be careful how you code each point on the scale.

i) Time/frequency estimates
Do you *deliberately* reflect upon your work:

About once a month	[ ]
About once every two weeks	[ ]
About once a week	[ ]
Every day	[ ]
Rarely	[ ]
Never	[ ]

Notice the order is not in sequence. Be careful how you code. The responses you obtain may be what the respondents think you want. Time estimates are notoriously unreliable so you should always add a cautionary note in your report or paper. Provisos such as ‘Please give your honest opinion’ or ‘We are interested in your personal opinions. There are no right or wrong answers.’ can minimise the ‘social desirability’ effect.

j) Frequency of action

Have you ever fudged experimental results?

Never	Rarely	Occasionally	Frequently	Mostly
[ ]	[ ]	[ ]	[ ]	[ ]

Few students would admit to ‘Mostly’ even if the information was strictly confidential. Totally anonymous questionnaires *might* obtain accurate information on such controversial issues.

A note on coding and inputting

Unlike in qualitative research, coding in quantitative research should be done before the data collection and when designing the questionnaire. It is sensible to ask a colleague to check the coding as well as the questions. Typically one uses a spreadsheet such as Excel. An identifier code (e.g. 01-99) should be assigned to each incoming questionnaire. The programme will re-sort the data into appropriate categories. Each aspect of the biographical data should have a code for each set of variables, e.g.:

What is your age:

	18 -25	26-30	31-35	Over 36
response	[ ]	[ ]	[X]	[ ]
coding	0	0	1	0

The coding should be 1 for the box marked and 0 for the other boxes. A difficulty here is what to do with non-responses. One way is to code each box either 1 or 0. A total series of 0s equals a non-response.

There is no advantage in putting the actual codes on the questionnaires. These clutter up the questionnaire and may reveal too much to the respondents. The data inputter (probably you!) needs to design the code sheet. It is sensible to check your codes with an experienced questionnaire designer before distributing the questionnaire.

Much of the drudgery of data inputting can be reduced by using online or email questionnaires. These can be programmed automatically to compile and summarise responses. External sources such as Survey Monkey (http://www.surveymonkey.com) or the Bristol online survey facility (http://www.survey.bris.ac.uk) are 'free'. (The Bristol online survey keep a copy of your data). Internal sources, such as your Library and Information Services, may have packages available. You have to weigh the possibility of a much lower response rate obtained in an online survey against the possibility of a higher response rate in class but the necessity of inputting the data. And you still have to think about the design of the questions, the survey and the coding.

Design of surveys

The questions you need to consider when designing your survey are:

Who will you sample?
How many will you sample?
How will you maximise your response rate
How will you collect the data?

Samples, sampling size and response rates

A sample should, ideally, be representative of a population so that the results of a study may be generalised from it to the population and therefore to other samples. In practice, few small-scale surveys can achieve this ideal. Instead, one reports the demographic data and leaves the referees or readers to judge whether the results might also apply to the samples of people they are working with. The various forms of sampling are shown in Box 8.4.

As a rule of thumb, thirty per subgroup is the minimum for a small-scale survey. This size allows statistical analyses to be used to identify similarities and differences in the samples. For more sophisticated analyses such as factor analyses, cluster analyses or multiple regression, then a much larger sample is required. Here a useful rule of thumb is that the sample should be at least four times the number of items on the questionnaire so that the various coefficients of the analyses are relatively stable.

For large-scale surveys, representative sampling becomes more important, but even in large scale surveys it is difficult to generalise statistically to populations since rarely does one's sample mirror precisely the population. However, in large-scale surveys, one can apply and report methods of statistical sampling. A useful way of estimating the sample size needed to obtain a statistically significant result in a large scale sample is

Box 8.4. Types of samples

Convenience and opportunity sampling
These are samples based on the individuals available such as students or work placement line managers.

Purposive sampling
The researcher deliberately chooses individuals to be sampled based on his/her intuitive judgements and the typicality of the sample compared with the population being studied. Examples include students from the different types of engineering such as Civil, Electrical, Mechanical and/or from different levels of academic achievement.

Quota sampling
Very similar to purposive sampling. The researchers decide how many in each subgroup of the population to sample. The decision may be intuitive or based on the statistical profile of the sample available. For example, if in a faculty there are 200 civil engineers and only 50 surveyors then one could set proportional quotas.

Snowball (Pyramid) sampling
Researchers choose a small number of respondents who are typical and then ask each individual in this sample for suggestion of who else the researcher should sample and so on. This form of sampling is also useful in qualitative research but some ethics committees are largely apprehensive about this approach (See Unit 14 on ethics).

Simple random sampling
Each member of the population has an equal chance of being selected. The method requires an accurate profile of the population being sampled: this is rarely possible.

Systematic sampling
Every nth person is sampled. Once needs to define narrowly the population and be sure that the sampling procedure is not distorting. For example, a systematic sample based on surnames might yield a much higher proportion of international students.

Stratified sampling
Sub samples are chosen. The choice is based upon what are hypothesised as key characteristics such as mathematicians versus mechanical engineers. A random selection is chosen within each subgroup. The population needs to be narrowly defined and the sampling represent the proportions in the population.

Cluster or unit sampling
When the defined population is large such as all chemical engineering students in the UK then one might select a sample of departments which represent a cross section of the departments. The unit of analysis is then the department not individuals.

Cluster-stage analysis
A more refined version of cluster sampling. One chooses a cross section of departments, within these departments one chooses randomly a sample of modules or classes, perhaps within these one chooses individuals.

All of the above are resource-intensive, difficult to achieve and the response rates may be low. The more remote the sample is from the researcher the lower the likely response rate. *Our advice is keep your sampling simple and your research design modest.*

provided by the tables of Cochran and Cox (1992). Do a fairly large pilot survey and analyse it statistically. If the results look promising then use their tables to obtain an estimate of the size of sample required to get a statistically significant result. If the sample needed is much more than the sample you will be using, then drop that research problem, or change the sample size.

Whatever sample one uses, there is always a sampling error. This error necessarily occurs in any sampling procedure. Without going into the implications of the Central Limit Theorem and its corollaries, one can say that the narrower the sample standard deviation and the larger the sample, the narrower is the standard error. This measure can give you the confidence limits (usually 95% confidence limits). The process is akin to estimating tolerance limits in machining. It is increasingly common to report confidence limits as well as means and standard deviations.

If you are interested in cross-linkage comparisons of responses to items in a questionnaire (cross-tabulation) then you do need significant numbers for statistical analyses. For example, if you are interested in whether female civil engineers dislike work placements on construction sites more than their male peers dislike working in drawing offices then you would need a large sample to make a meaningful comparison.

Finally, be aware. There is no guarantee that your chosen sample will yield worthwhile results; that depends, *inter alia* upon the response rate of the sample. In the National Student Survey, the response rate was overall about 38.8% (17,173/44,209) although it varied between 9.6% and 70.5% across institutions (Richardson et al, 2007). Note that the sample of 44,209 is of a population of students of approximately 2,175,115. As a rule of thumb, in-class and other captive audiences yield the highest response rates, e-mails the least. Online surveys usually have higher response rates than e-mail questionnaires. Follow up by a telephone call increases considerably the response rate (40-50%) but it is expensive. Second mailing yielded an extra 10% and email contact yielded an additional 10%. These figures are based on the report by Richardson et al (2007).

The implications of low response rates are rather frightening. If you want a sample size of 60 nationally then you might need to distribute 300 questionnaires to different engineering departments - and hope. An efficient way of increasing response rates in a national survey is to use your network of contacts in other universities or engineering firms and ask each contact to organise an in-class or on-site survey.

Box 8.5 offers some suggestions for maximising response rates. Some of these have already been alluded to.

Box 8.5. Ways of increasing your response rate

- Use in-class or on-site respondents wherever possible.
- Use your contacts to arrange these in their departments or companies.
- A prior telephone call or (less preferably) an e-mail to the co-ordinators
- An attractive layout.
- Be brief; about 4 sides of A4 in a friendly font (e.g. Times New Roman, Verdana).
- On the first page include a persuasive statement.
- An introductory letter by someone likely to be perceived as high status by the respondent.
- The questions are designed to interest the respondents.
- Easy to complete.
- A personal request to the respondent
- Address the questionnaire to a person, not a status.
- For postal questionnaire, use reply paid envelopes.
- Put the contact and address at the end of the questionnaire with a thank-you as well as on the introductory letter or e-mail.
- Use online surveys rather than email if you wish to preserve anonymity….but this will make follow up difficult.
- Arrange the distribution of the questionnaire at the best time for respondents, not you.
- Telephone or send a reminder.
- Then telephone or send another reminder expressing disappointment at the non-response.
- For those with family responsibilities avoid:
    - The summer holiday season
    - The marking seasons
    - Just before Christmas
    - School half terms
- For students, avoid:
    - Examination periods
    - Near assignment deadlines
    - Friday afternoons for in-class surveys
    - End of term for in-class surveys
- Many respondents find Friday is a better day than Monday for replying to postal questionnaires so try to get the questionnaires to them towards the end of the week.
- Use your computer for design and data compilation.
- Remember: you still need to use your brain as well as the software

For further advice, see ‘Further reading’

Activities

8.1. Look at the examples of questions in Box 8.6. What is wrong with them? How could they be improved?

8.2. Box 8.7 contains some extracts from a questionnaire used in a survey of first year engineers who spent one day per week in their second semester in an engineering workshop making simple artefacts which were marked by the workshop supervisors usually technicians.
What are the weaknesses in the design of the questionnaire? If you have time, discuss the weaknesses with a few colleagues.

8.3. Spend a few minutes thinking about how you would start to design a questionnaire and survey to investigate why practising engineers do part-time Master's degrees in engineering.

Box 8.6. Examples of questions in need of improvement

1. Female engineers are more reliable than male engineers
   1 2 3 4 5

2. Jacobians are always used to solve partial differential equations in thermodynamics.
   Agree Disagree

3. It is not true that MCQ's cannot test problem solving skills
   True False

4. A course in engineering design should not necessarily contain any mathematical concepts.
   Definitely True True False Definitely False

5. Female civil engineers on site are more of a hazard.
   6 5 4 3 2 1

6. Students who have been on work placements are better engineers.
   Agree - Disagree

Box 8.7. Extracts from a questionnaire

To all first years in Mechanical Engineering

This questionnaire has been devised to help us evaluate the methods used in the assessment of your performances in the mechanical engineering workshop and to seek ways in which this might be improved. Please spend a few minutes answering the following questions. Your responses should be anonymous and will be treated in confidence by the Head of Department. Please do not write frivolous remarks.

1. In your view, what should be the purposes of recording assessments of your performance in every workshop session? Please place these statements in order of preference where 1 = most important and 7 = least important.
   - to rank us in order
   - to inform staff of the quantity of our work
   - to provide feedback to us on our work
   - to encourage us to be self-critical and reflective
   - to provide information for students and staff on the quality of our work
   - to motivate us to improve
   - to keep a record of our progress
   - please add other purposes here:
2. Which of the following methods of assessment would you prefer? Please place in rank order.
   - Grade (A, B, C etc.) only
   - Grade and oral comment
   - Grade and written comment
   - Percentage and oral comment
   - Other: please specify
3. It has been suggested that students should have a greater role in the assessment process. Do you agree?
   - Yes
   - No

If yes, how could we introduce this?

If no, please explain why.

4. a) Do you think it would help if you recorded your own views of progress (e.g. in a log book or personal development file?).
   - Yes
   - No

   b) If so, should a summary of your log be provided as part of the assessment process?
   - Yes
   - No

   Now please write about your feelings about assessment of working in the mechanical engineering workshop.

Mail your completed questionnaire immediately to Professor ….., Department of Mechanical Engineering. Your responses will be treated in confidence and will have no effects whatsoever upon the marks that your class receive. Thank you.

Further reading

Questionnaire design
Burgess (2001) (http://www.leeds.ac.uk/iss/documentation/top/top2.pdf accessed 25 April 2009) provides a brief, useful guide to the design of questions and questionnaires.

Aldridge and Levine(2001) provides a clear guide to doing large scale surveys and is good on the design of questions and collecting data.

Bryman (2008) provide a clear approach to questionnaires and interviews and on the use of SPSS to analyse questionnaire data. It is a comprehensive text.

Cohen et al (2007) contains useful chapters on designing questionnaires and survey design.

Oppenheim (1992) is the seminal work on questionnaire design and attitude measurement. It is written in straightforward language.

The ‘Further reading’ in Unit 3 provides other references on designing questionnaires which are worth perusing.

Unit 9
Using psychological measures in surveys

Introduction

Surveys are not necessarily based solely upon fact or opinion-finding questionnaires. They might include learning style inventories, personality tests specially constructed attitude scales, measures of achievement and measures of ability. This unit provides an overview of these approaches and of research in these areas which may help you to decide whether to explore their use in your own pedagogical research.

Learning style inventories and personality tests

Learning inventories and personality tests are off the shelf sets of closed questions which have usually been subjected to rigorous statistical analysis and which yield reliable scores and profiles. If you are doing a large scale investigation then it is worth repeating and reporting the reliability and validity coefficients and performing a confirmatory factor analysis (Field, 2009). For small samples, take the original reports in the tests on trust with, maybe, a few reservations.

By far the most commonly used learning inventory was developed initially by Entwistle (1995) on the basis of qualitative research into deep and surface processing (Marton and Saljo, 1976). Deep processing involves integrating new learning tasks with earlier experiences; integrating the various learning tasks into a whole; trying to see the learning tasks in a wider perspective and actively searching for meaning and understanding. In contrast, surface processing consists of treating all tasks as memory tasks, not searching for connections between tasks and not reflecting upon various approaches to tasks. Later versions of the Approaches to

Study Inventory (ASI) measure predispositions towards reproductive learning, deep learning and strategic learning (choosing the best strategy to gain marks). People vary in their preferences for these approaches. The subject, the mode of assessment, the department's culture and the ability of the students can influence their approaches to study. The work of Biggs is also concerned with deep processing and levels of understanding. Biggs (1996, 2003) describes how his taxonomy, SOLO (Structure of the Observed Learning Outcome) and constructive alignment, may be used for analysing learning tasks, hierarchies of objectives and for assessing students' work. The five levels of Biggs' taxonomy are summarised in Box 9.1.

Box 9.1. The SOLO Taxonomy

Level of understanding	
Pre-structural	The task is not attacked appropriately. The student hasn't understood the point.
Unstructural	One or a few aspects of the task picked up or used but understanding is nominal.
Multi-structural	Several aspects of the task are learnt but are treated separately.
Relational	The components are integrated into a coherent whole with each part contributing to the overall meaning.
Extended abstract	The integrated whole at the relational level is re-conceptualised at a higher level of abstraction. This enables generalisation to a new topic or area, or it is turned reflexively on oneself (Understanding as transfer and as involving meta-cognition).

The Course Evaluation Questionnaire (CEQ) developed by Ramsden (1991) on the basis of Entwistle's work is widely used in Australia and provides a reliable and useful measure of students' perceptions of their departments and its effects upon their learning styles in engineering, medicine and other subjects.

Kolb's inventory (Kolb, 1984) on experiential learning styles has been widely used in engineering. Most engineers tend to be assimilators and convergers (Felder and Brent, 2005). Figure 9.1 summarises Kolb's model.

Honey and Mumford (2006) adapted Kolb's inventory and developed the Learning Styles Questionnaire which profiles tendencies towards 'Pragmatism. Activist, Reflector and Theorist'. This is a useful self-developmental tool but has not yet proved to be strongly related to academic performance or learning on work placements (Coffield et al, 2004).

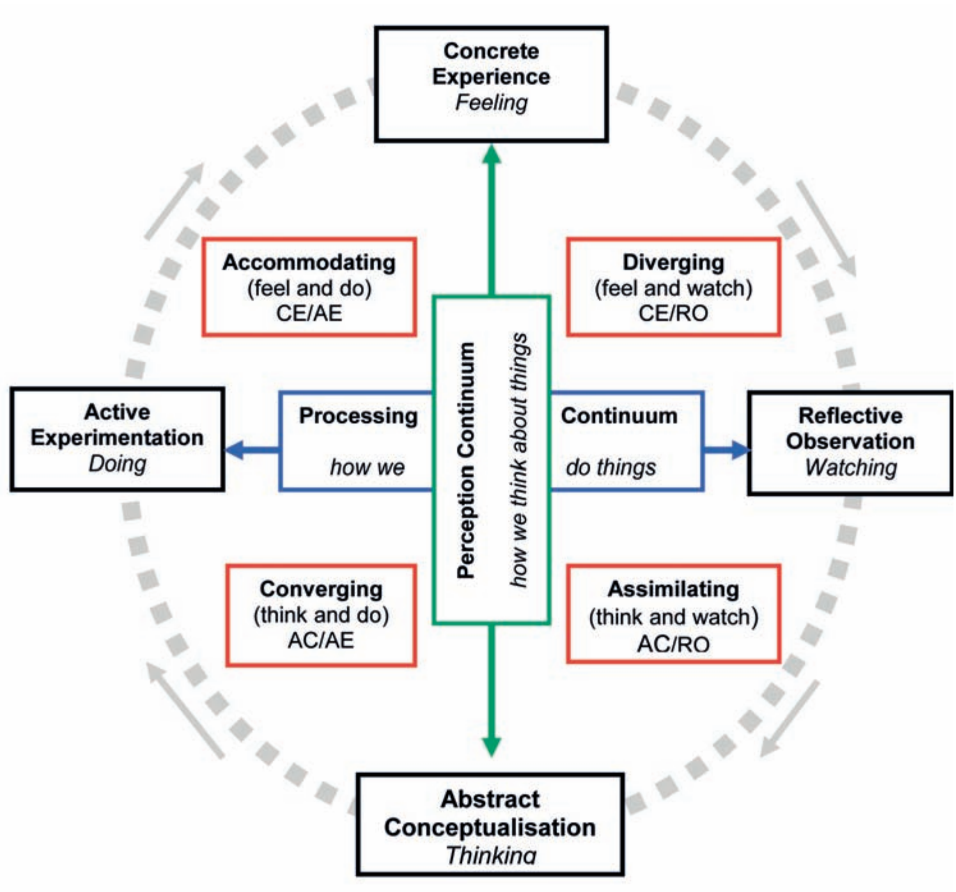


Figure 9.1 Kolb's model of styles of learning
Source: http://www.businessballs.com/kolblearningstyles.htm [accessed 12 February 2010]

Profiles of preferred learning modalities may be obtained from VARK This inventory measures preference for 'Visual, Aural/Auditory, Read/Write, Kinesthetic and Multimodality' (Fleming and Mills, 1992). The inventory was used in the design of Mechanical Engineering courses (Jensen and Wood, 2000).

Currently, the most ubiquitous personality test in use in pedagogical research in engineering is the MBTI, the Myers-Briggs Type Indicator. Box 9.2 summarises its characteristics.

Box 9.2. Personality indicators of the MBTI

Extraverts	Try things out, focus on the outer world of people
Introverts	Think things through, focus on the inner world of ideas
Sensors	Practical, detail-oriented, focus on facts and procedures
Intuitors	Imaginative, concept-oriented, focus on meanings and possibilities
Thinkers	Skeptical, tend to make decisions based on logic and rules
Feelers	Appreciative, tend to make decisions based on personal and humanistic considerations
Judgers	Set and follow agendas, seek closure even with incomplete data
Perceivers	Adapt to changing circumstances, postpone reaching closure to obtain more data

Source: Based on Felder and Brent (2005)

Evidence reviewed by Felder and Brent (2005) indicate students who are high scorers on the scales of intuitors, feelers and judgers tend to outperform lower scorers. Shen et al (2007) reports that Chinese students tend to have stronger preferences for 'Introverted, Sensing, Thinking and Judgment' than UK students but scored lower on the scales of 'Feelers, Intuitors and Perceivers'. Ahmed (2009) suggests this makes them good in organisation, detailed thinking and control, but not so good in terms of creativity, openness, warmth and perception. The report by Felder and Brent (2005 indicates there seems to be a mismatch between the broad personality characteristics of engineering teachers and students in the United States. Lecturers tended to be intuitors who emphasise theory, mathematical modelling and explanations based on physics and mathematics rather than practical applications. Engineering students have a preference for active rather than reflective learning, sensing rather than intuitive learning and for visual learning rather than verbal learning and are heavily oriented to sequential learning rather than global learning.

These are just some of the many learning inventories and personality tests which have been used in pedagogical research in engineering. A trawl of the Web will yield others. Some of these are copyrighted, some authors expect a fee, some others are agreeable to your use of them, and some give permission subject to you supplying them with your data. It is worth checking these conditions whilst designing your study.

Attitude scales and measures of achievement

Attitudes are usually considered to be predispositions to act but the link between attitudes and behaviour can be tenuous. (You may report you are strongly in favour of exercise - but rarely exercise.) Attitude scales are sets of items which have been shown statistically to be closely related and provide a reliable and valid measure. The processes of developing an attitude scale are well described by Oppenheim (1992) and Edenborough (1999). In essence it consists of field testing a large number of related items on a theme, conducting factor analysis and casting out those items which do not correlate closely with the major factors. As indicated in Unit Twelve, measures of the internal consistency of the scale are undertaken using Cronbach's alpha. An alpha coefficient of 0.7 or above is usually regarded as sufficient for an attitude scale. Attitude scales are assumed to be more stable than opinions and closer to tests of personality.

We have found little evidence of the development of attitude scales in engineering pedagogy. The brief paper by Tapia and Marsh (2004) provides a model of a procedure used to develop an instrument to measure attitudes towards mathematics which is transferable to attitude scale construction in engineering pedagogy and Hilpert et al. (2008) report their attempts to develop further a scale for measuring freshmans' attitudes towards engineering.

Measures of achievement may be based on the usual methods of assessment or specially devised tests. Diagnostic tests are available from http://www.mathstore.ac.uk/workshops/maths-support/diagnostic.pdf and http://www.mathcentre.ac.uk/. The usual methods of assessment, such as marks in projects or examinations, may be used but some caution is necessary in interpreting results based on these assessments since there can be wide variations in marking procedures. The use of standardised knowledge tests based on multiple choice questions and other forms of rapid response questions (Brown, Bull and Pendlebury, 1997; Wankat and Oreowicz, 1993) are preferable since one can determine the reliability and validity of such tests. Computer programmes designed for delivering MCQs such as Question Mark Perception can be used to design, deliver online and measure educational achievement.

One should not underestimate the value of knowledge tests as research tools in engineering pedagogy. They can be used in surveys of the knowledge of students at the point of entry to a degree course, at the beginning and end of a module, to test students ability to apply existing knowledge to new problems or to identify the profile of knowledge (what they know and don't know). You might be interested in current students' performance on old examination papers in applied mathematics or their basic knowledge of statistics (Mulhern and Wylie, 2006). Knowledge testing can also be used to identify the gaps in the knowledge of line managers or research supervisors of administrative procedures but such explorations needed to be handled sensitively.

Measures of cognitive ability

Measures of cognitive ability have re-emerged as fashionable tools in the past decade. Attempts have been made to use ability tests to supplement A level grades for undergraduate admissions in the UK and for entry into graduate courses in the US. Many of these tests are of cognitive abilities such as mathematical or verbal reasoning, critical thinking and writing skills but some have a strong knowledge bias.

The assumption underlying much of the research in the UK is that supplementary tests in conjunction with A level scores will provide a better selection for and predictor of performance at first degree level. Evidence from over thirty years ago indicated that A levels were a good predictor, 'O' levels a better predictor and the combination of A level and intelligence tests not as good as A levels alone (Choppin et al, 1973). GCSEs probably remain a better predictor of degree class than A levels since they test a wider variety of abilities over a longer period of testing. It has been argued that an examination which is more 'advanced' than the existing A level would be more effective than supplementary tests for selection in medicine (McManus et al, 2005). This may also be true in engineering but recruitment not selection seems to be a more important issue at the undergraduate level in engineering.

Nonetheless, research which uses tests of cognitive ability is useful for identifying strengths and weaknesses in cognitive ability of engineering undergraduates and for measuring whether a change in teaching strategy or course structure has improved cognitive ability. Measures such as the Watson-Glaser test of critical thinking and other tests of the Cambridge Assessment Centre or the Cambridge Psychometrics centre could be useful for this purpose (See Further reading). Perhaps more useful would be qualitative methods designed to capture the inner thoughts of participants engaged in critical thinking.

Activity

We have suggested only one activity for this unit since it is primarily concerned with extending your knowledge base of tests of personality, approaches to learning and achievement.

9.1 Obtain copies of a test such as one of those suggested in this unit. If that is not possible, use the light- hearted test available at http://www.brainboxx.co.uk/a3_aspects/pages/VAK_quest.htm

Do the test and score it. Then ask a small sample of students (10-30) to do the test, mark and report the results to you. Compile a profile of the group. Do some elementary statistical analysis such as tabulating male and female scores or listing anonymously the marks obtained by each student and their individual profile on the test. If you have time, discuss the test and the analyses with the participants.

Further reading

Basic texts on Learning and Teaching in Higher Education
Biggs (2003), Brown and Atkins (1988), Ramsden (2003) and the edited text of Fry et al (2003).

Texts on assessment
Brown, Bull and Pendlebury (1997)
Heywood (2000)
Spurlin et al (2008)

Teacher characteristics and student achievement
Wayne and Young (2003) reviewed teacher characteristics and their relationship with the achievement gains of students.

Learning styles
Atherton (2009)) *Learning and Teaching; Experiential Learning* [On-line] UK: Available: http://www.learningandteaching.info/learning/experience.htm
Accessed 11 May 2010
Coffield et al (2004) provides a very thorough review of research on learning styles.

Learning styles and personality in engineering
Felder and Brent (2005) review and report research on personality and learning styles in engineering

Houghton (2004) provides a good overview of learning in relation to engineering.
Wankat and Oreowicz (1993) consider learning styles, personality and much else.

Selection
Kirkup *et al* (2009) report the recent research by the National Foundation of Educational Research (NFER) on selection for undergraduate courses.

Tests of abilities and achievement
Useful sites on undergraduate and graduate admissions test based on cognitive abilities, aptitudes and knowledge are
http://www.psychometrics.ppsis.cam.ac.uk/page/196/critical-thinking.htm
http://www.admissionstests.cambridgeassessment.org.uk/adt/
http://www.spa.ac.uk/admission-tests/tests-being-used.html
http://www.ets.org/gre/

http://gate.iitm.ac.in/gateqps.php
(All accessed 12 February 2010)
If you want to use licensed psychological tests in your research then consult a chartered psychologist.

There are various diagnostic tests of mathematics for engineering students such as those available at http://www.mathstore.ac.uk/workshops/maths-support/diagnostic.pdf and http://www.mathcentre.ac.uk/. The mathtutor (http://www.mathtutor.ac.uk/) contains useful diagnostic tests and tutorials. For a discussion of diagnostic testing in mathematics go to http://www.mathstore.ac.uk/mathsteam/packs/diagnostic_test.pdf

Developing your own tests and scales
Consult Oppenheim (1992), Edenborough (1999) or the article by Kember and Leeung (2008) – although the latter is perhaps too critical of the use of Cronbach's alpha.

For a broad view of attitudes, personality and cognitive abilities
Consult Eysenck (2001), Eysenck and Keane, 2005, Hayes, 2000b or other standard texts in psychology.

Unit 10
Quantitative observation

Introduction

Quantitative observation is based on pre-determined categories of behaviour, which are observed, recorded and analysed statistically. Quantitative observation is sometimes referred to as 'activity sampling'. It is used widely in sports science for coaching purposes, in production engineering for job analysis and it is sometimes taught in metrology in engineering degrees. Most sports programmes on TV use it. In pedagogy, quantitative observation may be used to study:

- The performance of practical skills
- How novices handle unfamiliar equipment
- Team work
- Leadership
- Teaching
- Problem based learning
- To develop training protocols

For *quantitative* observational research, the usual research protocol applies:

- The purposes of the research should be clearly framed as hypotheses.
- The method of observation should match the purposes of the research.
- The statistical analyses should be appropriated to the method and hypotheses.

This approach is markedly different from a qualitative approach (see Unit Six)

Types of quantitative observation

Box 10.1 lists the main types of quantitative observation. All record what the observees do rather than what they think or feel. But there are filters. The primary filter is the observer, a secondary filter is the video-recording. All types of quantitative observation suffer from information loss compared with transcripts of interactions. The information loss is greatest when using global rating schedules although these do provide quick, often reliable judgements. For example, teacher behaviour may be rated on three major dimensions of:

- Organised, clear *versus* Disorganised, unclear
- Friendly, helpful *versus* Aloof, unhelpful
- Stimulating, Interesting *versus* Dull, Boring

These dimensions were derived from factor analysis over 50 years ago and have frequently been confirmed (Davies et al, 2010). Helpfulness and clarity are regarded highly in online surveys and in class evaluations of lecturers (Otto et al, 2008; Sonntag et al. 2009).

SETs (Student Evaluation of Teaching) and Course Evaluation Questionnaires (CEVs) are special cases of rating schedules. These are usually retrospective and the ratings based on observations and experiences perhaps over a semester, rather than on a direct observation of a single class. It is assumed the size of sample (usually a whole class) and the accumulation of their observations will ensure the measure is reliable and reasonably accurate. However Kember and Leung (2008) point to several other considerations when designing reliable and valid course evaluation questionnaires. In fact, SETs and CEQs are susceptible to various distorting effects. The current fashion of using 'hot' to rate professors in the United States (http://www.ratemyprofessors.com) is an example.

Global rating scales and rating schedules are sometimes referred to as high inference variables whereas checklists and interaction analysis systems are labelled as low inference. These schedules, whilst useful (and ubiquitous) provide the observer's *opinion* of the value of what the observees (participants) did; not *what* the observees actually did. They run the risk of the effects of halo (*"he's a good chap, he went to a good school, so he's bound to be good"*), or severity (*"nobody deserves top ratings"*), or uncertainty (*"I am not sure about this so I'll stick to the middle range"*). It is difficult to dissemble these observer effects from the actual behaviour of the observees. But from a set of observations it is possible to parcel out differences between observers and differences between observed using analysis of variance. (Bryman and Cramer, 2005; Field, 2009). Sometimes the variation between observers is greater than the variation between observees. If possible, video-record the observation period so you can make checks on your observations and obtain analyses by other people.

Box 10.1. Types of quantitative observation

Checklists	Tick the boxes. Useful for checking correct procedures are carried out. Sequential checklists also check whether the correct order of procedures was used. Useful in observation of use of new programmes or setting up experimental rigs. Used in flight simulators. Can be used for observing and consultation. Training is necessary to ensure consistency. Profiles of observees can be compared. Statistical analyses are straightforward
Sign Systems	At the end of a fixed time interval (usually 10-30 seconds) the category which occurred most frequently is selected. Training is necessary. Useful for estimating quality e.g. the quality of discussion in PBL. Results can be relayed back to the participants and their subsequent performance measured
Interaction Analyses	Used for recording interactions. At every nth second (usually 3 or 5 seconds) the activity occurring at that point is categorised (known sometimes as point sampling). After about 30 minutes observer fatigue sets in. Useful for small samples of interaction between lecturers, lecturers and students, or between students. Training is needed. The more complex the category system the more extensive the training required. Simpler category systems are usually better for both research and pedagogical development.
Global Rating Scales	The observees performance is rated on a few well chosen dimensions. Relatively easy to use. Inter-observer agreement is usually high. Little training needed. Useful for judging quality of activities. Statistical analyses straight forward. Serious information loss. Danger of halo effect.
Rating Schedules	The observees' performance is rated on several dimensions. Usually these should be used at the end of the observation period. Not easy to use reliably in live performance. Time consuming. Detailed rating schedules reduce reliability if only because there are more opportunities for disagreement. Intensive training needed to achieve inter-observer reliability. Statistical analyses are relatively straight forward. Serious information loss. Danger of halo effect.
Observe, Note and Rate	Based on *qualitative* observation. A qualitative method (Unit 6) can be used during the observation so the ratings are based on the notes or as a justification for the ratings. Use this approach if the observation period is long. Practice in the approach is essential. Statistical analysis on the ratings is straight forward.

Some examples of observation systems

Checklists and rating schedules are ubiquitous (probably too much so) in Faculties of Engineering. So here we provide only an example of a sign system and of a simple interaction analysis system. Both have been used for developmental purposes (Brown, Bull and Pendlebury, 1997) and are potentially useful as research instruments.

SAID: A System for Analysing Instructional Discourse

SAID provides a simple way of estimating the level of discussion in a small group learning session. It is best used on a video recording of a discussion. It is not useful for segments in which the tutor is lecturing or interrogating for most of the time. Classify the *predominant* type of discussion in each 30 second segment **or less. A discreet auditory signal is better than a stopwatch for this purpose.**

Box 10.2. SAID, A sign system

Level	Description
Explanatory	Providing or exploring connections, causes, reasons, underlying assumptions and perspectives.
Interpretive	Exploring meanings, providing different interpretations of the evidence, formalising definitions of terms.
Procedural	Outlining what was done in a task or situation rather than why. Listing what an author said rather than what the author was driving at.
Descriptive	Relating and exchanging experiences or opinions and assertions without supporting evidence.
Positive Social	Friendly conversations of a personal kind that are marginal to the task.
Negative Social	Unfriendly conversations of a personal kind that are marginal to the task.

BIAS: An interaction system

This system may be used to analyse interactions in a tutorial, a research supervision or a consultation with a client. In a tutorial one could code who is speaking, every third second by placing a tick in the appropriate cell. Use only one column for each third second. At the end of the sample of the tutorial, explore the patterns and summarise percentages of tutor talk, student talk and silence. After a little practice start using, in the cells, the subscripts **e** for explaining, **q** for questioning, **r** for responding or **rq** for recall question, **tq** for thought question. One can choose different subscripts for different purposes. The data can be simply summarised and reported. A common finding is that lecturers talk more than they realise in tutorials – on average about 67% of the time and many of their questions are at the level of recall, not thought. One can use the system to check whether the claims for a session are being met. For example, it is often claimed that there is more student discussion in PBL than in normal tutorials. The pattern of interaction will tell you if this seems to be the case.

No. of ovservations										10										20				Total
Lecturer																								
Student																								
Silence																								

P.S. The system was called BIAS because it is biased towards quantitative observation and was developed by Brown (Brown's Interaction Analysis System)

Choose or design your system

The choice here is to hunt for a suitable system in the research literature and modify it if necessary. or design your own system. To do the latter, it is useful to do some qualitative observations and clarify your ideas and hypotheses with colleagues and potential observees. Then formulate precisely your hypotheses and research questions and choose the system which seems most useful. Pilot the system, and test the system to check it provides you with useful statistical data. If you have doubts, modify the system or throw it away and start again. When you have a decent, user friendly observational system, start using it on your sample.

Sampling

There are two aspects to consider: sampling the appropriate units of behaviour and sampling the participants (observees).

The units of behaviour are determined by your research problem and hypotheses. You need to then decide which events you are going to sample and when. You may be interested in only sampling critical events or only in the stages of instrument calibration, or in one phase in a design class. You need to decide whether you will do long observation periods or short observation periods distributed throughout a session, a week, a month, even a module. For example, you might be interested in how students in a group project initially interact, how they interact in the middle of the project and towards the end. You might want to try to compare differences between the group process of 'successful' group projects and 'unsuccessful' group projects. If you do the latter then be aware that successful design projects are not solely dependent upon group processes.

Sampling the participants (observees) raises the usual question of 'how many' and gets the usual answer 'it depends….'. The size and characteristics of the sample should be determined by your research problem and objectives, time available and accessibility. Our advice is be realistic, modest about any claims for generalisability, make an intuitive judgement and check it out with a few colleagues. There are no 'closed' answers to this problem.

Reliability and validity of quantitative observation

Strictly speaking, the *observation instrument* is the observer in conjunction with the observation system not the observation system *per se*. Research reports that inform you that the reliability of the observation schedule was high but do not inform you of the sample of observers or their training should be treated cautiously and their results tested again in your own research. Cronbach's alpha (Field, 2009; Norussis, 2002, or any standard SPSS guide) is the most widely used method of measuring reliability of rating schedules). An alpha of about 0.7 is usually regarded as acceptable. Correlation coefficients are usually used for inter-observer reliability and intra-observer reliability (see Unit 12). These can be used providing the event is being observed by more than one observer or is videorecorded.

The validity of an observation system is often a matter of judgement (and argument!). The basic validity question is 'Does the instrument measure closely what it is supposed to measure'. One can use factor analysis and item analysis to check the validity of rating systems but not of other systems. For these systems, validity has to be argued for on the basis, of related experimental evidence and then taken on trust (an old fashioned concept we know).

Finally, a reminder, we mentioned in Unit 6 the possible effects of the observer on the observees. These can never be fully eliminated but they can be minimised by being unobtrusive, non-threatening and familiar to the observees. Remember the observees might be on their best behaviour, at least initially. If you have any doubts about the validity of your observations in the early stage of a session, then check them and, if necessary, discard them.

Activity

10.1 Devise a global rating schedule based on the three dimensions of teaching (See Types of quantitative observation). Observe the teaching of a few colleagues (with their permission, of course!) and use the rating schedule as a guide to feedback to them and to check its usefulness compared with guides used by mentors in the department or faculty.

10.2 Video a sample of about 15 minutes of your interactive teaching (with the permission of the students). Watch it and make notes then try using BIAS or SAID. Ask a couple of colleagues if you can video-record a brief sample of their interactive teaching and analyse it.

10.3 Watch an ‘expert’ student and a ‘novice’ student assembling the same experimental rig or setting up a survey or calibrating instruments for a remote laboratory exercise. Devise a checklist for the task and check if it differentiates weaker and stronger performances on the task.

10.4 Video or audio-record a sample of a research supervision (with the permission of the supervisor and student). View or listen to it and devise a simple interaction analysis system which captures the pattern of interaction and engagement with the research problem.

Further reading

Student Evaluation of Teaching

Student evaluation of teaching and courses is a massive field. Recent reports are:

Davies et al, 2010; Otto et al, 2008; Sonntag et al. 2009

Kember and Leung (2008) provides a useful blueprint for developing course evaluation questionnaires which is also useful for designing rating schedules.

Lin, Gan and Ng (2010)

Sign systems and interaction analysis

There is surprisingly little research based on sign systems and interaction analysis in higher education.

Cox and Cordray (2008) report the development of a fairly complex system used in bio-engineering.

Flanders (1970) is the seminal work on Interaction analysis.

Pazosa et al (2010) describes the development of a simple useful instrument for measuring peer group interaction and approaches to problem solving.

Reliability and validity

Most texts on social or educational research discuss these issues.

You will find slightly different views and perspectives in different texts. See Unit 12 for a summary of the different perspectives. For further discussion, go to: Bryman and Carter(2004); Cohen et al (2007) Field, (2009) or any other standard text.

Unit 11
Statistics and experimental design

Introduction

Most engineers are familiar with statistics and experimental design and some engineers are immersed in them. So this lengthy unit is a refresher rather than an introduction. The notes and further reading provide details of an introductory text and more advanced texts.

But before reviewing statistics it might be useful to note that in pedagogy and other forms of social research one is often mapping words on to numbers. These words may be opinions, attitudes or judgements. This approach enables one to then use all the power of mathematics and statistics to manipulate the data and draw conclusions from it. Unfortunately, it is very easy to become over-enthused about conclusions inferred from these numbers. So one needs to check whether the mapping process was robust. This caveat applies to relatively simple matters such as attitudes towards PBL or more telling matters such as the metrics used in RAE and QA. Nor should one underestimate the effect of changing the mapping process, the metric. Changing the metric slightly can change responses and behaviour.

Fundamental concepts of statistics

Counting and measuring

The basic concepts in statistics are discrete and continuous variables. One *counts discrete* variables and *measures continuous* variables. For convenience of analysis, sometimes one partitions continuous variables so one can use statistical analysis based on counting.

Levels of measurement
Four levels of 'measurement' are usually identified in statistics:

Nominal *-a set of categories such as Male v Female, Arts/Science.*
This is the lowest level of measurement. Counting can only be used in these categories so only statistics based on frequencies are possible.

Ordinal *– rank ordering: put in ascending or descending order.*
The intervals between numbers are not assumed to be equal. The top engineer of a class might be only a couple of marks ahead of the second (let's not get into confidence limits of examination marks) but there may be twelve marks between the second and third student. The ordinal level has no zero. So strictly speaking rating schedules are at the ordinal level and one should not treat them as real numbers – but most practitioners do.

Interval *- equal intervals between numbers imply equal differences in values.*
It is assumed that the difference between 5°C and 10°C is the same as the difference between 20°C and 25°C but you can't assume 20°C is twice as hot as 10°C.

Ratio *- as for interval but includes a 'real' zero.*
This is the highest level of measurement and the level engineers usually work with. The zero permits the full use of mathematical applications. If you don't understand the difference between the interval and ratio levels, try solving thermodynamics problems using the Centigrade scale instead of the Kelvin scale.

Since pedagogical research does not have real zeros (even when the participants are dead) the well known statistical package Statistical Package for the Social Sciences (SPSS, currently version 18) puts interval and ratio levels together.

Parametric or non-parametric?
Statistical methods of analysis that assume the ratio or interval levels of measurement are known as *parametric* statistics because they are based on mathematical distributions such as the normal curve (Gaussian Distribution). *Non-parametric* do not make strong assumptions about the underlying mathematical distributions. They are used for nominal and ordinal and sometimes interval statistics. In small samples, the use of non-parametric statistics are preferable. They can still inform you whether a result is significant.

Levels of significance
As engineers and scientists dug deeper into causes it became recognised that one could never be 100 percent sure of causes (Eisenberg said quite dogmatically that in physics 'nothing is certain'). From this recognition grew the notion of probable levels of certainty which led statisticians in the 1920's to suggest levels of significance based on probability (See Figure 11.1 and Box 11.1).

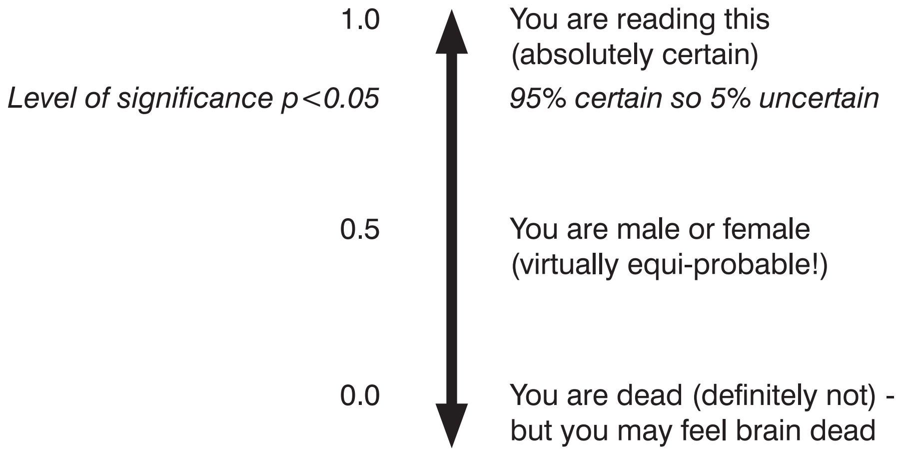


Figure 11.1. Levels of probability: a light hearted look (not to scale)

Box 11.1. Levels of significance

5% - Significant: that is that there is only a five percent probability that the result is random in your sample. Put another way, you can be 95% confident that your results are not random ($p< 0.05$).

1% - Highly significant: you can be 99% confident of your results ($p<0.01$).

0.1% - Very highly significant: you can be 99.9% confident of your results ($p<0.001$).

To which we would add:
0.0%: Absolutely certain. You should be very suspicious of such a result in pedagogy.

The level of significance is dependent upon the sample size (and the hypothesis one is testing). The bigger sample, the greater the likelihood of a significant result. Strictly speaking, it is not the size of the sample but its degrees of freedom which determine its significance. It is not proposed to discuss here the mathematical constructs underlying degrees of freedom. Most computer programmes automatically report the levels of significance and degrees of freedom for the sample size you use. But be aware of the one-tailed, two-tailed issue.

Two tailed or one tailed?
The levels of significance are the conventions for measuring probable levels of similarities and differences between sets of data. When one is only interested in whether there is a *difference* between two groups or two conditions one uses 'two-tailed' differences (the difference can go either way.). If your hypothesis is that one set of results will be *better* (higher) than the other set, one uses one tailed tests. This level of significance is half that of a two tailed test ($p<0.25$, $p<0.005$ and $p<0.0005$.) Confusingly, these are often referred to as '*one-tailed*' distributions of 5%, 1% and 0.1%!

Measures of effects
A result whether two tailed or one tailed which is statistically significant is not necessarily pedagogically significant. If you have very large samples you may get a significant statistical difference but its effect (or influence) may be small. In the last twenty years, methods of measuring the effects of an intervention have been developed. They use the attenuated Pearson Correlation coefficient as the indicator of the effect (0=no effect, 1= perfect effect). The convention is:

$r= 0.10$ (small effect: only 1% of variance explained)
$r= 0.30$ (medium effect: 9% of variance explained)
$r= 0.50$ (large effect: 25% of the variance explained)

For more details on effect sizes consult the texts given in Further reading.

Box 11.2. A very short history of statistics

Statistics were used for state purposes as far back as the Babylonian civilisation. Their use was then confined to tables and visual representations of data. In the post renaissance period summarising statistics such as mean, median, mode (central tendencies) and range, interquartile range, variance and standard deviation (measures of dispersion) began to emerge. Standard deviations are equivalent in engineering to moments of inertia although the notations are different. Means are equivalent to centres of gravity. Both these measures use all the data so they are more reliable than the other measures of dispersion and central tendency. There is currently a fashion to report median values and inter-quartile ranges (IQRs) for non-parametric statistics. Inferential statistics based on probability distributions did not emerge until the late 19th and early 20th century. These statistics allow you to compare, contrast and relate different sets of data and to infer whether the differences or similarities are at high levels of probability.

Types of statistics

These can be conveniently divided into three types: visual representation, derived statistics and inferential statistics.

Visual representations of data

The common methods are tables, histograms, charts and 'box and whiskers'. Spreadsheet programmes such as EXCEL allow you to create multicoloured complex charts, some in 3D perspective. One can lose hours playing with the visual representation of data. Our advice is if you are presenting a paper at a conference or submitting a paper for publication:

- Use simple visual representations which highlight best the key features of your paper.
- Only use tables if you are going to discuss in detail statistical results.
- Keep the tables as simple as possible. Sometimes two simple tables are better than one complicated one.
- Avoid data representation that obscures or distorts the data.
- Use 'box and whiskers' to illustrate means and standard errors or median and inter-quartile ranges.

Derived statistics

These are sometimes referred to as summary, or descriptive statistics. From a raw data set, a profile is derived which is based on its central tendency and a measure of its spread. These are usually mean, median and mode (central tendency) and range, inter-quartile range (middle 50%) variance and standard deviation (spread or dispersion). As indicated in Box 11.2, the mean, variance and standard deviation permit the use of more powerful and complex statistical calculations. They also can provide estimates of probability providing the data follows a mathematical distribution such as the normal curve. For example, intelligence tests (IQ - now frequently labelled as cognitive ability tests) are standardised with a mean ($\bar{x}$) score of 100 and a standard deviation (δ) of 15. Using the 'standard' normal probability curve ($\bar{x}$= 0: δ=1) yields these results:

$\bar{X} \pm 1\delta$ = 95% of the population have an IQ between 85 and 115
$\bar{X} \pm 2\delta$ = 98% of the population have an IQ between 70 and 130
$\bar{X} \pm 3\delta$ = 99.98% of the population have an IQ between 55 and 145
$\bar{X}+3\delta$ = approximately the top 50% of the population have an IQ between 100 and 145.

Assuming intelligence test quotients are a benchmark of potential academic achievement then an increase to 50% of the cohort of the eighteen year olds into degree courses will give a probable IQ profile of 100 to 145. Those statistics have implications for pedagogy in engineering ……..

Inferential statistics
These are statistical methods which enable one to draw conclusions from data. These are by far the most important statistics in pedagogical research. They have two functions: to estimate levels of probability of a hypothesis being correct and to examine similarities and differences in the data. Indeed a key question to ask yourself when analysing statistical data is *'Am I interested in whether the data sets are very similar or very different?'*

We have already outlined levels of probability and significance in earlier parts of this unit. Box 11.3 shows some common tests for examining similarities and differences in data sets. If the samples are large then one usually uses parametric statistics because the distribution of the data is likely to approximate normal, but be prepared for the occasional purist who objects.

Box 11.3. Which test to use?

Are you interested in the relationships between 2 or more sets of data?	**Are you interested in examining differences between 2 or more sets of data?**
Non-parametric Use chi-squared for counting frequencies.	**Non-parametric** Use chi-squared for counting frequencies.
Non-parametric Spearman's Rank correlation for ordinal data.	**Non-parametric** Use Kruskal Wallis for multiple samples of rank order data and Friedman for a repeated measure of ordinal data. Use Mann-Witney for comparing two samples and Wilcoxon for paired samples such as measuring changes in the same person.
Parametric Pearson's correlation for interval and ratio data (large samples).	**Parametric** Use Analyses of variance (ANOVA) for multiple samples. Several types including repeated measures (ANCOVAR). Uncorrelated t test based on two samples and correlated t test for repeated measures such as measuring changes in the same person.
Parametric Regression (goodness of fit) Different types – linear and curvilinear. Two variable linear most common. Related to correlation. Multiple linear regression models can be useful for predicting the effects of several variables on a predicted outcome.	**Parametric** Regression can also be used for showing differences between data sets.
Parametric Factor Analysis and Cluster Analysis.	**Parametric** Factor Analysis and Cluster Analysis.

Chi –square test

A rather crude but useful way of measuring relationships between data is the chi-squared test. This is based in the chi-squared distribution and it has many uses in measuring similarities in nominal data and differences between sets of interval data. Two common uses of chi-square are goodness of fit and contingency (strength of association).For goodness of fit, one compares the nominal data obtained in a sample with existing nominal data from another, preferable much larger, sample. For example, you may have substantial statistics of the different personality types of student engineers in the UK and wish to compare your sample of student engineers against these norms (see Shen et al, 2007).This use of the chi-square test is sometimes described as the one independent variable case.

The contingency tests the association between two independent variables so one categorises the data into a nxm matrix where n and m are preferably small. Otherwise you may not have enough data in each cell and you will have difficulty in interpreting the statistical analysis.

An example from a recent doctorate (Ahmed, 2009) illustrates the problem. He was interested in whether students who went on one year work placements obtained better degrees than those that did not go on one year work placements. The visual representation of the data is shown in Figure 11.2. The overall results are shown in Box 11.4

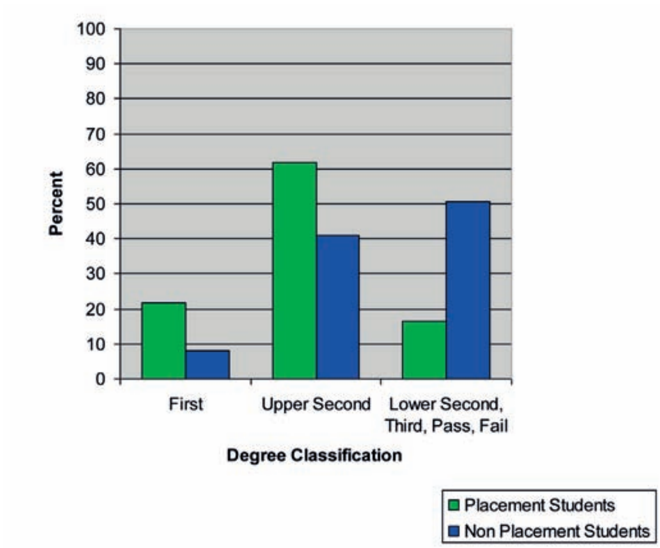


Figure 11.2. Examination Results 2006/07 (Chemical Engineering, Civil Engineering and IPTME Departments)

Box 11.4. Overall degree results

	1st	2nd Upper	2nd Lower	3rd	Pass	Fail
Placement	24	68	18	0	0	0
Non-Placement	6	30	25	2	3	7

Chi-square was not possible on the above data because several cells contained fewer than 5 individuals. So the table was collapsed as shown below:

	1st	2nd Upper	2nd Lower and below
Placement	24	68	18
Non-Placement	6	30	37

This table yielded a chi-square of 25.67 at 2df, $p < 0.001$

The results were very highly significant. So it can be concluded that in this sample, students who go on placements do obtain better degrees. But it cannot be concluded that this result was *solely* due to the students' experience of work placements.

Chi-squared is a popular test but it is difficult to interpret. For example, there may be a significant association between red hair and quick temper thus it could be expressed as a 'similarity'. But this finding could also be expressed as there is a significant difference between red heads and non-red heads on the dimension of quick temperedness.

Correlation coefficients

For estimating the strength of a relationship between two data sets one uses correlation coefficients. These are usually expressed on a scale of -1 (perfect inverse) to +1 (perfect relationship). When the relationship between two sets of data is perfect and all the data is on a straight line with a positive gradient ($y = mx+c$) then the correlation is +1. When the data is randomly distributed around 0,0 then the correlation is zero. When it is perfectly linear with a negative gradient then the correlation is -1.

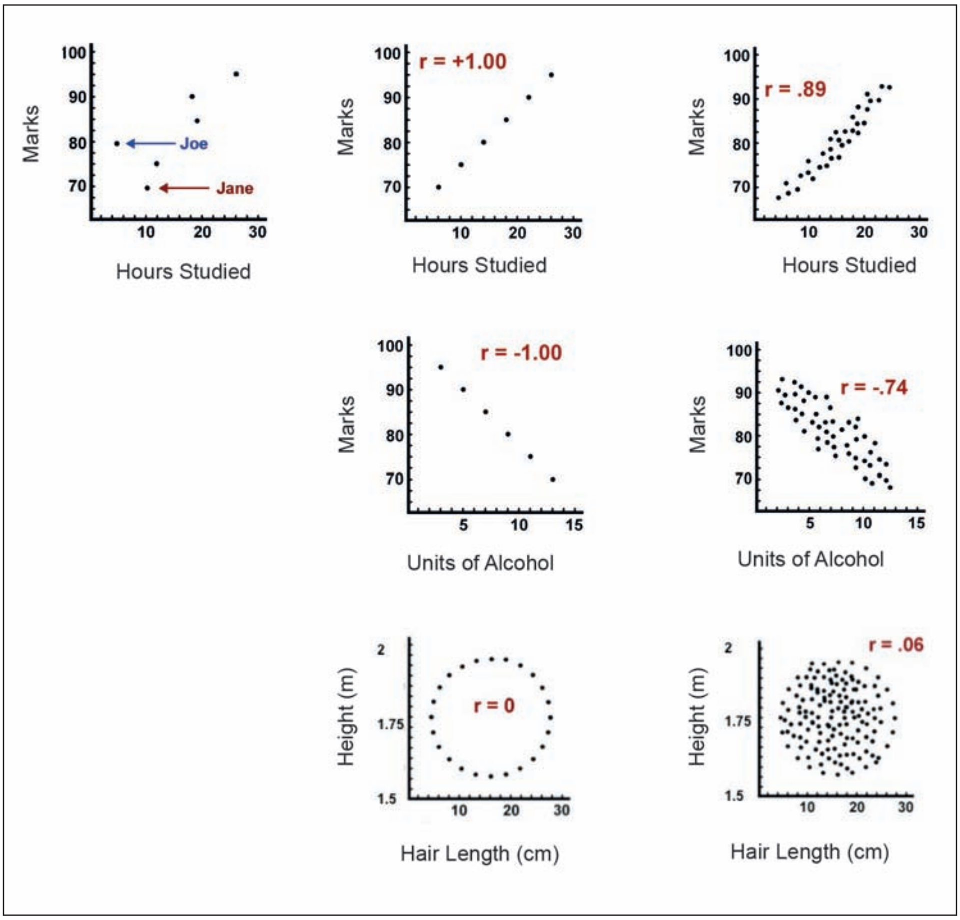


Figure 11.3. Scattergrams

The square of the correlation coefficient gives a measure of the shared variance between two variables. The typical correlation between A level physics and final degree class obtained in engineering was about 0.4. So it can be inferred that only 16% of work and performance at A level contributed to the degree awarded. Put rather crudely, 84% of the degree awarded was due to other factors. These probably include motivation and commitment during the undergraduate course.

A common error is to assume that correlations are causes. There is a fairly strong positive correlation between hours studied and performance in an examination. But other factors may have to be taken into account. The performance of the Welsh rugby team and the death of popes are positively correlated (See Box 11.5). Waist size and ability at mental arithmetic of students are correlated positively but the relationship is not directly causal. There is a strong negative correlation between alcohol units consumed the night before an examination and performance in the examination. This relationship is probably causal. The more you drink, the less likely you are to get a good mark.

In general correlation coefficients indicate one of the following:

- A probable causal relationship but other factors may contribute;
- A spurious relationship;
- A hidden variable which links the two variables is at work (e.g. males are usually better at mental arithmetic than females and usually have bigger waist sizes).

But note that correlation coefficients only give a measure of linear relationships, not of curvilinear or log–based relationships.

Regression

Regression is essentially 'goodness of fit' of the data set with a line. For most purposes in pedagogical research the line is assumed to be linear rather than curvilinear or log-based. Regression equations consist of three or more variables and their coefficients which together are used to predict an outcome. The predictive power of the equation can be estimated statistically. One way of doing this is by using the correlated t test to compare the differences between the actual scores obtained and the scores predicted by the regression equation (See Further reading).

't' tests and analyses of variance (ANOVA)

For examining the differences between two samples, the most common test is the 't' test. The independent groups 't' test is used when the data is from two separate samples such as electrical engineers and chemical engineers. The correlated 't' test is used when the same individuals are tested twice as in a before-after design of the same individuals. The 't' test is based on the 't' distribution and it can be used even on very small samples ($n>8$ preferably). Comparisons of very unequal samples by this method are not recommended because unequal samples produce different variance which render the test void. As far as possible, have equal numbers in your samples, even though the sample size may not be representative of the whole population (it rarely is). Express caution in your discussion of the results.

Box 11.5. Popes: Beware of Welsh Rugby

In a light hearted article in the British Medical Journal, Payne, Payne and Farewell (2008) examine the relationship between papal deaths and the performance of Wales in grand slam competitions using logistic regression analysis on data from 1883-2007. This was based on a sample size of 107 completed grand slams. There is a significant relationship ($p=0.047$) between the number of Papal deaths and the Welsh team's performance but no significant associations with Papal mortality on the performance of any other team.

The prediction from this data for 2008 was the Pope had a 60% (0.62) chance of dying in 2008. He didn't.

For three samples or more, one uses analyses of variance (often written as ANOVA). These are based on the F ratio which can be converted into probabilities using the tables of the F distribution for various sample sizes.

The F (Fisher) ratio is:

$$F = \frac{\text{variance between conditions (samples)}}{\text{variance within conditions}}$$

The F ratio tells you whether the differences between the samples (conditions) is greater than the differences within conditions (samples). But the F ratio does not tell you which of the samples differ significantly from one another. To do that one uses a 't' test on each pair of possible samples. So if you wish to investigate differences between mechanical, civil, electrical and production engineers in a sample, you would need to do six 't' tests. Most computer packages will do these automatically and also report if the F test is valid. The major test of the validity of these t tests is the Levene test of homogeneity of variance. If this is **not** significant, you are safe. If it is significant, say goodbye to the paper you were going to write or report the results in your paper and try to justify them.

Box 11.6. ANOVA and the Baccalaureate

Pieron (1963) used analyses of variance to investigate the Baccalaureate. The analyses led him to conclude that "assessment by different examiners produces considerable variability such that in the determination of those marks the part played by examiners can be greater than that of the performance of examinees"

Of course, this could not happen in Finals papers in the 21st Century. Could it?

Pieron, H. (1963) Examens et Docimologie

Factor and cluster analysis

For examining the similarities and differences of large data sets one uses factor analysis or cluster analysis or possibly both. Factor analysis tells you which items are closely related and whether they are worth keeping in a scale. Cluster analysis tells you which people are closely related (typologies) and which items are worth keeping for measuring these typologies. Both methods work on the principle of iterative correlations of correlations. From the analyses one obtains a few key features which account for much of the variance in the data. These are given names - and sometimes the names are misleading- and the rest of the factors or clusters are discarded. There are different forms of factor and cluster analysis and the computer outputs are initially difficult to understand. Consult a practically minded statistician or a good text. See Further reading.

Experimental design

There is a broad spectrum of methods of doing pedagogical research which ranges from tightly controlled laboratory experiments to complex case and field studies. Here we want to distinguish initially two broad types of design: the laboratory experimental and the quasi- experimental.

Laboratory experimental designs

Laboratory experimental designs are based on the principle that, as far as possible, all but two variables are held constant and the relationship between these two variables is measured. These two variables are the independent variable (e.g. temperature of a rail in a laboratory test) and the dependent variable (e.g. the expansion of the rail with respect to temperature). It is assumed if all the other variables but two were held constant and they vary then there must be a causal relationship between them, the independent variable (cause) and the dependent variable (effect). (In more sophisticated designs, one can vary three or more variables and measure their relationships using analyses of variance. But these factorial designs can be challenging to interpret.) All of the laboratory approaches assume that the objects of study can be randomly allocated to different conditions of the experiment. Whilst this may work for different types of rail, it does not work so easily for research on human beings. One cannot allocate randomly gender, age or ethnicity; one can, at best, only counterbalance these variables. A further complication is that, strictly speaking, an experimental design should permit the hypothesis to be disproved.

Box 11.7. The importance of disproof…

For a hypothesis to be regarded as strictly scientific, the test of it must permit disproof. An illustration of this principle is the discovery of one black swan disproves the hypothesis that 'All swans are white'. Whereas the discovery of several white swans merely confirm that white swans exist.

In summary, random assignment to experimental conditions, and hypotheses capable of being disproved are the ideal criteria for well-designed scientific experiments. These conditions are rarely met fully in experiments with materials in laboratories and are very difficult to achieve in experiments involving human beings. They remain, for quantitative researchers, ideals to aim at in experimental work and they are a guide on how to conduct 'quasi-experiments in naturalistic settings. Instead of experimental, scientific proof, in quasi-experimental designs, one relies on empirical proof.

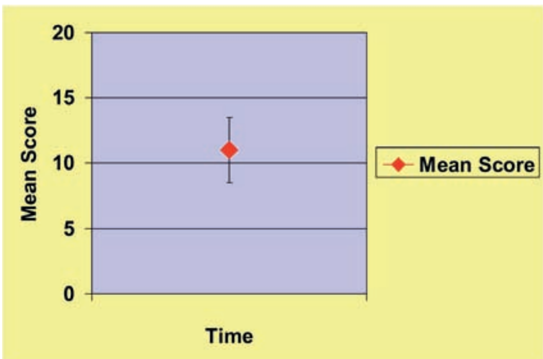
Quasi-experimental designs

Quasi-experimental designs are used in what is sometimes called 'observational research', 'correlational research' or 'naturalistic research'. These names are used to emphasise that the researcher observes (measures); that he or she has less control of the variables involved and is usually seeking for relationships between variables rather than cause-effects in a complex environment. The primary control the researcher exercises is data control: who to investigate, how, when and where. The primary reasons for quasi-experimental designs are to discover likely relationships within and between data, feasibility, and ethical considerations. The relationships are likely to be multi-causal rather than single cause-effect. In practice, it is often not possible to meet the stringent requirements of a pure experimental design: few studies in pedagogy permit random allocation of participants. There are constraints on admission to modules, work placements, industrial sites and even to laboratories and what one can do ethically or practically with participants by way of interventions.

Quasi-experimental designs do enable one to reduce errors and test hypotheses rigorously. The hypotheses may be about similarities or differences between two or more groups ('between participants') or changes within a group ('within participants') or, of course, both. Here are a few of the simpler designs. For more complex designs, consult the references in 'Further reading'.

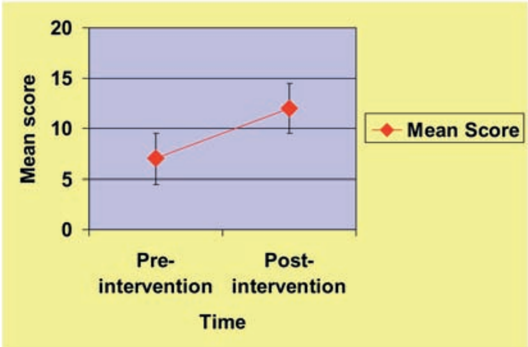
The one shot sample

This is sometimes referred to as a cross-sectional design. It is the most frequently used method in surveys. Comparisons between subgroups in the sample can be made. There is a danger of over-doing the analysis of different subgroups. Because it is only a one shot sample, one can only claim, at best, the results were valid on the occasion of sampling.



Simple within participants design

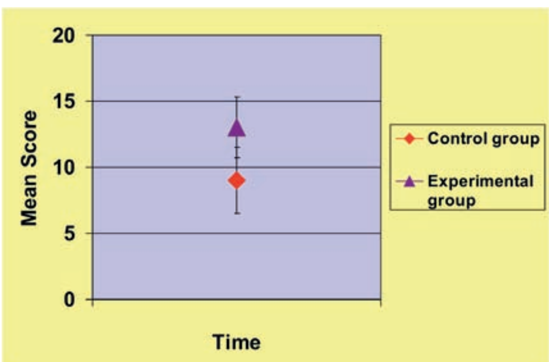
This is a two shot sample of the same group of participants. The standard approach is a pre-test followed by an intervention and a post test. The intervention may, inter alia, be new learning materials, a new teaching method or a change in the learning space. The method can be extended to three or more measures (pre, intermediate and post). Experience suggests that one is more likely to obtain significant differences between the pre and post test than between the intermediate and pre or post tests. ANCOVAR or t tests provide statistical estimates of changes which have occurred. But without a control group who did not experience the intervention, one cannot be sure the changes were due to the intervention. Even if there was a control group, one cannot be absolutely certain that the changes were due solely to the intervention.



Do not use self assessment measures within this design or any design involving interventions. The intervention itself can lower self assessment so you will almost certainly not get a significant result. For example, the self assessment of transferable skills by students before going on placements may be quite high. When they have worked with professional engineers, their self ratings are likely to be lower or much lower.

One way of avoiding, to some extent, this problem is to ask participants to make a retrospective self assessment after the intervention. But bear in mind that some participants may be dishonest or lack insight.

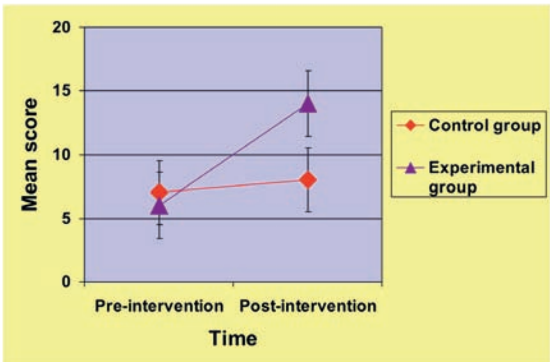
Simple between participants design
In this design a control group is used who have not experienced the intervention and their results are compared with the results of the experimental group. When using this design, if you can, try to match the participants on key variables such as gender, age, ethnicity and perhaps, achievement or personality measures. Be prepared for non-significant differences and that you might have missed a key variable. Contamination between experimental and control groups can occur particularly if they work in the same faculty.



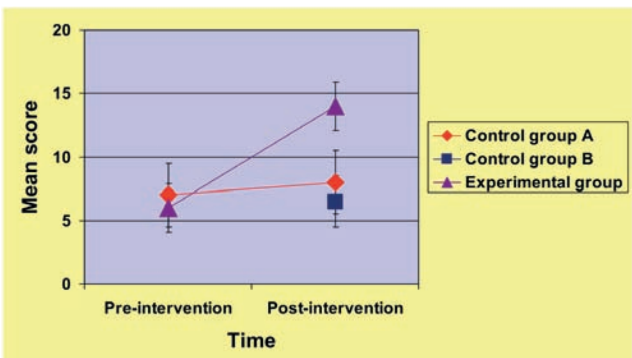
The method works well but without a pre-test, one cannot be sure that the experimental and control groups were initially comparable on the variables being studied. By chance, the experimental group may be better.

The pre-test post-test intervention model

This is a very powerful design. Check first that the scores on the pre-test are not significantly different or better still, are closely similar using t tests and confidence limits. Then check the post-test results. If they are significantly different you can be very confident that the intervention contributed substantially to the change. You can also examine the changes within the experimental and control group and the changes between the groups using ANOVA and t tests.



If you want to be even more rigorous, then use a second control group which only takes the post test and compare the results of the two control groups and the experimental group. So you can check whether the pre-test itself had any effect. Sometimes a pre-test can itself prompt the participants to think.



As a rule of thumb, the more complex the design, the bigger the sample needed and the more complex the statistical analysis. Our advice is stick to the simpler designs and hypotheses and, in your research report, adjust your claims accordingly and point to the limitations in your design.

Action research, case and field studies

Quasi-experimental designs and qualitative methods can be used in action research and in case and field studies.

Action research and learning

Action research is primarily concerned with bringing about change in individuals, groups or organisations. The basic approach is cyclical (see Figure 11.4)

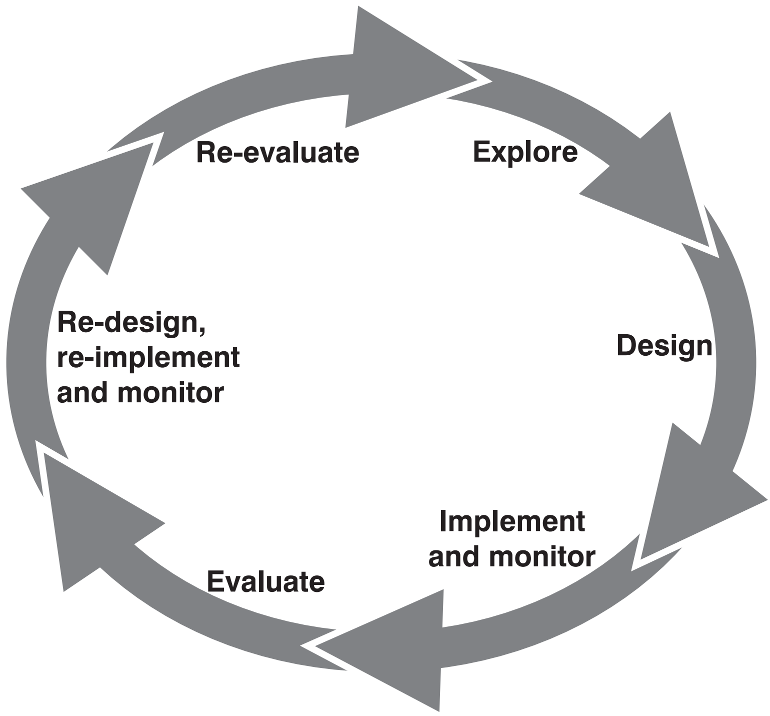


Figure 11.4. Process of Action Research and Learning

A minimum of two cycles is required for action research. The approach is partly analogous to a sequence of controlled experiments but it may use a rich variety of qualitative and quantitative methods of data collection and modes of data analysis.

Action research and action learning are virtually synonymous. Both are concerned with changes and enhancement. Both may go beyond single loop cycles of improvement within an existing situation to 'double loop learning' which seeks changes to the situation itself. In studying ways of improving the assessment of a module, one might conclude after the first loop of action research that what is needed is not merely a change in the assessment of the module but its re-design so one moves to a double loop of action research.

In practice, the difference between single and double loop learning may be blurred. Whether an action research project is regarded as single or double loop hinges on what counts as the existing situation.

There is some misunderstanding of the nature of action research. Sometimes it is not regarded as 'proper research'. Whether it is rigorous research is not dependent upon the label, but on the degree of rigour in the design and analysis of the action research. Ethics committees, please note.

Case studies
A case study is a sharply focussed exploration of a person's behaviour, a situation, incident or occurrence. When the study is of one or two persons, it is usually referred to as a clinical study and uses qualitative methods perhaps combined with some test results. The method can be used to explore how disabled students cope with some aspects of learning in engineering. Case studies of larger groups use qualitative and quantitative methods of research to examine the particular features of the case. The views of different groups of participants are often compared (triangulated) to examine similarities and differences in perspectives. Close agreement (consensual validation) between groups of participants is sometimes about as objective as one can get in one's judgement of a situation. Correlation measures can be used to identify similarities and ANOVA to compare differences in quantitative data. Cases *may* be studied over long periods of time: weeks, rather than hours.

A case may be studied in its own right, rather than as an exemplar of more general phenomena. This form of 'deviant case analysis' is useful for the study of 'critical' incidents in engineering. Exemplars of more general phenomena (instrumental case studies) are useful for formulating or testing principles or hypotheses which may be again tested in subsequent case studies or field experiments. Similarly, multiple case studies permit some generalisation and an estimate of transfer to other contexts (ecological validity).

In setting up a case study, one needs to consider its purpose, the boundaries, the initial case research questions, the appropriate methods and the individuals or organisation being studied. In short, one needs to consider the question: a case study of *what*? Often, in case study research, the ‘what’, the initial research problem, changes as one goes deeper into the problem - as in some laboratory research.

Field research

Field research in pedagogy is essentially concerned with the study of people in their academic environments. The studies may be based on quasi-experimental designs or simply involve unobtrusive observation and recording of what people do in a particular setting. The methods of data collection possible include the use of pre-determined categories, questionnaires, interviews and field notes based on ‘look and write’. The methods of data analysis may be statistical or based on thematic analysis, flow charts, networks or decision trees. As ever, methods of data collection and data analysis are determined by the purposes of the field research, the context, the constraints and the perspectives of the researcher.

The differences between a field study and a case study are marginal but, broadly speaking, field studies tend to be concerned with what people do in their habitats and, perhaps, with identifying patterns of behaviour whereas case studies can embrace these but they may also be more concerned with examining motives and hidden determinants of behaviour.

Activities

Only a couple of activities are included here. At this stage, the important task is to master a good statistical package such as SPSS and think about designing your own pedagogical project.

11.1 If you have time, obtain the A level scores and marks awarded in the degree examinations of a sample of last year’s students and explore the relationship between the A level scores and the degree performance. **You could also explore levels of attendance and degree results**

.

11.2 How would you test the hypothesis that lecturers’ knowledge of pedagogy improves their teaching?

Further reading

Statistics and principles of experimental design
Brace *et al* (2009), Bryman and Carter (2004), Coolican (2009), Field and Hole (2008), Field (2009)

The following e-book on engineering statistics is useful (http/::www.itl.nist.gov:div898:handbook:) and the website http://dogsbody.psych.mun.ca/VassarStats/ is very useful for simple statistical calculations and descriptions of statistical techniques. (Accessed in April 2010)

There really is no substitute for consulting a practically minded statistician. He or she does not have to be a mathematical statistician but should be familiar with the practical issues of experimental design.

Action research, case studies and field studies
Bell (2005) or
Cohen *et al* (2007)
Coolican (2009)

Take a look at journals such as Engineering Education for examples of how researchers have designed and discussed the limitations of their research. And do return to Unit 8 to refresh your knowledge of samples.

Section D
Some Issues to Consider

This section might be described by textile engineers as 'tying up loose ends'. It has three functions. First, to provide you with an opportunity to review and reflect upon different views of reliability and validity and on the similarities and differences of qualitative and quantitative pedagogical research. Secondly, to offer comments and suggestions for writing research submissions, piloting the research through ethics committees and writing for publication. Thirdly, to provide you with a brief overview of the content and structure of the book.

Unit 12
Approaches to reliability and validity

Introduction

Reliability and validity are analogous to precision and accuracy in instrumentation. A precise instrument gives stable, consistent readings but the readings are not necessarily correct (valid or true). So one has to either trust the instrument or calibrate it. Unless the instrument is reliable, one can never be sure that the measurements obtained are valid.

Ensuring instruments are precise and accurate (reliable and valid) in engineering can be challenging. It is even more so in pedagogy. For within pedagogical research, reliability and validity is determined by the instruments used, such as achievement tests or attitude scales, and the participants using them. The latter can be a major source of 'error'. To complicate matters further, in pedagogy, the concepts of reliability and validity are themselves challenged philosophically. There are debates about questions such as 'What is truth?', 'How do you decide something is true?' and 'How do we come to know?'. These are ontological and epistemological questions (See Box 12.1) which make some engineers feel uncomfortable. But they are important questions to address by pedagogical researchers. They are at the root of the three broad approaches to reliability and validity outlined in this unit. For convenience, these are classified as the psychometric approach, the sociological approach and the qualitative approach.

Box 12.1. Heavy words

Ontology: The study of existence. It is concerned with the question what does 'to exist' mean. Are abstract entities such as electrons, electricity, personality, love, social class real? Are they merely useful constructions for explaining the world? What does objective mean? Is 'objective' no more than collective opinion in some contexts? Science and engineering is based on an ontology known as realism. The world is real and can be explained in terms of laws based on causes and effects.

Epistemology: The study of the different types of knowledge such as knowing that and knowing how. Topics studied include the differences between knowledge and belief, how do we know when something is true, how do we acquire knowledge. Epistemology overlaps with ontology on questions of objectivity, truth and subjectivity. The epistemology of Science and Engineering is generally regarded as objectivism. It is assumed that researchers can objectively collect and interpret data without influencing the object of study and the study can yield proven truths: facts.

The psychometric approach

This approach is the closest to instrument calibration in Science and Engineering. It is almost wholly based upon mathematical and statistical theories and methods.

Psychometric reliability

There are two facets of reliability, the reliability or consistency of the observers and the reliability of the instruments: the tests, observation schedules or rating scales. As indicated in Unit Nine and Ten, the reliability of the observers may be measured by inter-observer correlations and intra-observer correlations (internal consistency of the observer). One hopes for significance in both cases. Differences between observers can sometimes be coped with by adjusting scores to a standard deviation and mean. Difference within observers is random variance and cannot be easily coped with.
The reliability of a test (sometimes also called the internal consistency) and its subscales can be measured by using Cronbach's Alpha which computes a value between 0 and 1. An alpha of 0.7 is usually regarded as good for attitude scales.

Test –retest of the same or equivalent tests or scales provide a measure of external reliability but one needs to be cautious of tests labelled as 'equivalent'. There is also a dilemma about high test-retest correlations. If the test is very stable (reliable) it might be insensitive for the measurement of change. The usual practical answer to this problem is to measure test-retest over a short period preferably with a small sample of comparable participants and then use the test or scale on your main sample.

Psychometric validity

Psychometric validity is usually described as the extent to which the instrument measures what it is claimed it measures. These measures can be intrinsic or extrinsic. For intrinsic content validity, the test items are matched to the purposes of the research. This matching is a matter of judgement and the researcher may not be the best person to make this judgement. A panel of experts may be better. One can use more complicated, time-consuming techniques, such as the Delphi Method (see Further reading) in which judges from different sources (e.g. line managers, tutors or final year students) are asked to judge the importance of each of a set of items and provide reasons why they are important. The researcher then collates the results, perhaps reduces the number of items and then re-submits the revised list to the judges who again sort and rate them. Two or three iterations are the norm. The method provides consensual validity which is about as close as one can get to objectivity in many situations. Box 12.2 summarises the common forms of validity.

Box 12.2. Forms of psychometric validity

Face Validity: The instrument looks as if it should be a valid one. This is a weak form of validity but unless an instrument has some face validity it might not be treated seriously by participants.

Content Validity: As indicated this is a non-statistical form of validity testing in which the content of an instrument is matched against its purposes to ensure the test is representative of what it claims to be measuring.

Concurrent validity: The extent to which an instrument correlates well with an already validated measure. A danger here is the already validated instrument may have been validated against an earlier instrument and so on. So one is involved in an infinite regress. This form of validity is also known as convergent validity.

Construct Validity: As indicated above, the extent to which the instrument measures what it claims to measure. Often factor analysis is used to match the factors being measured against the claims or theory on which the instrument is based, e.g. do intelligence tests measure intelligence?

Discriminant Validity: The extent to which an instrument does reveal differences between samples which it claims to (e.g. between level one and level four students or between architects and civil engineers). Sometimes this form of validity is refereed to as divergent validity.

Predictive Validity: The extent to which an instrument predicts accurately subsequent performance or attitudes. Difficulties here are establishing the criteria for current and subsequent performances or attitudes and the limitations of the samples used. Does a good honours degree predict performance in a PhD? Does performance in a PhD predict success in research?

Ecological Validity: This is more a judgement than a measure. It is the extent to which findings in laboratory experiments are true in natural settings. A laboratory finding might have validity (be true) in a laboratory but not necessarily true in a natural setting. See Unit 11.

Consequential Validity: This is a judgement of the extent to which the instrument has upon the attitudes and behaviour of the participants. Thus, it would be unwise, usually, to choose a test which might lower subsequent motivation and performance.

The sociological approach

Quantitative sociologists use psychometric approaches when developing attitude scales but for the most part eschew psychometric measures of reliability and validity. They share with psychometricians concerns for appropriate sampling and the 'ities' of generalisability, replicability, feasibility, acceptability, reliability and validity. But they do not necessarily calculate reliability and validity coefficients of data based on fact-finding or opinion-seeking. Instead they may use the same or similar questions to check for consistency of responses, cross-tabulation to check for connections between viewpoints or similarities and differences of views of different subgroups. Triangulation is also used to check the degree of agreement between different groups. The extent to which the triangulation signifies agreement is regarded as the measure of validity (truth).

There are debates within sociology and pedagogy about whether research is ever objective (Box 12.1). For some sociologists, objectivity is an ideal to be aimed at, but not necessarily achieved. Others argue that what some claim as objective is no more than collective opinion or inter-subjectivity (shared meanings and understandings). For example, a recent doctoral study in engineering pedagogy reported industrial sponsorship was valued highly by companies, graduates, undergraduates and academic engineers as a way of developing the quality of student performance in engineering degree courses. This is an important finding. But, as the author pointed out (Soltani-Talfreshi, 2010) the high value of sponsorship is not a cause, in a scientific sense, but it is an inter-subjective view that industrial sponsorship does improve performance in engineering degrees. A hundred years ago that idea would have seemed risible.

The qualitative approach

The approach of qualitative researchers moves even further away from the psychometric approach although a few do concede that inter-observer measures of reliability can be useful (Mays and Pope, 2000). But in line with their view that words and their meaning are more important than numbers and their significance (Unit 3), most qualitative researchers reject the statistical notions of reliability and validity. Instead they take a phenomenological stance on data. That is, it is assumed the responses and accounts by individual participants are true (valid) for them: it is their way of looking at the world. The role of the researcher is to interpret these views of the world and set them in a wider, perhaps theoretical, context. The test of validity for qualitative researchers is 'Does the account ring true to its readers?' Herein lies the difficulty of what is known as response validation. The account may ring true to an outside audience with knowledge of other, similar contexts but not to the participants inside the research. *Whose view is correct?*

Ways of ensuring consistency (reliability) and checking validity used by qualitative researchers are shown in Box 12.3:

Box 12.3. Qualitative methods of ensuring reliability and validity

Transparency: Thorough account of the methods of data collection and analysis so the study or at least its data coding could be replicated.

Triangulation: The search for patterns of convergent views either derived from different sub groups or from different methods of investigation. This is an extension of triangulation as used by quantitative sociologists and civil engineers.

Abduction: More popularly known as 'deviant case analysis' or 'attention to negative cases'. In this approach one identifies inconsistencies, paradoxes or contradictions in the data, seeks to explain them and thereby produce a more comprehensive (truer) account.

Reflexivity: There are two types of reflexivity: personal and epistemological. Personal reflexivity refers to the researchers' awareness of how their background, values and beliefs and relationships with the participants may have influenced the research. Epistemological reflexivity refers to the researcher's awareness of how the research has changed their conceptions of knowledge. Some qualitative researchers argue that reports of reflexivity should be included in accounts of research so readers are aware of the perspective of the researchers.

Respondent Validation: This can be useful for improving the reliability of the data collection. In some circumstances, participants can be invited to check summaries of conversations or field notes to reduce misrepresentation or errors in understanding. We suggest 'summaries' since our experience is that full transcripts including the 'ums' and 'ers' are often rejected by the participants even though they are accurate records of the interviews!

Activity

12.1 Think about and discuss with a colleague how you would establish and report the reliability and validity of the marking of a module paper.

Further reading

Psychometric approaches to reliability and validity
As for Experimental Design and Statistics;
Brace *et al* (2009), Coolican (2009), Field and Hole (2008), Field (2009) provide good discussions of reliability and validity from a psychological stand point.
Meadows and Billington (2005) on the reliability of marking provide a good entrée into the issues of reliability and it may be of particular interest to researchers interested in the reliability of assessment.

Sociological approaches
Bryman and Carter (2004)
Harambolos and Holborn (2009) provide a thorough account of sociological and qualitative approaches to reliability, validity and related matters (Chapter 14).

Qualitative approaches
Harambolos and Holborn (2009) *cit. op.*
Willig (2001) provides a good discussion of what constitutes a good qualitative report which includes concepts used by qualitative researchers instead of ‘reliability’ and ‘validity’.

Delphi method
Hsu and Sandford (2007) provide an account of how to use the Delphi approach and its strengths and weaknesses.

Unit 13
So what's the difference?

Introduction

If you have read the previous sections and tried a few of the activities then you will be aware of your own personal (even emotional!) reactions to the broad perspectives of quantitative and qualitative research. We hope that you have recognised that the approaches are deeper than you first thought.

This unit gives you an opportunity to consolidate and reflect on your knowledge and views of qualitative and quantitative research. The unit provides a summary of the general similarities and differences of the two perspectives; an outline of the research models which underlie the perspectives; points to the different philosophies which are at the root of the perspectives; explores whether the perspectives are complementary or mutually exclusive.

As indicated in Unit Three, the two broad perspectives of qualitative and quantitative research may be characterised respectively as primarily concerned with words and their meanings and numbers and their significance. These broad perspectives have been variously described as *phenomenological* or *analytical*, the *humanistic* and *scientific* paradigm, the *interpretive* and *experimental* approach or the *normative* and *positivistic* model. As one might expect, there are subtle differences within these different terminologies but broadly speaking the two perspectives can be likened to two families. There is some overlap in common features and not every member of a family shares every characteristic of their own family. Both perspectives demand a knowledge of the relevant literature, attention to the design and planning of the study, choice of the appropriate method of analysis and a genre of writing appropriate for the audience or journal.

In addition, both require the use of strategies for piloting the research through ethics committees, for obtaining grant applications or other forms of funding and a willingness to change emphases during the research. Last, but not least, some skill is required for persuading colleagues and participants to engage in the research.

General differences

The general differences between the two perspectives are summarised in Boxes 13.1 and 13.2. Many of these differences have been alluded to in the earlier units. Arguably, the pivotal concepts of these differences are 'erklarung' and 'verstehen', the terms used by 19th Century German phenomenologists, to distinguish the search for scientific explanations based on covering laws and the search for personal understanding of people, situations and how they see their worlds (think Engineering and English Literature).

In our experience, undergraduates and graduates find lengthy tables overwhelming so we have deliberately split the comparison of qualitative and quantitative perspectives into two tables and placed the relatively unfamiliar qualitative perspective in the first column.

Box 13.1. General differences of Quantitative and Qualitative Research

Qualitative - 'Humanistic'	**Quantitative -'Scientific'**
Emphasis on words and their meanings to different people	Emphasis on numbers, their significance and measurement.
Set in the context of understanding the worlds of human experience. (verstehen)	Set in the context of scientific theories. (erklarung).
Meanings are constructed in social interaction (social constructionism) and can be interpreted from different perspectives.	Verifiable facts are searched for (positivism) and used to confirm or refute theories.
Qualitative methods provide approaches to different truths.	Quantitative methods are the only approaches to the truth.
Emphasises inter-subjective meaning. Questions whether study of most phenomena is ever purely objective. Stresses importance of knowledge of background and value system of researchers and the effect the research has had on their views (Reflexivity)	Attempts to be 'Objective' rather than 'Subjective'. Regards background and value system of researcher as irrelevant. Stresses the 'neutral' stance. Reflection primarily concerned with improving experimental design.
Cautious about prediction and generalisation. Emphasis is on how the report seems to the users of the research. Generalisations are verbal (as in History) and based on accumulation of data from contexts perceived as similar.	Prediction and generalisation based on statistics.
Linguistic consistency, transparency, triangulation.	Statistical reliability of tests and observers.
Validity determined by agreement between participants (consensual validation and triangulation) and success in transfer to other contexts (ecological validity). The test is whether the report 'rings true'. **See Box 12.3.**	Statistical validity based on 'does the test measure what it purports to measure?' **See Box 12.2.**

Box 13.2. More general differences

Qualitative - 'Humanistic'	Quantitative -'Scientific'
Aims to deepen personal understanding theories, insights and perspectives.	Aims to validate and advance scientific theories.
Primarily exploratory-driven. But insights and further explorations may be initiated during the research.	Primarily hypothesis-driven. But hypotheses may emerge during the research.
Preferably in naturalistic settings	Preferably laboratory based or quasi-experimental.
Responses controlled primarily by participants	Responses controlled primarily by researcher.
Observer *may* participate.	Observer detached.
Research pathway is determined primarily by what emerges from the data. Theories which emerge from the data may be interpreted according to a specific perspective or theory.	Research pathway is structured primarily by specific objectives and accepted theory.
Reports often written in active voices.	Reports written in third person passive voice.
Seen as *avant-garde* (even suspicious!) in the engineering community.	Well accepted in the engineering community. So much so that some engineers seem not aware that there are other approaches to research than the 'scientific'.

Paradigms of research

Figures 13.1 and 13.2 summarise the research paradigms (models) of qualitative and quantitative research.

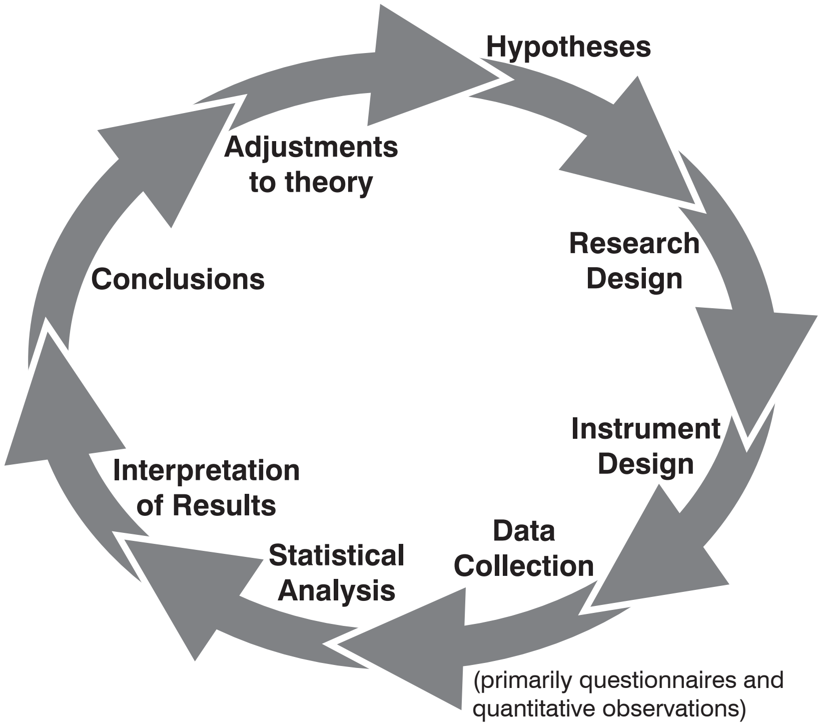


Figure 13.1. Research paradigm of quantitative research

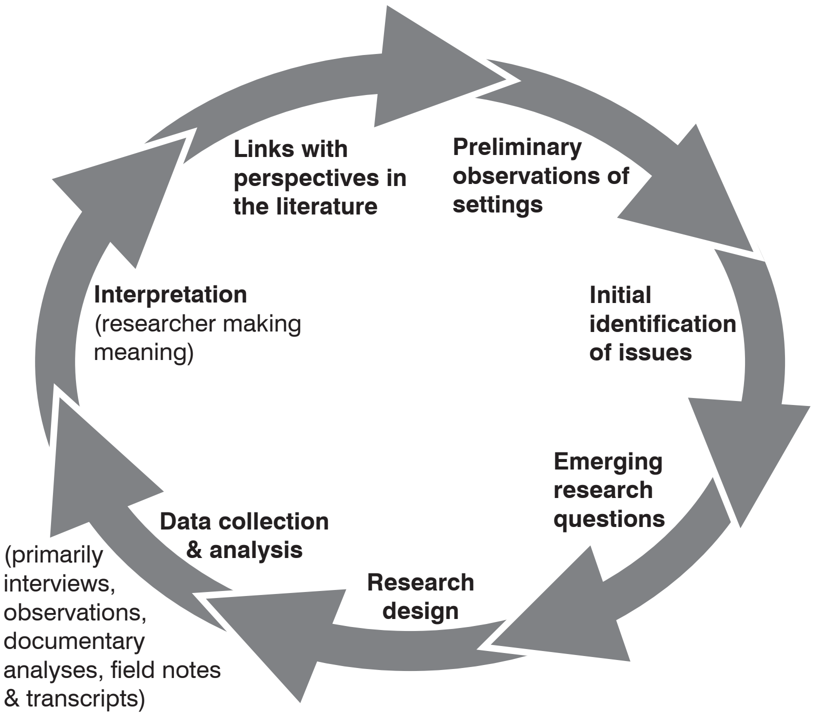


Figure 13.2. Research paradigm of qualitative research

As you can see, the paradigm of qualitative research is rather more messy and less systematic than quantitative research. Its protagonists argue that these characteristics reflect the nature of the chaos and complexity of everyday life and that quantitative researchers oversimplify in their efforts to explain phenomena. Researchers in the quantitative tradition recognise that chaos, complexity and general messiness can occur in a research project but regard their model as an ideal to be aimed at. Some of them regard qualitative research as woolly and of little value. This theme is returned to in the section 'Are the differences in perspectives irreconcilable?'

Differences in philosophy

Box 12.1 introduced you to two key concepts in the philosophy underlying quantitative and qualitative perspectives: ontology and epistemology. Each of these theoretical perspectives has its own ontology and epistemology which shapes its methodology (the rationale underlying its methods).

The ontology of classical positivism is there is a real world independent of the observer. Its epistemology (way of knowing) is that the world can be known by objective means and the researcher can control variables, collect objective data, identify causes and effects and arrive at definite conclusions. Most scientists and engineers nowadays are post-positivists. They recognise the above are ideals to pursue; they search for the highly probable rather than for absolute certitude and recognise that scientific truth has the characteristics of an asymptote.

The philosophical term often applied to the family of qualitative research perspectives is social constructionism. Its ontology is relativism. Truth is relative. Each person constructs his or her own perspectives of the world based on experiences, social interactions and the culture inhabited. So perspectives and what is thought to be true change over time and across cultures. This stance is sometimes misunderstood and derided. ('If you think this brick wall is just a social construct, let me bang your head on it.') Relativism does not deny the existence of concrete objects. What it does do is highlight that the same objects may have different meanings for different people. A work bench only becomes a work bench when it is generally recognised as one. This is its nomothetic meaning. It may have meanings which are common to a group and it may have a particular personal meaning to an individual. These are ideographic meanings. Rather than a single reality, social constructionists argue there are multiple realities. The epistemology of social constructionism is that reality is an inter-subjective space. This leads to a methodology based on the interaction of the researcher and the subject of study. Social constructionists argue that to understand the research and make judgements of its quality, one needs to know the background and value systems of the researchers and participants.

Are the differences in perspectives irreconcilable?

The answer to this question depends on whether you are a purist or a pragmatist (See Box 2.1). Purists, whether positivists or social constructionists, may argue that the differences in ontology and epistemology prohibit the combination of quantitative and qualitative methods. They often dismiss the 'other perspective' through the use of pejorative terms such as rigid, woolly, anal, soft-centred, naïve, unnecessarily complicated. Pragmatists will argue that the methods can mutually inform each other. No amount of statistics can tell you how it feels to have cancer. No amount of qualitative data can tell you the incidence or likely causes of cancer. Both are necessary for a well-rounded understanding of cancer and its effects.

Obviously, if one is only interested in one facet of a topic then one chooses the approach which is most informative and feasible. Sometimes one may use qualitative methods as a preliminary to quantitative research or as a follow up to quantitative research. Box 13.3 summarises other ways in which the mixed methods of qualitative and quantitative research can be complementary. This approach to research is sometimes known as 'q' research whereas purely quantitative or qualitative research is known as 'Q' research (Willig, 2001). Inevitably, in the little 'q' approach, there is a danger that qualitative methods will be the handmaiden of quantitative approaches rather than vice versa. Our view is that at this stage in the development of pedagogical research, that in many projects, some use of qualitative methods is better than no use of qualitative methods.

Box 13.3. Mixed methods

Generation of hypotheses	**Use qualitative research to identify issues and generate hypotheses.**
Triangulation	Use quantitative research to cross check qualitative findings and vice versa.
Exploration	Use both methods to explore different facets of the same problem.
Gap fill	One method may not provide all the information required for the purposes of the research project -so use both.
Screening	A quantitative approach can used to screen a large sample to search for people with the required characteristics for in-depth study.
Problem Identification	Use qualitative approaches to identify the problem and quantitative methods to map the extent of the problem. Alternatively, use quantitative methods to identify the extent of the problem and qualitative methods to explore possible solutions.
Illumination	Use qualitative research to illuminate or illustrate findings from a quantitative survey.
Speculation	Use qualitative research to explore possible explanations or relationships between the variables studied.

Activities

13.1 Here are three quotations attributed to eminent scientists. Put them in your rank order of preference (1 = most preferred). Compare your decision with that of a colleague and justify it. Which quotation is closest to the underlying philosophy of this book?

a. "Measure that which is measurable. Make measurable that which is not."
b. "If a thing exists, it exists in quantity. If it exists in quantity, it can be measured."
c. "Not everything that can be counted counts, and not everything that counts can be counted."

13.2 Consider the meaning of the phrase 'This book examines the nature of pedagogical research' from the standpoint of a quantitative researcher and a qualitative researcher. If you have the opportunity, discuss your views with a few colleagues.

13.3 Think of an example of pedagogical research project in which quantitative and qualitative approaches would complement each other.

Further reading

Most texts on research methods discuss the differences between qualitative and quantitative methods and many advocate the use of mixed methods.

Particularly useful introductions to this topic are
Bryman (2008). Basit (2010), Cohen *et al* (2007) and Coolican (2009). Other suggestions were given at the end of Unit Five.

Unit 14
Ethical considerations and ethics committees

Ethical considerations

Pedagogical research, like all research is ‘an activity that aims to generate knowledge that can be trusted and valued by the researchers and others’ (Oates 2006). Where human beings are the focus of the research, it is increasingly recognised that their rights and safety must be respected. So too must the rights and safety of the researchers. So ethical frameworks are necessary not only to protect participants, but also to protect researchers from the possibility of litigation. In recent years there has been an increase in the number of legal actions by members of the public against professionals for misconduct and as researchers you should be aware that such action against you is a possibility if participants feel their rights or dignity were not respected, or worse, they see litigation as a way of making money.

This unit is designed to help you think about ethical frameworks, the ethical issues which may arise in your research and how to carry out pedagogical studies within an ethical framework.

The emergence of ethical frameworks

Up until the middle of the last century there were relatively few formal controls on the way in which research on people was conducted, or the topics which were investigated (Oates, 2006). However, public condemnation of research carried out by the Nazis on concentration camp inmates led to the implementation of the Nuremberg Code in 1947 which prohibited research being carried out on people against their will. In the 1950’s, 60’s and 70’s there were several studies which further raised public concerns about the treatment of people by researchers. The simulation study known as the Stanford Prison Experiment is a well known example (http://www.prisonexp.org/). These concerns led to the development of ethical codes of practice and legal controls to regulate research in the United States and subsequently in the UK and Europe. Ethics committees were established in Universities and the professions to ensure that research affecting humans followed these codes of practice.

Most professions now have their own code of conduct for research which provides an ethical framework for researchers. The two most relevant frameworks for pedagogical research are those of the British Educational Research Association (BERA) and the British Psychological Society (BPS). The BERA ethical guidelines for educational research (http://www.bera.ac.uk/blog/category/publications/guidelines/) state that all educational research should be conducted within an ethic of respect for: the person, knowledge, democratic values, the quality of educational research and academic freedom. The BPS code of ethics and conduct for psychologists in professional situations, including research, is based on four ethical principles: respect for participants, competence in conducting research, responsibility to participants and the community and integrity of the reports of the findings (http://www.bps.org.uk/the-society/code-of-conduct/).

Using these frameworks as guidance, ethical guidelines for conducting pedagogical research are discussed under two headings: responsibilities to participants and responsibilities to the wider academic community, including research sponsors.

Activity 14.1.

Think about a pedagogical study you would like to carry out. What are the ethical issues to consider? Write these down and put them to one side for now.

Responsibilities to participants

Informed consent

A key ethical principle is that participants must provide informed consent prior to taking part in any research. Participants should be informed through an information sheet which explains: what is being done, why it is being done, what a participant would be required to do, any potential risks or benefits associated with participating, how the data will be handled, and how the final research will be presented. The benefits and risks of the study should not be exaggerated and the information sheet should be written in clear, non-technical language. The length and detail required obviously vary depending on the nature of the study but about 1 side of A4 is a good guide. The consent form should ask participants to indicate that they have been provided with the above information before they agree to take part in a study (See Box 14.1).

Finding people to take part in your study can sometimes be difficult. This may lead to a conflict of interests if you are under pressure to recruit sufficient participants within a given timeframe to meet the demands of sponsors, or managers, but also bound by the requirement that agreement to participate must be given without any pressure or duress being placed on the individual. The use of incentives to encourage participation can often help recruitment but be careful about what is offered and how. The timing of any incentive is relevant; a small token of thanks given after data collection raises few ethical issues whereas an incentive given prior to participation, or a large incentive, is likely to be seen as coercive and so not ethically acceptable. Also, if using an incentive consider whether this may bias the sample or the participants' responses in any way.

Box 14.1. Consent form for Pedagogical Research

I have been asked to participate in an experiment that investigates an area of pedagogy in engineering.

- I have been informed about the research and why it is taking place.
- I understand that my participation in this research is voluntary.
- I understand that I can withdraw from the research at any time.
- I understand that my data will be anonymous.
- I understand that I will be provided with a debrief after taking part in the experiment.

I give my free consent by signing this form.

Signature ______________________________

Date ___________________________________

In the case of pedagogical research where students are being asked to participate in research by a professor or lecturer there is an imbalance of power in the relationship. So take care not to use your position of authority to pressurise students to participate in your research. Indicate to the students that they are free to take part or not with no impact on their grades, or any other aspect of their course. But do not emphasise these points unduly lest the students come to believe they might!

For most observational research, one should seek permission on the consent form for direct observation or for making audio or video recordings. It is customary to reassure participants that the recordings are for research purposes only and will not be used without permission in presentations. If the recordings are very sensitive, one should assure the participants that the data will be destroyed. An exception to these rules is when informing the participants prior to the study would affect strongly their behaviour. In this case, debrief them. Occasionally, in covert-participant (ethnographic) research (See Unit 6), it would be unwise, sometimes even life-threatening (!), to inform participants that you were observing or recording their behaviour. We suggest you discuss this moral dilemma with a researcher experienced in these matters.

There are further issues which relate to consent for children and young people under 18 years and members of vulnerable groups. The BERA and BPS guidelines (*cit. op*.) cover these issues as do some of the references given in 'Further reading'

Right to withdraw

In any pedagogical study participants should be made aware from the outset that they are free to withdraw from the research at any time and for any reason. Participants may decide to withdraw during data collection, or retrospectively (within a reasonable timeframe). The most sensitive data is often from qualitative research, particularly interviews. The possibility of withdrawal from interviews can be reduced by negotiating the areas that will be discussed beforehand and reassuring participants that they do not have to answer questions which they do not wish to.

But it can be difficult for participants to withdraw as they may feel they are letting the researcher down (particularly where the researcher is also their lecturer who they feel an obligation to help), as part of your duty of care to your participants you should try to create a relationship which enables participants to withdraw and reassure them that they will suffer no adverse consequences as a result.

Confidentiality and anonymity

Data collected about individuals should remain anonymous unless agreed otherwise in advance. Data would be considered confidential when none of an individual's results are presented and data are instead presented as summary data (e.g. frequencies or means). In some cases it may not be possible to promise your participants confidentiality. For example, qualitative data is often presented on a case by case basis. In these situations participants should be promised anonymity, which means that participants will not be identifiable from data which is passed on to third parties. However, simply removing a participant's name may not be sufficient to provide anonymity. For example, references to experiences discussed or a seminar group to which they belong may mean the participant could be easily identified. If this is the case then these references should be removed before data is passed on to a third party. Removing references which identify participants could be particularly relevant for research within an academic department where the staff who will be discussing the data know, and are still teaching, the students who provided the data.

The use of electronic means of communication has added further complication to this aspect of the ethical framework. When information is collected or sent electronically, the communications may not necessarily be secure. For example emails can in some instances be read by third parties - as can information collected on remote web servers.

Disclosure/giving advice

There may be cases, more often in qualitative than quantitative studies, where the researcher considers that behaviour or facts have come to light during the research which could result in harm to the participant. As a researcher, you have a responsibility to let the participant know you think this is the case. Unless there are exceptional circumstances you should discuss such concerns with the participant rather than a third party, so that the agreement of confidentiality is maintained. But be wary of offering advice directly unless you are appropriately qualified. It is better to recommend to the participant a relevant source of professional advice: for example, the university counselling service may be appropriate.

Data protection

Personal data must be stored and used in accordance with the Data Protection Act (1998). A key requirement of this act is that people are entitled to know how and why their personal data is being stored, what it is being used for and to whom it may be made available (BERA, 2004). Participants have the right to access any personal data which is stored in relation to them. Furthermore researchers must ensure that data is kept securely and that any publication using the data does not directly or indirectly lead to a breach of agreed confidentiality and anonymity.

Feedback
Participants should be debriefed once their participation is completed. This means providing participants with any additional information necessary for them to have a full understanding of the research. It should also include a discussion with participants of their experience of the research. This is a useful method for researchers to monitor any unforeseen effects or any misconceptions about the research. It is good practice to feedback the findings of the study to participants once the data have been analysed. Publishing the results on a webpage can be a practical and efficient way of doing this.

Some researchers advocate that participants should see the transcript and analysis of interviews they have taken part in so that they know how their contribution to the study has been interpreted. Others take the view that the interpretation is the researcher's own perspective and such response validation is not necessary (See Box 12.3).

Protection of participants
Researchers have a responsibility to protect participants from undue risk of mental or physical harm during a study. All activities involve some risk of harm so, to clarify what is expected of researchers, the BPS ethical guidelines have defined 'undue risk' as increasing the risk that a participant would come to any form of harm compared to their normal lifestyle. In pedagogical research psychological distress is the most likely risk associated with participation.

Researchers should also minimise the effects of designs that advantage, or are perceived to advantage, one group of participants over another. For example, in an experimental study in which the treatment is perceived as desirable but by definition is not available to the control or comparison group. This could be pertinent for interventions where a change in teaching or learning approach is perceived to give an advantage to students in an experimental group over those in the control group. However there is a paradox here. Unless new approaches are tried, the pedagogy of the subject cannot develop: one can never know whether the experimental method is actually better. Further, the reverse may be the concern of a traditional ethics committee. Its members may believe the traditional method is superior and so object to the experimental method even when their belief in the traditional method is not based on strong evidence.

Deception

Researchers should avoid misleading participants or withholding information from them where possible. However, there may be times when it is acceptable to withhold certain aspects of a hypothesis or hunch until after the research has been completed. The BPS ethical guidelines provide further guidance on this point. Deception is a delicate area ethically and we suggest any study which uses it should be considered by an ethics committee before going ahead.

Responsibilities to the wider academic community

It is generally agreed that researchers must ensure that they carry out and report research with integrity and do not engage in any academic misconduct. Examples of misconduct would include falsifying or distorting a study's findings, sensationalising findings to maximise public exposure at the expense of intellectual capital, and publishing work which was carried out with co-researchers as a single author paper without the co-researchers agreement. However, there are differences in traditions in Arts and Science/Engineering with regard to supervised research projects. In Arts, the research student usually has ownership of the research and supervisors are not necessarily involved as joint authors. In science and engineering, there seems to be an expectation that research supervisors are automatically joint authors even if their input has been minimal. This difference in tradition raises ethical issues (See Activity 14.3c). Further discussion of responsibilities to the community of researchers can be found in the BERA (2004) guidelines.

Most of the larger sponsors of pedagogical research such as the Higher Education Academy or the Research Councils work within an ethical framework. However, if research is funded by an organisation which is not aware of the ethical principles of research it is the responsibility of the researcher to bring these to the sponsor's attention. It is usual to have a written agreement between the sponsor of the research and the institution conducting the study covering issues such as access to and ownership of data and rights to publish. These agreements can sometimes prohibit researchers from publishing their findings even if they are in the public interest. Again, this issue raises moral questions.

Activity 14.2.

Go back to the list of ethical issues you made earlier in this Unit. Is there anything else you feel you should add?

Gaining ethical approval

Research ethics committees are the bodies which make decisions about whether proposed research studies meet ethical guidelines or not. In the UK each Higher Education Institute (HEI) has its own ethics committee which considers the ethical implications of research proposed by its staff and students. Having your research proposal approved by your HEI's ethics committee *should* provide legal protection under that institution's indemnity policy if there are any unforeseen negative consequences of the research (But do check). Peer reviewed journals will also require evidence that your study was approved by a research ethics committee before they agree to publish your findings.

HEI's follow national frameworks for ethics but each HEI is free to determine its own policy of ethical approval and there are variations within the sector (Oates, 2006). It is becoming more common for universities to have a tiered approval system where researchers are asked to answer a series of yes/no questions regarding the risks associated with their study. If no risks are identified by this process the proposal may be able to be signed off at school level without going to a full ethics committee. If possible risks are identified, a full application for ethical approval would normally have to be made to the HEI's ethics committee.

Application forms for ethical approval by these committees vary but typically would require an explanation of the rationale for the study, a detailed description of the protocol to be used with participants and discussion of any risk of harm to participants along with the proposed information sheet and consent form. Ethics committees usually meet once every few months and proposals to be considered must be submitted several weeks in advance of the next meeting. Gaining ethical approval can be a lengthy process, particularly if the committee asks you to modify your proposal and resubmit it to the next committee meeting. So it is a good idea to familiarise yourself with the procedures of your particular HEI and apply for ethical approval early enough to ensure that your data collection is not unduly delayed.

It would be good to be able to report that all ethical committees behave ethically. Whilst there is no formal proof on this issue, apocryphal comments suggest that some ethical committees confuse ethical and methodological issues and some committees have an aversion to certain kinds of research. It would be wise to ascertain the stance of your ethics committee on these issues before embarking on writing a research application.

Activity 14.3.

What would you do in the situations below? What ethical issues are raised and how would you address them? If you have the opportunity, discuss the situations with a few colleagues.

a) A student is interviewed as part of a study into assessment and reveals that one of his or her peers is frequently plagiarising work and not being detected.

b) Students reveal in interviews for a study into student retention that they are under huge financial and emotional pressure and are struggling to keep up with work and may well drop out of the course as a result.

c) You are doing a pedagogical research project as part of a master's degree. Your two supervisors have had very little input into the project but expect to be listed as senior co-authors in your first publication of the research. What is your view?

d) Your head of department/head of school becomes aware of the study which you have been conducting into student and staff evaluations of modules and asks to have access to the data to use as part of the forthcoming staff appraisals.

Further reading

The guidelines of BERA (British Educational Research Association) and the BPS (British Psychological Society) provide the essential framework. (http://www.bera.ac.uk/blog/category/publications/guidelines/ and http://www.bps.org.uk/the-society/code-of-conduct/) Accessed 12 April 2010.
A search of the HEA website (http://www.heacademy.ac.uk/) will provide hints of ethical approval by various Subject Centres.
The pdf file by Paul Connolly discussing ethical principles involved in working with vulnerable participants. (http://cain.ulst.ac.uk/issues/victims/docs/connolly03.pdf; Accessed 12 April 2010)

ESRC (Economics and Social Research Council) has a website devoted to research and resources on informed consent and related matters (http://www.sociology.soton.ac.uk/Proj/Informed_Consent/Resources.htm Accessed 12 April 2010).

The chapters by Coolican (2010), Kumar (2005) and Oates (2006) provide a good overview of ethical considerations.

The text by Oliver (2003) provides a more comprehensive view.

Unit 15
Writing a research proposal

Introduction

Readers may already be familiar with the challenge and disappointment of submitting a research proposal so this unit is a set of suggestions and pointers rather than a set of step by step instructions.

As you will know from your experience of writing research proposals for funds for research in engineering, developing your research idea would in an ideal world come first but in reality the idea often develops in parallel with an awareness of the current and future funding calls. This unit offers some suggestions which are useful for applying for research monies for pedagogical research but also is relevant to applying for research funds for other purposes.

Finding a funding call

The first thing to say here is start modestly. There may well be local funds available within your university which are ring fenced for pedagogical research. Alternatively local employers or specialist groups such as Eng CETL would be possibilities for an initial pedagogical funding application. One or two small awards from these local sources will allow you to build up your track record of publications and funding in a new research area and so put you in a much stronger position to compete for larger national or international funds.

Having said start small and local it is worth being aware of the current funding calls from research councils, the Higher Education Academy, the European Union and charitable organisations. These will give you an overview of the research topics which are currently in fashion and may also prompt ideas for your own proposals. Funding organisations such as ESRC and the Higher Education Academy have email distribution lists which you can join to receive updates on new funding calls as they are published. This saves you having to remember to regularly check their websites and you are alerted to new opportunities at the earliest opportunity. Time frames for submitting proposals are often short so an extra week or two's notice can make a difference to your application. There are several websites which are dedicated to bringing the numerous funding opportunities together into one place (see for example http://www.researchprofessional and http://www.researchresearch.com). These sites can be useful and again save time.

Some bodies have open calls where the review committee meets 3 or 4 times a year and there is no specific deadline for applications. This has advantages in that it allows time to develop a solid proposal and submit it when you are ready. But without a deadline either the submission is delayed unnecessarily or worse is never finished by the applicant (you?).

As gaining research funding becomes increasing competitive it pays to try to stay one step ahead of the game in terms of awareness of the opportunities out there. Insider knowledge about the forthcoming calls before they are published and/or the thoughts of the panel who have put out the call about what type of proposals they are keen to receive can be very useful. Contacts in the right places are needed for this. If you are not lucky enough to have these then it can be worthwhile telephoning the organisation you are thinking about applying to for funding and seeing if there is any further information you can glean from them about what type of proposals they are interested in supporting.

Some organisations, including research councils, publish priority areas for funding over next few years. Although these lack the specificity to develop a full proposal around they are worth noting and bearing in mind while developing your own ideas. If you have a general research idea which can be tweaked to fit several different calls as they are published you will be better prepared to apply and save yourself time.

Developing your proposal

We assume that most readers who have read this far through the book will have one or more initial ideas for pedagogical research in engineering. It can be very useful to discuss these ideas with a few colleagues and perhaps also practising engineers at an early stage of the application process. If these people have varying expertise it is likely that you will get a range of reactions to your idea and so hopefully food for thought in terms of how to develop and enhance your research application. A note of caution here though is to make sure that you can trust the people you talk to. It should not happen, but it is not unknown, that someone who has been consulted for advice about a proposal goes away and incorporates the idea into their own research. If this person has a better track record than you then they may end up with funding for what was initially your idea.

Most proposals are submitted by a group of collaborators rather than an individual. We would advocate this approach but suggest it is important to make sure that you choose people who you work well with. The application process can be demanding so it is preferable not to add stress to it through personality clashes or missed deadlines. Do think about the strengths and expertise of each collaborator on the bid and the role that they could take in writing the proposal and/or running the project.

Once you have a draft proposal it is a good idea to ask others to read it and give you constructive feedback. You cannot be sure who will review your application and what their expertise will be so it is useful to ask one or two people out of your immediate discipline to read your draft proposal as well as someone who is familiar with the subject area. The same note of caution as above applies in relation to keeping this feedback process to those you trust.

The project budget is an aspect of proposals which should be kept in mind throughout the proposal development phase. A ball park figure of the required budget is necessary in order to identify a suitable funding call. Or, less ideally but as sometimes happens, the proposal methodology is developed to be practical to carry out within the maximum budget available in your chosen funding call. Do check if funding is limited to one per institution or there is an upper limit of funding available, although some calls, particularly from larger funding organisations, do not state an upper limit for funding. It can also be helpful, particularly where no upper limit for funding is stated, to look at projects which have previously been funded by the organisation you are targeting to get a rough idea the scale of projects they fund. Perhaps the most important point to keep in mind is to strike a balance between asking for so much that your proposal seems poor value for money and asking for unrealistically little. Value for money is often emphasised in the guidance given by funding organisations for writing a successful proposal.

Difficulties and realities you may face
The proportion of research proposals which are successful relative to the number submitted to funding bodies is low. It is sometimes quoted that about 1 in 7 applications are successful. Some of the larger bodies provide statistics on the proportion of successful applications for a particular fund. Given these figures try not to be too disheartened if your proposal is rejected. Take on board feedback where it is offered, although it is not unusual for this to be fairly limited. Recycle your ideas and resubmit the proposal to further calls.

Be aware of the procedures within your institution for signing off a bid to an external funding body, for example there may be a number of signatures required from senior members of staff and submitting a bid from multiple institutions may cause unexpected administrative complications. So build in time to meet your institution's internal requirements when thinking about the deadline you are working to for the external funding call.

Increasing your chances of success

The success or failure of funding proposals can sometimes seem fairly random, and not necessarily fair. However, there are steps you can take to ensure you have the best chance of impressing the review panel.

Proposals generally have a fairly tight word limit, so use a succinct writing style. Moreover focus primarily on what you are proposing to do and try not to get bogged down in a very detailed review of the existing literature. The methods section is important as it can show the funders that you have thought through the detail of your proposed study and that it is realistic within the budget and timeframe. Mentioning any pilot work that has been carried out and existing relationships with those who will be required to cooperate on the project is also recommended. The section on potential outcomes of your research and the benefits that will result from the findings is used to help the review panel consider the value for money the proposal offers so spend some time thinking about how you can present your proposal in the best light here.

Above all, make sure you address the specific call of the fund provider, match their criteria and answer any questions they ask.

In an ideal world leave yourself plenty of time to write your proposal. Write a first draft, put it to one side for a week or so and then come back to it with fresh eyes, it is likely that you will see plenty of things you want to change. In reality though you're likely to be working to a tight deadline to complete your proposal. In this case asking people who are not very familiar with your idea to read over the proposal and give feedback can be a good alternative.

Funding bodies often look for an established track record of successful grant applications and publications in the area which you are applying to research. As discussed above starting modestly and building up to a larger application is a way of dealing with this requirement. An alternative option if you are more impatient is to persuade someone who already has an established track record to collaborate with you.

Matched funding can also be very attractive to funders. So if you are successful in securing a small (or even large) amount of money from one source it can be worthwhile applying to further funding calls for an extension to the project which has already been funded. Alternatively if you have good networking skills and can ‘pitch’ an idea well you may choose to approach businesses or even your university and make a case for them adding money to the grant you have won. The fact that one organisation has decided to invest in you will make them more likely to choose to invest too.

Finally we suggest: be pragmatic. Weigh up what you would like to research against what funding bodies are interested in supporting at this time and the experience and track record of yourself and your collaborators.

If possible, talk to the fund providers during the process of writing the proposal. But do not expect every fund provider to be helpful.

Activities

15.1 Spend some time looking for potential funding organisations for pedagogical research on the internet (Eng CETL or the Higher Education Academy would be a good place to start). When you have identified one or two possible bodies make a note of any current funding calls. If information about previously funded projects is available write down the titles and amount of funding given to some recent studies.

15.2 If you have the outline of an idea for a research study spend a few minutes thinking who you would like to collaborate with to write a funding proposal for this study and what their complementary strengths are.

Who would be useful people to talk to more generally to develop your idea?

Further reading

There is plenty of advice on how to write research proposals in standard texts on educational and psychological research but little on writing for funding.

A web document that gives down to earth advice is:
http://research.microsoft.com/en-us/um/people/simonpj/papers/proposal.html

The McMaster website:
http://www.mcmaster.ca/ors/guide/successful_proposal.htm
provides a useful checklist of the constituents of a successful research proposal.

Unit 16
Getting your research published

Introduction

Most readers of this book will already have presented papers at engineering conferences and, perhaps, published in engineering journals. So this unit focuses primarily upon getting pedagogical research published: although many of the suggestions are also relevant to publishing research in engineering, science and social science.

Figure 16.1 provides a visual representation of the two processes of:

- Writing to clarify your thinking;
- Writing to communicate your research to others.

As Figure 16.1 shows as one moves towards writing the final version, writing to communicate to others takes precedence over writing to clarify one's thinking. But it should also be noted that even in the early stages of writing one needs to consider writing to communicate with others and in the final stage there still may be some clarification of thinking required. The general direction is from clarification to communication but the process is not linear. One may oscillate between the two processes. This observation should not be surprising: thinking, particularly creative thinking, is a non-linear process whereas writing is a linear process. Many of the difficulties in writing may be attributed to the task of transforming non-linear processes of thinking into linear prose.

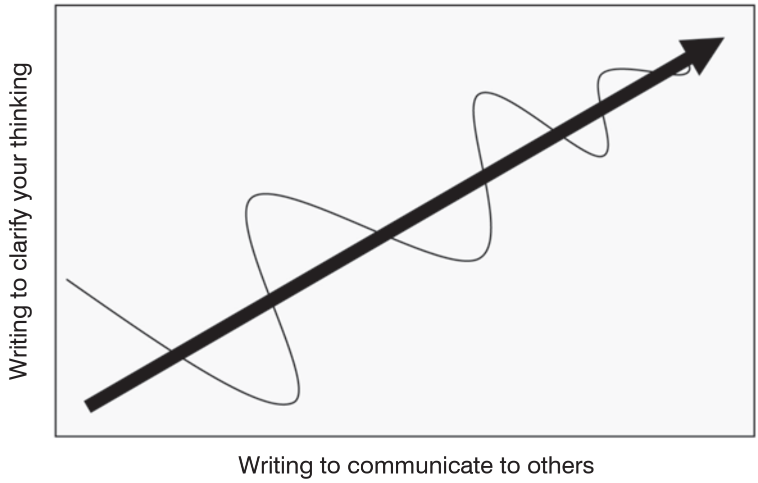


Figure 16.1. Processes of writing

Writing to clarify your thinking

This form of writing springs out of the reading and practical research you have been doing. Initially, it may be tiny fragments or single thoughts or a collection of thoughts that have coalesced. At this stage it is useful to think about *who* you are writing for. Thinking about your potential audience will help you to start clarifying the structure and content of what you want to write. From these beginnings you can start to put down your thoughts and then redraft them. But, as you may have discovered, sometimes the opening paragraph just will not emerge. We will be looking at ways of writing an introduction later in the Unit (See Writing to communicate your research).

For the moment let us look at ways in which PhD students clarified their thinking when writing their theses. This information may help you to reflect on how you clarify your thinking when writing (See Activity 16.1). The PhD students with whom we have discussed this topic in workshops seemed to use one of four strategies when they *initially* started to write. At one extreme were those who used the strategy of ‘free association’: they wrote whatever came into their heads whether relevant or not and then redrafted and redrafted and redrafted. At the other extreme were those who tried to write very tiny sections, group them and put them in order, reorder and regroup them and so on. Neither of these extremes worked well for them so they adopted one of two strategies which were used by the majority of the PhD students. The first of these consisted of scribbling a few major headings and brief notes or bullet points under each heading, putting the writing on one side to allow the unconscious to work on it, and then writing sections of the first draft. Others developed a series of headings and subheadings and sub-subheadings, played with the order and then wrote a few sentences for the sub-sub headings and built up the paper gradually. Whether one uses these holistic or serialistic strategies of writing is probably dependent on one's learning preferences.

Whichever approach you use, the process of writing can prompt clarification of thoughts and trigger connections hitherto unseen. But the process can go wrong – digressions can creep in and take you in a direction you do not want to go. If this occurs then try *saying aloud* what you want to write and if that does not work, take notes on your own writing: rather like thematic analysis (See Box 5.4). By getting a clear picture of *what you have said*, you can often realise more sharply what it was that *you meant to say* and where the argument started to skew. Then you can go back and rebuild your text with a stronger grasp of what you are trying to write.

Drafting and editing

You can then begin to redraft and edit your text. Expect to do at least three drafts, more if the research is complex. Often one initially writes too much and in a style closer to speech than academic writing. So the first task is to cross out redundant words and redraft sentences. At this stage you should also check grammatical constructions and spelling. Box 16.1 lists the common errors. Again you need to think of your audience. If you are preparing notes for a presentation at a conference then write your notes as speech, not prose. The rhythm and vocabulary of speech is different from the style of prose. If you are writing a paper, then use a more academic style which matches the style of the conference proceedings or the journal you are writing for (See Activity 16.2).

Once you have corrected the obvious errors you can then move to the more difficult task of making sure there are connections in the text so it flows smoothly from one paragraph to the next and one section to the next. These connections are sentences at the end of a paragraph or section or at the beginning of the following paragraph or section. Whilst you are doing this task you might also check whether there are contradictions or inconsistencies in the paragraphs and sections. When these tasks have been completed then check the content of the paper matches the title of the paper. If it does not: change the title of the paper or rewrite the paper (see Activity 16.3).

Box 16.1. Common errors in writing

The following characteristics are generally regarded as common errors in writing. There are also differences in genres of writing. Bullet points and the numbering of sections may be acceptable in a paper in engineering but not usually in a paper in an educational journal. So check the style of the publication you are writing for, its layout and method of referencing.

- Incomplete sentences.
- Mixture and confusion of plurals and singulars.
- Incorrect spelling.
- Absence of commas and other punctuation marks.
- Overuse of pronouns so the reader has difficulty in deciding which previous noun the pronoun refers to.
- Unduly long sentences.
- Too many short sentences.
- Unduly long paragraphs.
- Too many short paragraphs.
- Not stating the meaning of an acronym the first time you use it.

At this stage of editing you might use constructive self-talk (See Unit 7). Box 16.2 suggests questions you might ask yourself when reading aloud your draft paper.

Box 16.2. Constructive self-talk for editing

- Why am I writing this paragraph?
- Why is this important?
- Will they know why?
- Am I going into too much detail?
- Could I be more concise?
- Will this bit be understood?
- Is this true?
- Could this be said more directly?
- Why is this sentence so long?
- What is the main point in this paragraph? Where is it?
- Should this sentence be the other way round?
- Should I change the order?
- What is the structure? Will the reader know?
- What's the title of my paper? Is it still correct?
- Can I cross words out without losing meaning?
- Have I wandered off into asides?

Like many hints in this book, the above are easy to understand: the important point is to put them into practice.

Finally, it is easy to lose track of which drafts you have edited. So do date each draft and put old drafts in a separate folder.

Writing to communicate your research to others

In this section we consider the structure of research articles or conference papers whether based on quantitative, qualitative or mixed methods of research. We offer suggestions on the sections in the order they appear in the finished article or paper. This order is not necessarily the order in which you might write them. In writing sections do ensure they link well together and with the title of the paper.

Writing the abstract

Use the standard format for abstracts provided by the editors of the journal or organisers of conferences. If they do not provide one then you could use the following structure:

1. Brief background information
2. Indication of aim and nature of study
3. Indication of method
4. Results and brief explanation or discussion
5. Conclusions

Allocate about a couple of sentences for each point.

Some people use subheadings such as Background:, Aim:, etc and others prefer to write in continuous prose. If you are reporting qualitative research you should indicate briefly in 3 why you chose the method and in 4 what themes emerged and how they are related to your chosen theoretical perspective: if you have one.

Some people write the abstract first and use it as the structure of the article. This approach works better for reporting quantitative or mixed methods than for qualitative research but it can go awry.

Writing the introduction

As you proceed towards the final version of your paper, it is often necessary to rewrite the introduction so it matches the content of your paper and is appropriate for your audience. Our advice is '*Write a dummy introduction to get you started then write the real introduction when you have finished the paper*.'

There are four basic moves one should make in an introduction to a paper whether it is a presentation or an article based on quantitative, qualitative or mixed methods pedagogical research. These are:

1. Introduce the broad subject area briefly.
2. Describe briefly previous work in the field.
3. Establish the links between previous work and your research.
4. Introduce your research, the method and include the research problem, hypotheses or questions.

In 3, you can point to the gap in the literature your research is attempting to fill and, if you are reporting qualitative research, provide a brief reference to theory (but see The review section below). In 4, a brief justification of the method should be included in a report of qualitative research but it is usually not necessary in quantitative research. Reports of qualitative research do not state research hypotheses but usually do state succinctly the research problem being addressed. If you are reporting mixed methods research then ensure you also report briefly the two strands of the study and show how they are related. If you are doing a presentation then four Powerpoint slides should be sufficient as an introduction. Some presenters also use an initial slide which summarises the whole presentation. If you use Powerpoint slides then ensure the font sizes, colour and number of words or diagrams are clearly visible, attractive and are not likely to induce information overload (See also the 'Visual representations of data' section in Unit 11).

The review

The review should be closely related to the design and findings of the research and the links between the subsections of the review and the research problem made explicit.

In quantitative research there is sometimes a separate review section which summarises the key research relevant to the present article but does not go into fine detail as one might in the literature review of a PhD thesis. In qualitative research, this section includes an explication of the relevant theoretical perspectives. But not all qualitative research reports contain a separate review section. Instead, an indication of the literature of relevant findings and theories is included in the introduction and the review is interwoven with the discussion of themes which emerge from the data. This approach can be challenging to write so before using this approach, analyse some articles which use it. If you use a mixed methods approach do cite, if it is available, relevant quantitative and qualitative research. For presentations on slides (Powerpoint), one should only provide a few references to the key relevant texts, cite a few relevant statistics or a few pertinent quotations from texts. Some common errors in reviews are described in Box 16.3. These errors can lead to rejection of your manuscript by editors or referees.

Box 16.3. Common errors in review sections

The litany
Uncritical lengthy recitation of the relevant and marginally relevant research literature, usually in historical order.

The hobby horse
Reports only evidence that supports the view and/or dismisses other evidence.

The non-critical
Provides a structured review but never comments on or criticises conclusions or findings.

The non-discriminate
Reports blogs, opinions, newspaper articles, government documents, other official documents, research reports and articles in prestigious journals, as if they all have the same status. The review seems to be based on the assumption that if it has been written, it must be true. …..If only that was the case!

Methods

Essentially this section is a report of what you actually did. Whatever approach to research you used, include brief accounts of the following:

- Any pilots or development of materials such as questionnaires or interview schedules
- Choice of participants (sample)
- Briefing of participants (instructions, reassurances and information given: see Unit 13)
- Data collection and analyses used (methods of statistical analyses, coding, thematic analysis etc.)
- Unforeseen difficulties or ethical dilemmas

In qualitative research papers, sometimes there is a separate section on methodology which justifies the choice of method. In quantitative based research papers there is usually only a brief reference to the underlying choice of method. In mixed methods research papers it is prudent to stat the reason for using mixed methods. Also in mixed methods research try to obtain realistic but sizeable data sets for the qualitative and quantitative aspects of the study and report these.

Results

In quantitative research this section contains the profile of the sample of participants investigated, the statistical results relevant to the testing of the hypotheses and any limitations of the statistical analysis. In qualitative research the section is sometimes labelled ‘Analysis’ and the section is much more discursive. The section usually begins with a brief account of the different levels of coding used and how these led to the identification of the main themes. These themes may be merely listed. If there are connections between the themes, these connections can be shown in a diagram or mind map. Examples of quotations or excerpts from observational data should be used to illustrate the themes. Cite the transcript and line number for quotations and date, time and location for reported observations. In the mixed methods approach some researchers report the frequency of themes mentioned by participants. For presentations only show on slides a few key findings and, if appropriate quotations. You can always report more findings if there is a discussion session after the presentation. You can also have a storehouse of relevant but not central information available via live links or action buttons on your laptop.

As a rule of thumb, comments in the results/analysis section should stay close to the data. But you may find you have slipped into discussing rather than reporting the findings. If you do find you are writing a discussion of the interpretation or meaning of the results: stop writing the section on results/analysis, start writing the discussion section, then go back to writing the results/analysis section.

Discussion

In articles based on quantitative research the discussion usually focuses upon interpreting the results, and linking them to the research hypotheses and to the research cited in the review. The discussion usually includes some cautionary note about the limitations in methods, analyses and generalisability and it may offer suggestions for further research. In qualitative research the discussion may not be separate from the ‘Analysis’ section but an extension of it. Look at the journals in which you are hoping to publish and then consider whether you prefer to use an extension or a separate section. Whatever your preference, link clearly the discussion to the research problem and theory you outlined in your introduction and, if possible, how your findings have contributed to an understanding of the issues involved, despite their limitations. This section sometimes contains reminders that other researchers may interpret the data differently and use different theoretical perspectives. In an extended discussion you might wish to argue that your approach is better. In mixed methods research, make sure the discussion links closely the two parts of the study through comparing, contrasting and drawing conclusions from both aspects of the study. In presentations at conferences, cite only a few discussion points on your slides but be prepared to respond to questions about your methods, findings and their limitations. You might also prepare yourself for questioners more interested in being noticed than in discussing your findings.

Conclusion

The conclusion is not necessarily a separate section but you should have a paragraph which summarises the extent to which the research hypotheses were confirmed or your answer to the research questions posed in the introduction

Obstacles to writing

The major obstacle to writing papers is oneself followed closely by one's department. Avoidance tactics, writer's block and poor time management delay writing. Demands of one's department, particularly unanticipated demands, can delay one even more.

There are three sets of avoidance tactics. Personal distractors such as 'I must ring my mother. I might as well ring my sister as well.' or 'I really must tidy my desktop/filing cabinet/room'. Departmental distractors such as 'I must mark these assignments' or I must go to this meeting' and research distractors such as "I must read more' or 'I must spend more time on the design before I begin'. All of these distractors may initially be necessary activities but can easily become ways of avoiding writing.

Writer's block is rather more pernicious. Some experts suggest that to minimise the risk of writer's block, one should stop a session of writing in mid-sentence. If writer's block does occur, one can try talking aloud; explaining what you are trying to say to someone else; putting the writing to one side and doing something completely different or writing another section of the article.

Poor time management is often due to optimistic estimates of the time required to do academic tasks such as preparing a lecture, marking scripts, writing reports or applications to committees, negotiating to collect data, analysing data and, of course, writing. If you can, allot and jealously guard time for doing and writing up research. Box 16.4 offers some suggestions for improving time management.

Box 16.4. Managing time for writing

- Give yourself time to think and write in half day or evening blocks.
- Plan what you are going to do **before the block of time**.
- Ask yourself what you can do in a spare hour. Plan it and do it.
- Do mechanical tasks when you are ‘brain dead’.
- Do appendices and references as you write each section.
- Write notes and drafts as you go - keep your eye on the title and your time.
- Put old drafts in a separate folder.
- If you have thoughts about a section which you are not currently writing, note them and put in a folder.
- Keep a check on how long it is taking you to do various tasks so you can estimate realistically what time you need.
- Put other work out of sight so it does not distract you.
- Keep all the data, research papers etc in a box and/or on your computer.

Some general hints on writing

Box 16.5. Summary of some general hints on writing made by colleagues

1. Choose a working title for your paper/article. It will give you a focus.
2. Decide on the actual title when you have finished the paper.
3. If you are writing an article for a journal then use the journal’s style.
4. Draw up a framework before writing - and be prepared to change it.
5. Use ‘Endnote’ or a similar package for referencing.
6. From the start: do the references in the format of the journal/proceedings.
7. Write an introduction for you and then another at the end for your audience.
8. Write the methods section first.
9. Don’t write the final version of the review until you have written up the results section
10. Don’t overstate your case.
11. Start writing early - don’t leave it all to the end.
12. Write down your ideas when you think of them. You can arrange them in order later.
13. Keep writing.
14. Get a friend to read your paper.
15. At conferences, adapt your style of presentation to your audience.
16. An article isn’t finished until it is in print.

Getting published

The final hurdle in research is getting it published. The halcyon days of doing research just to satisfy one's curiosity have long gone, and perhaps never existed.

The first step is to get to know the range of conferences and journals available. Read carefully the notes of guidance and analyse the style and content of recent papers or articles to check how well they match. Some claims in the notes of guidance seem unfulfilled in practice. The notes may indicate that reports of qualitative research are welcomed but the journal does not contain any.

There are only a few conferences and journals which specialise in engineering pedagogy so if your research has relevance to other disciplines then consider submitting papers and articles to generic pedagogical conferences or journals. Box 16.6 lists journals which publish engineering pedagogical research. Box 16.7 lists a sample of the journals which publish generic pedagogical articles. Further details are available on the website (www.engsc.ac.uk/).

A safe strategy is to start publishing by presenting papers at conferences. This approach has the advantage of enabling you to meet other researchers and perhaps members of editorial boards. Alternatively, submit your article to a journal with a relatively modest reputation. A higher risk strategy is to submit your article to a prestigious journal. If you do, be sure your article is well written, fits the conventions of the journal and its database is robust. Some prestigious journals only accept articles based on research which has not been published elsewhere. So check with the editors if this proviso includes reports to funding bodies or which have had a limited circulation.

Almost all articles and conference papers nowadays will be commented upon by referees, who remain anonymous. Some editors send you the full comments of the referees; other editors just provide a summary and their decisions.

Box 16.6. Journals which publish engineering pedagogy

Australasian Journal of Engineering Education (online)
http://www.aaee.com.au/journal/index.htm

Computer applications in Engineering Education (CAEE)
http://www.interscience.wiley.com/jpages/1061-3773/

Connections (e-newsletter)
http://www.asee.org/about/publications/connections/index.cfm

DISTILATE (dissemination, Innovation, Scholarship and Transformation in Teaching, Learning and Assessment (online journal)
http://caseeconduit.org/zcstore/index.php?main_page=index&cPath=6_11

Education for Chemica; Engineers
http://cms.icheme.org/mainwebsite/general-bar7ddc91997e4763f.aspx?map=3c5fc51347648ea242939429f89d8727

Engineering Education – Journal of the Higher Education Acdemy engineering Subject Centre
http://www.engsc.ac.uk/journal/index.php/ee

Engineering Studies – Journal of the International Network forEngineering Studies
http://www.tandf.co.uk/journals/engineeringstudies

European Journal of Engineering Education
http://www.tandf.co.uk/journals/titles/03043797.asp

Global Journal of Engineering Education
http://digitalcommons.uri.edu/ojgee/

International Journal of Continuing Engineering Education and Lifelong Learning (IJCELL)
https://www.inderscience.com/browse/index.php?journalID=6

International Journal of Engineering Education (IJEE)
http://www.ijee.dit.ie/

IEEE Transactions on Education
http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?puNumber=13

Journal of Engineering Education (JEE)
http://www.asee.org/about/publications/jee/index.cfm

Journal of Professional Issues in Engineering Education and Practice (JPIEEP)
http://pubs.asce.org/journals/professionalissues/

Prism online
http://www.asee.org/prism/

World transactions on Engineering and Technology Education (WTE&TE)
http://www.wiete.com.au/Journals/WTE&TE/call for articles.html

Box 16.7. Journals which publish pedagogy

Active Learning in Higher Education
http://alh.sagepub.com/

Assessment and Evaluation in Higher Education
http://www.tandf.co.uk/journals/carfax/02602938.html

Association for Learning Technology Journal (ALT-J)
http://www.alt.ac.uk/alt_j.html

British Journal of Educational Technology
http://www.blackwellpublishing.com/journal.asp?ref=0007-1013&site=1

British Journal of Higher Education in Further Education (BJHinFE)
http://www.bjheinfe.org/

Computers in Education
http://www.sciencedirect.com/science/journal/03601315

Innovations in Education and Teaching International
http://www.tandf.co.uk/journals/routledge/14703297.html

Journal of Computer Assisted Learning
http://www.blackwellpublishing.com/jca

Journal of Further and Higher Education
www.tandf.co.uk/journals/titles/0309877X.asp

Journal of Technology Education
http://scholar.lib.vt.edu/ejournals/JTE

Learning and Teaching in Higher Education (LATHE)
http://www.glos.ac.uk/vision/teachinglearning/Pages/lathe.aspx

Practice and Evidence of the Scholarship of Teaching and Learning in Higher Education (PESTLHE)
http://www.pestlhe.org.uk/index.php/pestlhe

Studies in Higher Education
http://www.tandf.co.uk/journals/carfax/03075079.html

Teaching in Higher Education
www.tandf.co.uk/journals/titles/13562517.asp

Some referees seem to relish rejecting papers: not always for good reasons. (If you think all referees are 'objective': think again.) Other referees are balanced in their judgements and sometimes encouraging. But it is rare for an article to be accepted without some amendments recommended by referees so allocate time for amending and rewriting sections of your article. If your article is rejected, don't be disheartened. If you think it is worth publishing then reshape it for a different journal. The information in Box 16.8 is worth consideration when checking or revising an article.

Box 16.8. Why editors reject articles or request rewrites

1. The title does not correspond to the content of the article.
2. Some sections or the article itself are too long.
3. The article does not conform to the conventions of the journal.
4. The references do not conform to the conventions of the journal.
5. The abstract is too long or uninformative or both.
6. The research question is not clearly stated
7. The research is not related to earlier research.
8. The research findings are not set in the context of earlier research.
9. The structure of the paper is unclear.
10. The method, data collection and data analyses are unclear or weak.
11. The defence of the method, data analyses or findings is weak.
12. Unsound conclusions or generalisations.
13. The article is too descriptive.
14. Ethical approval and issues are not mentioned.

In qualitative research:

15. The choice of theoretical perspective, if used, is not defended.
16. The data analyses are not related clearly to the theoretical perspective.

In mixed methods research:

17. The findings from the quantitative and qualitative analyses are not integrated.

Take heed of these and you are well on the way to writing a publishable article.

This information is based on experience of editing and refereeing by one of the authors and discussions with other editors.

Qualitative research is still relatively new in engineering pedagogy and some referees do not understand it or are hostile to it. Mixed methods and quantitative research are more likely to be considered favourably. But if you have completed a good piece of qualitative research then it is worth asking an editor if he/she would be willing to consider your article for publication. You might even suggest the names of well respected referees who are familiar with qualitative research. But, of course, there is no guarantee that an editor would take up your suggestions.

Finally, it is worth noting that the similarities between a good article, whether quantitative, qualitative or mixed methods, are greater than the differences.

Activities

16.1 Think about, or preferably, discuss with colleagues approaches to writing papers for conferences and articles for journals.

16.2 Compare the following passages. Which would be most appropriate for a journal article?

i) Noel Entwistle (1987) studied students' styles of learning using an inventory that was developed at Lancaster and in Edinburgh. The inventory is well designed and it has been used in several studies. It is based upon several earlier qualitative investigations conducted by Ferenc Marton and his co-workers at Gotenburg, Sweden (Marton et al 1976) of student's approaches to learning. The inventory has been used by several research workers to explore and demonstrate various relationships between styles of learning and teaching , learning, assessment and curriculum design.

ii) Qualitative studies by Marton et al (1976) led Entwistle (1987) to develop a factor-analytic based inventory for identifying approaches to learning. The two predominant approaches are described as deep and surface learning. Deep learners use study and revision methods based primarily on the search for understanding and meaning whereas surface learners tend to learn by rote. Deep learners value and are more successful in departments where assessment tasks are concerned with understanding, there is some choice of assessment and a reasonable work load. (Entwistle and Ramsden, 1993)

16.3 These little exercises are designed to raise your awareness of the importance of sentence construction and links between paragraphs in a research article.

a) What is wrong with second and third sentences in this paragraph?
In recent years there has been growing concern about non-life threatening injuries and permanently disabling injuries in automobile accidents. The reductions in serious and fatal injuries of the head, chest and abdomen by greater seat belt use, improved occupant restraint with air bags and other crash-worthiness countermeasures are the cause of concern. Foot ankle injuries have increased in importance. By controlling both intrusion into the foot-area and the acceleration of the lower leg, the protection of lower extremities in car crashes is now being paid more attention.

b) Edit this paragraph by cutting out redundant words and altering the sentences:
A group of men rendered signal service in diffusion of knowledge of physics were the scientific instrument makers. It goes without saying that without them research in science would have been slowed down: scientific instruments are indispensable allies in scientific discovery. It was only after the discovery of the microscope that such sciences as histology and microbiology could begin. It was only after apparatus for the creation of high vacua had been perfected that the study of electrical discharges in rarefied gases became possible. It was only with the invention of the cloud chamber, which made visible the track of a charged particle, that subatomic physics could make another leap forward.

c) Rewrite the following sentences and write a sentence which links the two paragraphs:

True/False Questions (T/F)

In these types of questions, the respondent is asked to tick or circle the correct answer, whether true of false. Thus it is a type of multiple choice question. (End of paragraph)
(Beginning of next paragraph) The major criticism is its tendency to encourage basic rote learning.

16.4 What are the issues underlying co-authorship of articles?

Further reading

Writing up research
The website, http://www.writing.engr.psu.edu/, provides general advice on writing in engineering.

Beer (2005) provides general guidance on writing for engineers.

Murray (2006) and Murray and Moore (2006) provide detailed advice on writing dissertations and articles.

http://www.psy.dmu.ac.uk/michael/qual_writing.htm, (accessed 27 April 2010) contains useful, succinct advice on writing up qualitative research

Stenius *et al*, although concerned with addiction studies, offers useful, extended advice on writing for qualitative journals.

Cresswell and Plano Clark (2006) and the article by Cresswell and Tashakkori (2007) offer sound advice on writing up mixed methods research.

Research on writing

Torrance and Thomas (1994) reports their research into how PhD students write their theses.

Caffarella and Barnett (2000) reports their qualitative research into the value for doctoral students of giving and receiving critiques.

Both these articles provide insights into the processes of writing up research.

Unit 17
Overview

The aim of this book was to introduce pedagogical research methods to those who teach engineering. The study of pedagogy is useful to help understand the needs of students and what makes a good engineering course. Both of these change over time thus making pedagogical research as relevant today as it ever has been and a constantly evolving field of study. **Section A** explored these ideas further.

Both qualitative and quantitative methods are appropriate to answer questions in engineering pedagogy. We focussed initially on qualitative methods as these are likely to be new to many engineers, we then discussed the quantitative methods which are commonly used in pedagogical research. We emphasise that neither approach is superior over the other. Rather the methodology chosen for a particular study should be appropriate to answer the question posed. In many cases using a combination of quantitative and qualitative methods will be the best way to answer a question fully.

Section B focussed on qualitative research and first discussed the core skills of questioning and listening. We hope that by doing so we allowed readers to identify with qualitative research as these are skills which everyone will be familiar with. There are differences when these skills are used for research compared to their use in everyday life. In the research context it is necessary to attend to the subtleties of questioning and listening.

There are different types of question; open ones are the most useful in qualitative research as they facilitate the participant to talk. Closed questions and checklists are most useful in quantitative research. Plan questions in advance of asking them and think about their order, start with questions which are easy to answer and move on to more challenging ones. Listening should be active. This means cognitively processing what we hear and listening is different from merely hearing. Listening allows the speakers to feel understood and will encourage them to tell the listener relevant information. Listening can be done on several levels from surface to very deep. There are also different types of listener: people oriented; task orientated; time oriented; and analytically oriented. Ideally a good interviewer has a balance of all four.

Interviews and focus groups are common methods used to collect qualitative data. Both require good questioning and listening skills. A number of suggestions were made for running effective interviews and focus groups in Unit 5, we also pointed out common pitfalls. As suggested in several of the activities in **Section B**, there is no substitute for practising one's interviewing technique. Recording these practice sessions, listening back to them and reflecting on strengths and weaknesses will lead to further improvements in skills. The analysis of qualitative data is challenging and time consuming. We suggest those new to qualitative research use the most straightforward method of analysis: thematic analysis.

Observation is another important qualitative method of data collection. We observe the world all the time but as discussed in Unit 6 how we interpret these observations is influenced by our own mood states, preconceptions about the person observed and knowledge about the topic being observed. Being aware of these influences should allow one to observe more deeply and see things that would otherwise be missed. Observation can be done overtly or covertly: both methods have strengths and weaknesses.

Alternative methods of qualitative research were discussed in Unit 7. These included mind maps, self-talk, narratives, studying leaderless groups and documentary analysis. Some readers more familiar with quantitative research methods may feel rather uncomfortable considering these as *research* methods. But all do provide useful alternative ways of investigating complex problems such as those involved in the study of pedagogy.

In **Section C** we discussed quantitative research methods used in pedagogical research. The predominant method used is questionnaires containing closed questions. Such questionnaires appear simple to create and use at first but as explained in Unit 8 there are considerations around questionnaire design, formatting and coding questions, and sampling which must be addressed in order to make the data from questionnaire based studies meaningful. As well as assessing facts, opinions and behaviours, questionnaires are also used to assess learning styles, personality, attitudes and cognitive ability. A number of validated questionnaires to assess these latter factors exist and some of the most relevant to pedagogical research were described in Unit 9. We recommend using a previously validated questionnaire where a suitable one is available.

Quantitative observation was considered in Unit 10. This is a useful way of categorising behaviour. Observations can be global or very detailed and specific. For example one can observe the behaviour of a lecturer over a semester and make summary ratings of his or her behaviour, alternatively observations of the interaction between a tutor and students during a seminar can be recorded every few seconds. Some validated observation tools exist but it may be necessary to adapt these or develop one's own to answer the particular research question at hand.

As indicated in Unit 11, Quantitative analysis in pedagogy uses visual representation, descriptive and inferential statistics. An important point to keep in mind with these analyses in pedagogical research is that the data are generally derived by mapping opinions, attitudes or judgements onto numbers. It is easy to become very enthused by statistical results but be sure that the mapping process was robust first. Despite this note of caution, inferential statistics are a powerful and frequently used tool in pedagogical research. They can be used to look for both differences and relationships between two or more sets of data. Experimental design in pedagogy varies from tightly controlled randomised controlled trials to quasi-experimental or naturalistic designs. In practice it is very difficult to control all extraneous variables when working with people and so quasi-experimental study designs are common.

In **Section D**, Unit 12, three broad approaches to reliability and validity were discussed: psychometric, sociological and qualitative. These were framed within the context of ontology (the study of existence) and epistemology (the study of different types of knowledge) to explain the variation in approach. No one approach is better, or more correct, than the other rather they represent different ways of seeing the world.

The similarities and differences between quantitative and qualitative research methods were summarised in **Section D**, Unit 13. Then Units 14-16 provided a refresher on ethics and ethical committees, writing research proposals and writing for publication. We expect that readers have experience of these areas in relation to engineering research and so provided an overview of each with hints and tips for applying existing knowledge to pedagogical research.

Ethics committees play an important role in protecting participants from harm as a result of their participation in research. From a researcher's point of view, these committees also provide protection from litigation by participants against the researcher. Given our current 'blame culture' and the increased tendency for people to resort to legal action to resolve grievances, gaining ethical approval prior to beginning a research study is strongly recommended.

The process of applying for grants is challenging and often leads to disappointment given that the number of applications submitted far outweighs the number of grants available. If one is starting out in pedagogical research it is wise to apply for modest sums from local sources. Larger funding organisations tend to look for work in partnership with other more experienced researchers or a successful track record of research in the area which your proposal relates to. So you need to build up this evidence over time. Writing for publication can also be a challenging process and many of us spend time focussing on the obstacles and barriers rather than on the business of actually writing. The process of writing a qualitative article is quite different from the perhaps more familiar process of writing a quantitative one in terms of style and content.

In conclusion, in this book we have piloted you through the process of doing pedagogical research from the modest beginnings of asking open questions in qualitative research to the tasks of writing research papers and articles.

We wish you well as you continue your journey in this important and challenging field of pedagogical research in engineering.

Notes on activities

Unit 1

Activity 1.1: 'Participants' has connotations of active engagement in the research. Participants can influence the research by sharing with the researcher what they think and do. 'Respondents' has connotations of complying with the requests of the researcher so we occasionally use this term in discussing questionnaires. 'Clients' implies a power relationship. 'Subjects' and 'objects' seem remote.

Unit 2

Activity 2.1: The consensus in some workshops on pedagogy in engineering was that one needs to test out ideas through one's experience and one is more likely to believe the craft knowledge of experienced engineering teachers than what educational researchers report. This is in line with Kolb's theory discussed in Unit 10. The evidence base of detailed references was considered important but not as important as the craft knowledge of pedagogy in engineering.

Activity 2.2: This a rather half-baked definition. Original research begs the question of what is original. If the research is so original that it is unique it may not fit the canons of acceptable good research. The second statement includes the phrase 'theoretical and/or conceptual understanding' which sounds good but what is the difference between theoretical and conceptual understanding? Reference to empirical findings is missing. The full report is rather coy about its position on quantitative and qualitative research, developmental research, action research or large scale evaluation.

Activity 2.3: The arguments for and against doing pedagogical research may be classified under the broad headings of personal interests, career development and the development of the profession and of education for the profession. It could be argued that every engineering teacher should also be a researcher of his or her own teaching, the courses provided, and the development of his or her students and of ways of assessing them.

Activity 2.4: This activity is designed to get you thinking broadly about a topic. There are several issues arising from the use of learning outcomes. Here are a few examples: What are the origins of the current vogue for learning outcomes? What is the relationship between learning outcomes, intended learning outcomes, learning objectives, and behavioural objectives? Should learning outcomes always be recited at the beginning of a text? Should they always be imposed by the authors? How do students use learning outcomes? How do lecturers develop learning outcomes for their students? Are learning outcomes a disguised form of social control and accountability? Are they merely an outcrop of behaviourism? Are they always useful?

Unit 3

Activity 3.1: This activity will provide you with some useful feedback on your technique of asking open questions which will stand you in good stead when doing any form of qualitative research. You may be surprised at the frequency of ums, ers and hesitations of participants (and you). Participants often use an open question as a springboard for their views rather than provide a direct answer to the question. You have to make a judgement on how much digression to allow and how best to return to the main aspects of the topic.

Activity 3.2: This activity is challenging but worthwhile. If you can't think of a task then look at the work reported or done by Laurillard (2002), You may be surprised that students seem capable of doing calculations but do not understand the core principles of what they are doing. Without understanding, it is difficult to transfer to new notations or solve new problems.

Unit 4

Activity 4.1: One could produce a detailed account of the reported effects of contexts and personal relationships on levels and approaches to listening. The important point of the activity is to consider which is your typical approach and level of listening and where necessary change your approach to listening even if this requires deliberate practice. Contrary to popular belief, there is plenty of evidence that one can improve listening through training (Hargie, 2009)

Activity 4.2: This activity will sharpen your listening and observing skills.

Activity 4.3: This activity also sharpens observing and listening skills but your inferences of hidden motives, agendas etc would require more than one observation to test their correctness. The ethical question ‘to eavesdrop’ or ‘not to eavesdrop’ is discussed in Unit 14 on ethics. In the meantime you might ponder on how else one can gain access to private thoughts.

Activity 4.4: Careful observations of video-recordings can help you to develop your own approach to talking and listening. Consider how both verbal and non-verbal cues are used to indicate turn taking and interest in the conversation. You may gain even more insights if you watch and discuss the video with the participants.

Activity 4.5: This activity will help you to improve your telephone manner as well as specifically improving your telephone interview technique.

Unit 5

Activity 5.1: Don’t read this until you have read your own responses.
This activity has been used in workshops on pedagogical research. The responses of the engineers included for:

‘Science’ - progress, physics, chemistry, theory;
‘Arts’ –books, history, reading, waste of time;
Qualitative – woolly, soft, just words, fiction, not research, anecdotal, trendy;
Quantitative – numbers, hard, true, measurement, only way, truth;
‘Renaissance’ – painting, sculpture, history;
‘God’ –All seeing, Dawkins, guilt, irrelevant, the great engineer.

From more detailed associations, it is possible to construct a group’s sets of meanings and beliefs which can be useful as a profile or for use in designing questions. The engineers did not seem to know that the Renaissance gave impetus to science and literature and to quantitative and qualitative methods. They were more positive about science and quantitative methods than Arts lecturers who favoured qualitative approaches, words and meanings.

P.S. Some of your thoughts were probably not associated with the stimulus word. 'Lunch, things you have forgotten to do, anxieties and private matters' often emerge. These too can be analysed but these provide a different story…..

Activity 5.2: Most lecturers who were about to run focus groups found this exercise useful.

Activity 5.3: We have deliberately not given our analysis of the transcripts. Compare your analyses with those of other's. Some engineers found this activity difficult. Others thought it was a useful exercise for analysing structures in presentations and articles as well as in quality research. Some pointed out that it was 'harder than it looked' and that it would be even harder to analyse a transcript of a focus group. It is. We recommend that you use thematic analysis based on your broad questions in your qualitative investigations. Leave the other forms of analysis to linguistic experts and qualitative psychologists.

Unit 6

Activity 6.1:
Picture 1: This is an ambiguous figure. One initially sees a young woman or an old woman. Some people find seeing the alternative view is difficult.
Picture 2: Some people see a saxophone player and, with difficulty, see the woman's face. Others see the woman's face first.

The implications for qualitative observations are there is more than one view and first impressions may not always be of all there is to see.

Activity 6.2: Mathematicians and some engineers often report seeing a Roman 20. Others report seeing two crosses, a diamond with two half diamonds, a diamond with whiskers, a mirror image of a M or W, two fishes kissing cheek to cheek, or part of sugar tongs just two sets of parallel lines. As you read these alternatives, you may be able to see them in the figure in Box 6.2. The implications for qualitative observation is what you see is partly determined by what is in your working memory and salient in your long term memory.

Activity 6.3: Some people see 'God is nowhere', others see 'God is now here' (This is not a measure of theological orientation). Some people see 'News wipe', others see 'New swipe'. The implication here is that how one segments the events one is observing can change one's interpretation.

Activity 6.4: Some people look first at the legs of the women and note it is a beauty competition. Others notice first the audience of black people and a few note the head of the white man looking at the stage. Feminists sometimes comment that this is yet another example of male chauvinism. Others see the presence of a black audience and no black women in the competition as an instance of racism.

The implication for qualitative observation is that the same picture can be interpreted in different ways and different values can be read into an observation. There are no absolute right or wrong answers in qualitative observations: only different ones. This thought is disquieting to some engineers.

> **Note:** The picture is of 'Miss Lovely Legs Boksburg, 1974' by David Goldblatt. The example was first used by Terre Blanche and Durrheim (1974) in their text and subsequently cited by Potter (2006). It has been used by one of the authors in workshops for several years – even though some feminists object. In so doing, they demonstrate the point the author is making: that what we see is determined partly by our values. The photograph may be accessed at http://www.michaelstevenson.com/contemporary/exhibitions/goldblatt/boksburg/2_29513_15.htm

Unit 7

Activity 7.1: You will almost certainly find differences in the mind maps which reflect differing level of knowledge. Some suggestions for assessing the differences are given in this unit. You might like to try developing your own system – keep it simple.

Activity 7.2: This exercise will take you a couple of hours but it will give you an entrée into how students tackle problems. The exercise will help you to understand problem solving processes of students as well as providing a basis for a research project. Capable problem solvers, such as you (?), often have difficulty in understanding why weaker students have difficulties. For you the approach is obvious, not so for a weaker student.

Activity 7.3: You may find that the early part of the interview is slow. Participants take a little time to recall their experiences. It is not necessary in this first practice to transcribe and analyse. Instead listen to each recording and make notes, preferably under similar headings.

Activity 7.4: This activity will give you some pointers for analysing group processes and identifying roles. It is also useful to playback and discuss the recording with the group. They can then reflect upon their own group processes – with a little help from you.

Activity 7.5: Opinions about the project and the report will differ. Our view is that there are several claims for the project but these are not supported by evidence or references to evidence.

Unit 8

We do not give detailed comments on these activities – they would be too lengthy. A discussion of the activities with colleagues will provide you with plenty of views!

Activity 8.1: There are several errors. The meanings of the numbers on the scale are not indicated. The statements are ambiguous or contain double negatives or are too dogmatic. It is not clear whether an item is supposed to be eliciting opinion or testing knowledge. (Agree/Disagree for eliciting opinions. True/False for testing knowledge.)

Activity 8.2: The questionnaire is very close to one which was actually used. It has too many errors to enumerate here. But basically the tone of the questionnaire is unfriendly, its aim is unclear and it contains formats which are confused or are difficult to understand. The information obtained would be difficult to analyse meaningfully. The errors are worth discussing with a few colleagues as a preliminary to designing your own questionnaires.

Activity 8.3: We emphasised 'start to' since we are not expecting you to produce a full design in a few minutes. We hope you have followed the pattern we outlined in Section 8.3.1 or at least a comparable procedure. It would be worth doing a little qualitative research as a preliminary to an actual survey. You might have also considered who would be in your sample. The obvious sample are the Part time Master's students but if your purpose is to improve recruitment you might think of also asking practising engineers who are doing a full-time Masters' courses and those who are not doing any Masters' degree course.

Unit 9

Activity 9.1: It is always useful to do a test (or examination question) which you are going to administer to students yourself. The experience helps you to understand and evaluate the test qualitatively.

Students are often interested in their profiles and how they compare within their group. The elementary statistical tasks are a useful preliminary exercise to the next unit which is concerned with statistics and experimental design.

Unit 10

Activity 10.1: Although there are only three broad dimensions, these do subsume most of the observable characteristics of teaching. Their use will sharpen your perception of teaching as well as providing the basis for developing SETS and CEQs. The discussion with colleagues might spark ideas for research and development.

Activity 10.2: The initial attempts might be a little frustrating. You may be surprised by how much activity can take place in 3 seconds. (BIAS) or 30 seconds (SAID). For timing, we use a bleep with an ear plug attachment (easily made in an electronics workshop). Try using subscripts and look for patterns. One can use different rows for different students (S1, S2 etc). Beyond four, the system becomes difficult.

Activity 10.3: Focus particularly on the novice's attempts. The checklist and your observations could lead to useful error analyses and training protocols.

Activity 10.4: We know very little about the dialogue between research supervisors and students in engineering. The activity might lead to the development of a useful simple research instrument which could also be used for training purposes.

Unit 11

Activity 11.1: One can do quite a lot of pedagogical research with extant data providing one is aware of its limitations. Data on 'A' level scores and degree marks can be correlated. Data for males and females or for different engineering departments can be correlated and the correlations compared. The study could be extended to other years or to students who entered the course by non-traditional routes. If there has been a radical change in the curriculum one can examine if the change has altered the proportion of honours degrees awarded or the correlations between A levels and degree awards changed.

Activity 11.2: This is a much trickier question than it first appears. Any method chosen has limitations so one has to search for the approach which is practicable, given your resources, and ethical limitations. One way would be to examine student assessments (SATS) before a person attends a course on pedagogy and again subsequently. Preferably, you might have a closely similar control group of participants who did not study pedagogy. However, even if you obtain significant results for change or differences between the groups, this would not be a scientific test of the hypothesis. Other factors would have played their part such as the motivation of the lecturers, the quality and relevance to teaching of the course attended and the comparability of the difficulty of the courses being taught. Quasi-experimental studies can provide substantial empirical evidence but never full scientific proof.

Unit 12

Activity 12.1: As you may have discovered, this is a rather more challenging task than it appears. There are the difficulties of the micro-politics of access to the information, the request to the ethics committee to do the research and the persuasion of colleagues to participate in the study. Then there is the selection of which methods of measuring reliability and validity you will use, their strengths and limitations and how you would report your findings. An ancillary, qualitative study might provide you with useful information on how colleagues or students or both see the problem of reliability and validity and how they might be improved.

Unit 13

Activity 13.1: At pedagogical workshops given by the authors, the top ranking selection is often ‘C’, attributed to Einstein. This may be because at the workshop, it is stressed that qualitative and quantitative methods are complementary rather than completely separate approaches. Quotation A is attributed to Galileo, one of the founding fathers of modern scientific method. Quotation B is attributed to the atomic physicist, Rutherford. There are of course no right or wrong answers.

Activity 13.2: Most quantitative researchers would take for granted this phrase (actually it is a clause!) means the book would contain an account of the nature of pedagogical and point to the strengths and limitations of different aspects of pedagogical research. What might immediately strike a qualitative researcher is the pseudo-objectivity of the phrase. Books do not examine natures, authors and readers do. A common criticism by writers in qualitative research is that writing in quantitative research often depersonalises and masquerades as objective when it is not. A common criticism by writers in quantitative research is that writers in qualitative research often use language which obscures rather than clarifies meaning.

Activity 13.3: Many pedagogical projects concerned with introducing a new mode of learning or assessment would benefit from the use of mixed methods. The qualitative research could reveal anxieties and feelings which quantitative measures could not capture. The quantitative aspects could give a base for evaluation of the efficacy of the innovation, particularly if the quantitative aspect included cognitive or achievement tests.

Unit 14

Activity 14.1: This activity was designed to start you thinking about a possible research project and the ethical considerations implicit in it. Even if you abandon the research project, the activity will help you to think of ethical considerations in subsequent projects.

Activity 14.2: The sub-sections in 14.2 cover the essential ground viz: *Informed Consent; Right to withdraw; Confidentiality and Anonymity; Disclosure/Giving advice; Data Protection; Feedback; Protection of participants; Deception*.

Activity 14.3:

a) This moral dilemma is not simple. One has to balance the agreement made with the participant to maintain confidentiality against the alleged illegal action. There are several possibilities and ultimately you must choose which you think is the most appropriate for you. One could keep the information confidential and so avoid the issue of wider responsibility for the academic standards of the department. One could suggest to the Head of Department that your research indicates it would be timely to issue a reminder to all students about the penalties for plagiarism – but do not divulge to him or her the source of your information or the name of the alleged plagiarist. If you think the plagiarism is severe, such as in a final year project, you might want to suggest to the examination co-ordinator that some further checks on plagiarism in a 'random' sample of projects or assignments is undertaken but again be coy about the source of your information. (See 14.2.4).

b) You might advise the student to discuss the matter with a counsellor. Or, if you think it appropriate, step out of the role of researcher into the role of tutor, and say you are doing so. (See 14.2.2 and 14.2.4).

c) This is a deeper issue than it first appears. The obvious path is to conform to traditions of the subject and thereby avoid issues of career prospects. Arguably, a stronger moral stance is to question the ethics of the tradition. But if the tradition did change, this would affect CVs, departmental lists of research and outcomes of research assessment exercises. Would you be willing to risk the opprobrium of attempting to do this?

d) Your argument should be that you have a contract with the participants, that the data they supplied is confidential and confidentiality is part of the ethical protocol approved by the Head of Department (and perhaps more senior managers). Standing your ground on this issue with some Heads of Department could be difficult even though right is on your side. (See Box 14.23).

Unit 15

Activities 15.1 & 15.2: These activities will help you to move closer to actually doing pedagogical research rather than reading about it.

Unit 16

Activity 16.1: Most sections of this unit are relevant to this activity. You may have a different approach from those we discussed. Is it efficient? You may find some of the suggestions of your colleagues trigger tactics you had forgotten.

Activity 16.2: The second one is more substantive and therefore more suitable for a journal. The first example is descriptive rather than substantive and it is written in a style closer to speech. It might be appropriate in a presentation at some conferences.

Activity 16.3:

a) It is not the reductions in serious and fatal injuries etc. which are the causes of concern. Not all the items are causes of concern. The list is plural so it should be causes not cause. Some would argue that the list should follow the summary. E.g. ‘The causes of concern are…
The third sentence needs a linking word such as ‘Consequently …..

b) One of many possible rewrites is:
Without scientific instruments many discoveries would not have been made. Microbiology and histology were made possible by the invention of the microscope; the study of electrical discharges in rarefied gases by the construction of a high vacuum apparatus; and the tracking of charged particles by the invention of the cloud chamber.

c) A possibility is:
True/False questions are a type of multiple choice question in which the respondent is required to indicate whether each of the statements provided is true or false.

The major criticism of this type of question is it is likely to encourage rote learning. Other criticisms are.............

In the original, the first sentence is slightly confusing. The final sentence does not connect to the beginning of the next paragraph. The sentence at the beginning of the next paragraph uses the singular but the first sentence of the previous paragraph uses the plural.

> **Note:** Many of the flaws in writing are grammatical. Such flaws are often the roots of logical inconsistencies.
> Look carefully at the beginning and end of paragraphs to check if a slight change in wording would produce a better flow of argument.

Activity 16.4: These were hinted at in Unit 15 (Section 15.2) when considering joint proposals. At least three forms of co-authorship can be distinguished: spurious, apprentice, authentic. In spurious co-authorship, one person does the bulk of the work and the others do very little. This form raises ethical issues. In apprentice co-authorship, the project is designed primarily by the senior authors and the ‘apprentice’, with guidance and feedback, does much of the data collection, analysis and drafting. The more senior authors then help in the interpretation of results and editing. Difficulties arise when the senior authors disagree on what to do, how to interpret the results and or how to write the article. It is often easier for two people rather than three or more to co-author. In authentic co-authorship, the authors work together on the design and planning of the project, share the task of doing the research and writing and checking sections of the article. This form requires a degree of personal harmony in which the partners can disagree without rancour.

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Available to download from the website:
www.engcetl.ac.uk/iit

ISBN: 978 0 9565098 5 7 (printed version)
ISBN: 978 0 9565098 6 4 (online version)

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