CHAPTER 4

Literature searching and literature reviews

Aims
To introduce the skills of literature surveys.

Learning objectives
When you have completed this chapter, you should be able to:

- understand the process of literature surveys;
- define and conduct a literature search;
- manage information obtained during a literature search;
- understand how to conduct critical evaluation;
- write a literature review.

4.1 Introduction

In virtually all computing projects (especially at postgraduate level) you are assessed on what you submit at the end of the day – be it a written report, a working program, a specification, detailed system designs, test plans or whatever. However, it is often the initial investigative work that you perform that can make the difference between a good project and a borderline fail, even for practically-based programming projects in which the development of a piece of software is the main component. The initial foundation for your project is a *literature survey*. This survey is composed of two main components: a *literature search* and a *literature review*. The literature search represents the mechanics of looking for, sorting, managing and digesting research material that is available. The literature review represents your written understanding, critical evaluation, conceptualisation and presentation of the material you have obtained. A skill related closely to both of these components is *referencing*. How to reference material correctly is discussed in Chapter 6.

A literature survey acts as an introduction to your computing project and serves a number of purposes:

- It justifies your project – that is, it shows that your project is worth

doing; the area that you are investigating is recognised and meaningful. At postgraduate level you will also be showing that your project is not merely repeating the work of others, but has a contribution to make, perhaps by identifying a current gap in the literature of your field of study which you intend to fill.

- It sets your project within context by discussing and critically evaluating past and current research in your area. Through this contextualisation you will identify how your project fits within, and contributes to, wider issues. This will depend on the level (postgraduate or undergraduate) of computing project you are undertaking.
- It provides other researchers with a starting point from which they can understand how your project evolved and to identify what literature is relevant to your project in order that they can continue where you left off.

Justification

The importance of a literature survey within academic projects cannot be over-emphasised. For example, Figure 4.1 helps to illustrate a literature survey's contribution within the context of a computing project by analogy to building a block of flats. Although people might come from far and wide to visit your luxury penthouse on the top floor (i.e. they are interested in reading your *project report*), this penthouse (report) will be unstable, of poor quality and limited in its academic worth, if it doesn't rest on firm foundations (the literature survey). Sometimes students start their projects at the ground floor; tackling what they feel is the main content of their project without justifying it or identifying its context within the wider issues. This can often prove disastrous because the project is not properly planned, investigations are narrow, conclusions are weak, and impacts and influences of other relevant issues are ignored.

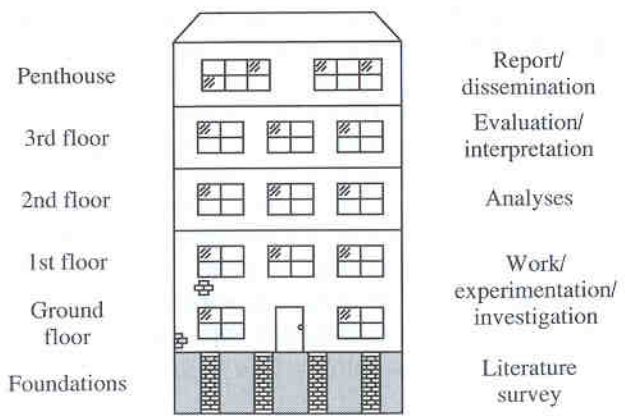

Figure 4.1 *The importance of the literature survey*

Context

It is very important for any academic project to justify its content by identifying how it fits into a broader context. Figure 4.2 shows two potential student projects; one at undergraduate level and one at postgraduate (PhD) level. This is an alternative viewpoint to that shown in Figure 1.1, which aimed to show your own understanding within world knowledge. Figure 4.2 represents a somewhat simplified interpretation of world thinking, knowledge, understanding, theories and philosophies (and an undergraduate project probably represents a lot less than the 10% of all world thinking as indicated in this diagram!). Advances to current understanding, through research discoveries and inventions, are shown as expansions to this domain by a dashed line. Conversely, contractions in world understanding might also occur as historical skills are forgotten. However, although Duell (Commissioner of the US Office of Patents) stated in 1899 that 'Everything that can be invented has been invented', on the whole, world knowledge continues to expand as new discoveries are made.

Figure 4.2 also recognises that the world is by no means at the limits of understanding and there are (possibly) an infinite number of discoveries and inventions yet to be made. This is highlighted by the isolated region towards the top right of the diagram. This knowledge domain may seem ridiculous and fanciful at the moment, based on current philosophies and understandings, but it might in future become an area of accepted theory and knowledge. For

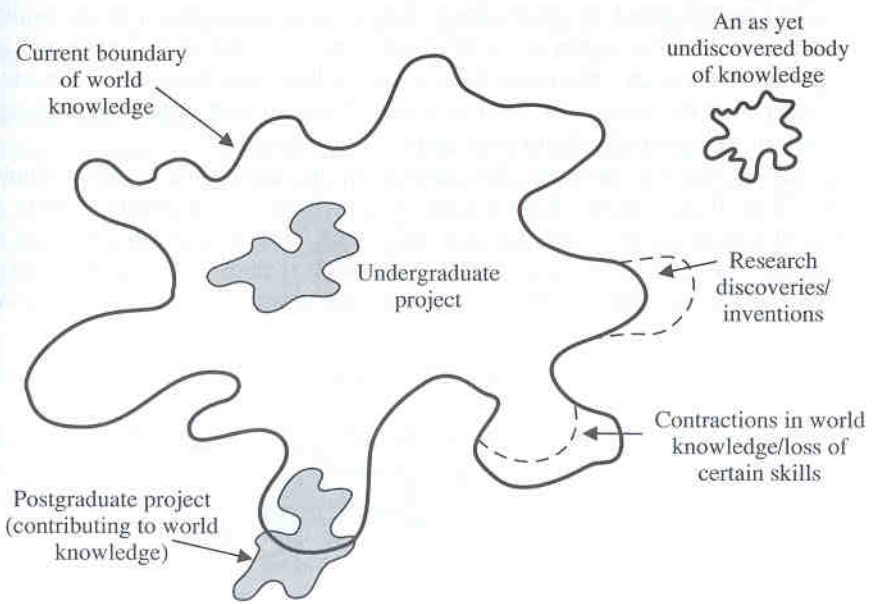

Figure 4.2 *Projects within their wider context*

example, 500 years ago people thought the earth was flat. The understanding that the earth was round and revolved around the sun appeared a ridiculous notion at that time and would have appeared as the disjoint region shown in Figure 4.2. World knowledge has now expanded to accept this understanding/belief within its boundaries. Other interesting examples where world understanding has changed over time are highlighted by the following two quotations:

> Computers of the future may weigh no more than 1.5 tons.
> (*Popular Mechanics* magazine, 1949)

> I think there is a world market for maybe five computers
> (Thomas Watson, IBM Chairman, 1943)

Postgraduate versus undergraduate projects

If you are pursuing a PhD, an MPhil or even an MSc your project should be at the boundaries of world understanding in your particular field of study – see Figure 4.2. Completing a PhD must enhance world knowledge. In other words, you would be expected to make a *contribution* to world knowledge and consequently expand its boundaries. An MPhil and an MSc, on the other hand, would not necessarily make a major contribution to knowledge, but they would be involved with an investigation into potential developments to world knowledge and be concerned with work at the boundaries.

At undergraduate level, however, this would not be expected. At this level you would be required to understand how your project fits into its wider context and have some appreciation of developments in that area. Examiners at undergraduate level are interested in your own ideas, interpretations, theories and concepts of the particular field of study. They are not expecting a major contribution to knowledge from your project at this level.

Figure 4.3 focuses more on the context of an individual undergraduate project. This figure shows how a project can draw on information from a number of different topic areas (in this case, two). This project's main focus is the overlap between these two subjects, although it does concentrate a little more on field B than field A. The project does not ignore issues from these two

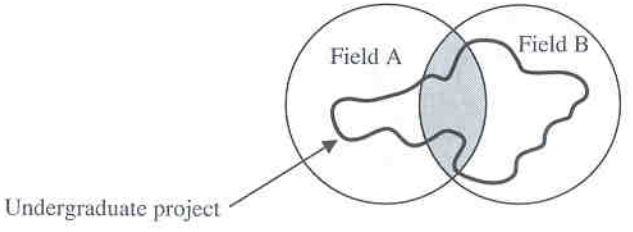

Figure 4.3 *An undergraduate project in context within two subject areas*

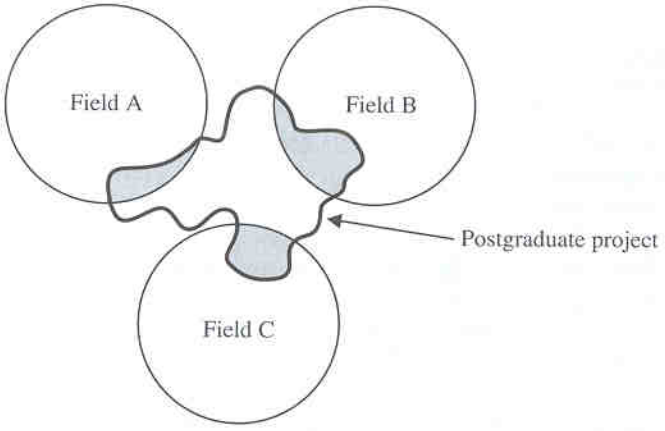

Figure 4.4 *A postgraduate project that draws together three previously unrelated subject areas*

fields on their own, but uses material from them to identify the broader context in which the project lies.

Figure 4.4 shows a potential PhD project along similar lines. This time the project might draw on three currently unrelated fields and contribute to knowledge by filling the gap between these fields. In both these cases the projects have been identified within their wider contexts and the reader has an understanding of how the projects draw together and focus on particular subject areas.

A starting point

Your literature survey also enables other people interested in your work to see the grounds from which your project developed. A thorough literature survey will give other researchers a starting point for their studies and provide anyone wishing to develop your project work further with a comprehensive literature base.

4.2 The literature survey process

In Chapter 3, when project planning was discussed, the literature survey was split into the two distinct, concurrent stages of the search and the review. For planning purposes it might well be acceptable to define the literature survey in this simplistic way to aid clarity. However, the literature survey process is more complicated than this. Although these two components represent the bulk of the work involved in performing a literature survey, there is more to a survey than just this. Figure 4.5 provides a far more accurate representation of

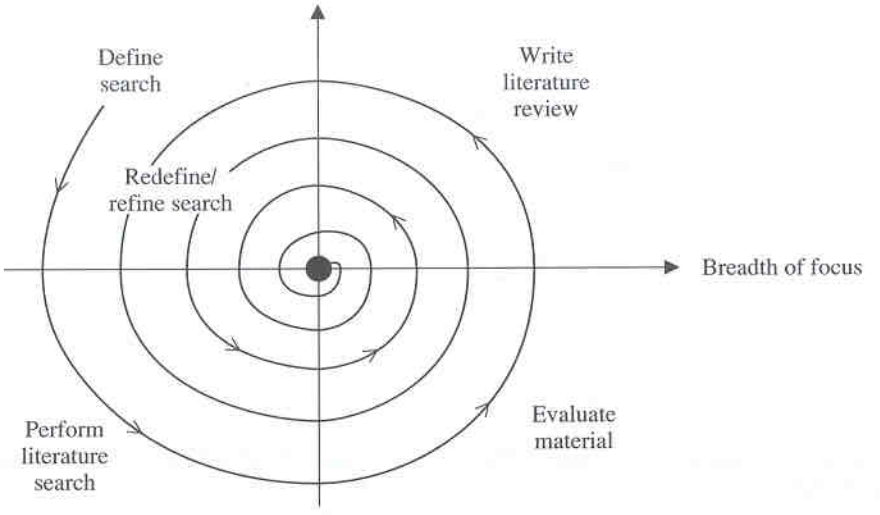

Figure 4.5 *The literature survey process*

this process. In this figure the angular axis represents time and the radial axis represents your subject focus.

The starting point for your literature survey is the *definition* of your literature search – starting in the top left-hand quadrant of Figure 4.5. This definition begins to identify the boundaries of your literature search, it identifies the topics in which you are interested and provides you with a starting point from which to focus on appropriate research material. This definition might be as simple as your subjective understanding of your project area and might lead you to popular texts in your field. You may, however, be more focused and limit your search definition to key authors, specific journals and/or particular research articles. Alternatively, you might want to use a conceptual model such as a *relevance tree*, *spider diagram* or *research territory map*, introduced in Chapter 2, whereby the relationships between topics within your project are identified. These conceptual maps will help you to identify the starting point for your literature search.

Continuing around the spiral of Figure 4.5, having decided broadly (or specifically) what you are interested in searching for, you can then begin to perform your *literature search* (this stage and the following two stages are discussed in more detail in separate sections later). Your literature search will provide you with material that requires your *critical evaluation*. This critical evaluation will provide you with a firm understanding of your chosen subject area and will form the basis of the next stage of the process – your *literature review*. Note that these stages are not independent – you will not visit your university's library, gather all the references you need, return to your desk, read and evaluate them and complete your literature review. You will perform some

of these tasks in parallel. For example, you may be evaluating some articles while you wait for others on order through inter-library loans. You might read part of an article or a book relating to a topic you are currently focusing on and tackle the rest of the article or book at a later date. You might use only part of a book to provide you with insight into one aspect of your project or you might use one article you have obtained to direct you quickly to other papers on a subject.

Having completed one cycle of the literature survey process you will find that you are really just beginning. You may have uncovered more questions and misunderstandings than you started off with. You may feel that other issues, which you had not considered, appear to be influencing your project and justify further investigation. You may feel that you have been too broad with your initial aims and decide to focus on one particular aspect that interests you. Alternatively, you may feel that you were too focused on a particular issue and need to broaden your search. Whatever the case you will find that you are moving back into the cycle once again by refining and redefining your search for material. Once again, you may define your search explicitly or maintain a subjective understanding of material in which you are interested. The cycle thus proceeds as you continue to search and evaluate the literature, focusing ever more closely on information relevant to your project.

The 'spiralling in' effect apparent in Figure 4.5 represents your increased focus on the particular *topic* of interest. This is not to say that your search focuses in consistently over time as indicated in Figure 4.5. There are times when your search may broaden, but the focus on material relevant to your project will always improve. Thus, from a broad starting point, which might include books, journals, documentation, news reports and so on, you will find yourself drawn more and more towards specific articles relating directly to your project. Your literature review is therefore seen to 'evolve' over a period of time as you become more confident with the subject material and your conceptual understanding of the topic area increases.

This iterative process highlights the fact that the literature review is not something that you can write as a one-off having read everything you can get your hands on. It must develop over time. Although you will have to stop work on your literature survey at some point and move onto the main content of your project, you may well find that you are making changes to your literature review right up until the end. This will be inevitable as you should continue to gather and evaluate material throughout the lifetime of your project to keep your understanding of the field fresh and up-to-date.

4.3 Literature searching

A literature search is a '*systematic* gathering of *published* information relating to a subject' (University of Derby 1995). There are two important terms

italicised within this statement that require further explanation. The first is *systematic*. A literature search should not be performed in an *ad hoc* manner, but should be approached in a structured and professional way. Reading anything and everything you come across will eventually be boring and will certainly be a waste of time. It is important to focus your literature search on those articles, books and so on that are relevant. Of course, when you first begin your literature search you won't know which material is relevant and which is extraneous. However, as you continue to cycle through the literature survey process, your focus will improve as your boundaries draw in towards your specific topic of interest. You should, therefore, identify your boundaries and know when to stop. Although this can be difficult at the start of your project, you should try to limit your search as much as possible. Knowing when to stop can also be hard as you will still have a lot of unanswered questions you may wish to solve before moving on to the main part of your project. However, remember that you will never actually stop literature searching as you might still be gathering/understanding material in parallel with the rest of your work to the conclusion of your project.

The second significant term within the definition is *published*. This implies that the material which you trace should be *recognised*. In other words, the material is not merely somebody's opinions you happened across through a conversation in a corridor, or a block of unrefereed text downloaded from the Internet. Recognised works are those that have been suitably *refereed* before publication. In other words, they have been assessed for their academic worth by other 'experts' in the field and accepted as significant artefacts that contribute to that field.

Bearing these two points in mind, there are also two golden rules you should remember when performing a literature search:

- Allow plenty of time – it can, and probably will, take a long time. Therefore, you should start as soon as possible, avoid procrastinating (see Chapter 5) and avoid gathering material unrelated to your chosen topic.
- Ensure that you make note of the full reference of any material you obtain. This will save a significant amount of time at the end of your project as you won't waste time trying to pin down precise details of articles you have read but have since lost or returned to your local library. The full reference will also be needed if you wish to apply for inter-library loans.

It is also worth noting that you should not be overwhelmed by the enormity of literature you might find on your topic. You need to be selective and focus in on precisely those articles and books that are specifically relevant to your work. If, however, you find several books and numerous articles that cover your specific subject area in detail, then it might mean that your subject aim is still too broad and you should focus even more.

When you are assessing whether a book is worth reading you should begin (obviously) with the title, move on to the contents listing and scan the index for keywords that are important to you. Is the author well recognised in his or her field? Is the book up-to-date? Is it the latest edition? When you are thinking of reading or obtaining an article, again, begin with the title and ask yourself if it is up-to-date or might it have been overtaken by now? Read the abstract and keywords, look at the list of references at the back (Are the key works cited? Are there useful references you can use?). Move on to reading the introduction and the summary/conclusions. Assess its level: is it highly technical, readable, is it a review paper, an introductory paper, a discussion paper? Only if you are satisfied that books and articles address all your needs should you read them from cover to cover. In many cases a select number of chapters in a book may be of use to you and only some sections of an article may be relevant.

Not only will your search require you to obtain literature on your chosen subject but it might also involve you searching for, identifying and obtaining suitable software for your project. For example, if your project is aiming to evaluate different software tools in different organisational environments you will need to ensure you have traced suitable, up-to-date tools for this evaluation. While software you obtain will not be used to justify and contextualise your project in a literature review, it may well be crucial for you to complete your project successfully. It is important, therefore, that you begin to search for and obtain this software as soon as possible and you may well find yourself pursuing this at the same time as your literature survey.

The points made above and the rules which you should follow provide you with a broad, subjective understanding of the nature of a literature search. In addition to these points you will need to understand the mechanics of the search. There are two aspects to this – understanding the format in which the information can be found and tracing this information. These two aspects are now discussed in turn.

4.3.1 *Format of information*

Literature is presented in a number of different formats. Some forms are more accessible than others and some are recognised as being more 'academically' valuable and worthy (see the points made on *recognised* works earlier). The following subsections give a summary of the forms of material you might come across during your literature search. The list is by no means exhaustive and for more details on these and other sources you should refer to texts such as Blaxter *et al.* (1996: 96–101), Saunders *et al.* (1997: 43–47) and Gash (1989).

Books

Books will probably prove to be the starting point for your literature survey. They will provide you with a good grounding and a good overview of your chosen topic area. However, remember that they may be outdated and out of

line with current thinking in your field. Books are also written for different audiences, some being more technical than others. You should ensure that any books you acquire provide sufficient detail for your needs. Generally speaking, books *are* refereed and do provide a suitable basis for a literature survey.

Journals

Journals contain (normally refereed) articles discussing up-to-date issues in their field. You may find it daunting at first to read journal articles as they (should) represent the current limits and developments in your subject area. You may, therefore, find it easier to build a solid understanding in your chosen subject using books before attempting to investigate the latest developments and theories from journal articles.

Journal articles will also tend to be quite specific, focusing on developments in detailed aspects of a particular topic. You may find, then, as mentioned earlier, that only part of an article is suited to your needs.

As you continue your literature survey you should find yourself using journal articles more and more as your understanding of your subject becomes deeper. Indeed, when you complete your literature review you should find that the majority of references you make are to journal articles which represent the latest thinking in your field.

Conference proceedings

Conference proceedings contain articles and papers that have been presented at national and international conferences. The quality of articles in conference proceedings varies widely – some conferences are not refereed at all while others bring together the latest findings from internationally renowned experts in particular fields. Sometimes conference proceedings may contain more up-to-date ideas than you can find in journal articles and sometimes they present preliminary results from research that has yet to mature.

CD-ROM

Increasingly these days material is being presented on CD-ROMs. CD-ROMs really only present information from other sources in a more easily accessible format. For example, CD-ROMs contain varying types of information, from book-type material and conference proceedings to journal articles.

Company reports

Company reports and documentation can provide valuable information for case studies. However, care must be taken with these kinds of material as they might be subjectively biased in favour of the company and may contain information that you cannot use as the company does not wish it to be made public.

Theses

Theses are the published reports/dissertations of PhDs and MPhils. They will

represent the work of a postgraduate's project and provide a contribution in their particular field. Not only will they supply you with ideas on current thinking in a particular area but they will also provide a useful source of relevant references and, if you are a postgraduate student, an idea of the scope and requirements of a postgraduate degree. Having said that, theses are sometimes difficult to obtain – probably being lodged only at the awarding institution – although they can be obtained through inter-library loan.

Manuals

Particularly within technical computing projects, manuals may prove to be a valuable source of information. It might, for example, be impossible for you to perform your project without having access to the relevant technical manual. However, remember that they are just manuals, they are not refereed academic articles providing insight into current thinking in your field. You should treat manuals just as they are and not use them as foundations for academic discussion within your report.

Software

Any software that you require for your project, such as software tools, libraries and reusable components, should be obtained as soon as possible. You would not want to be halfway through your project and find that the software you needed was no longer available or too expensive. You may have identified some relevant software when you completed your project proposal (see the discussion of resource requirements in Section 2.3.3) but it is important that you obtain this as soon as you can. Sources you can use to trace relevant software include the Internet (using keyword searches and company web sites), local companies (who may well be using suitable software tools) and professional organisations. Professional organisations (such as the British Computer Society, the Project Management Institute and so on) often have *special interest groups* in particular areas, which can be contacted for help and information. This might include software reviews on tools used in their particular field of study and databases of companies supplying relevant software.

In addition to the above media you may also find material in forms such as video and microfiche. Treat these sources with the respect they deserve. For example, a refereed journal presented on microfiche is as valuable as a refereed journal on paper. An introductory video on your subject area may provide you with as good a grounding in your topic as an introductory text book.

Other sources of information that should be treated with more caution include letters and memos, newspapers, computing magazines, the Internet, company sales literature and television programmes. Newspapers, television programmes and computing magazines may provide popular material but their depth may be somewhat limited. However, computing magazines often discuss up-to-date technical issues and provide topical quotations from key orators for

use in your report. Letters, memos and company sales literature will provide limited material and are likely to be quite biased.

The Internet may seem a valuable source of information but it must be treated with extreme caution. You can spend hours 'surfing' the Internet wasting time, without finding anything of value. In addition, material that you do trace might well be unqualified, unrefereed opinion that has no recognised grounding within your particular field of study. Data are also 'unstable', being updated and modified regularly. While this can be a good thing in that material is always up-to-date, it can mean that the information disappears quickly as well. Having said that, the Internet can prove to be a useful search tool for academically sound material, company information and software, and you can often find works published elsewhere (journal articles, for example) that are difficult to obtain through normal sources – for example, through digital library resources. Make sure if you do use any material from the Internet that you note the full web address of the material for referencing purposes. For more detail on how to use the Internet wisely for research purposes you can read Campbell and Campbell (1995), which is an entire book devoted to this topic.

4.3.2 *Tracing the information*

You now know the format that literature is presented in, but how do you actually trace these sources of information? The best place to start any literature search is in your own institution's library. You should also make good use of the librarians, who know the most efficient ways to trace particular sources of information within your institution. Detailed below are some examples of material you can use to trace literature on your subject. The list is by no means exhaustive and you should consult your own library and library staff for other search material they might have.

Internet

Although, as discussed earlier, you should be careful when using the Internet to access literature for your project, the Internet *is* a valuable tool for tracing articles and information. The Internet in this context refers to the use of web browsers (such as Netscape Navigator or Microsoft Internet Explorer) to access web *sites*. It is useful to employ some form of *search engine* when looking for particular items on the Internet. Two such engines can be accessed at:

http://www.yahoo.co.uk/
http://www.infoseek.com/

Web sites that prove useful for tracing information include those produced by publishers such as Elsevier Science, which publishes numerous journals. Elsevier provides a service whereby you are emailed with the contents listings

of recent journals in which you are interested. Their Internet site can be accessed at:

http://www.elsevier.nl:80/

Through your connection to the Internet you will also be able to access *mailing lists* and *newsgroups*. Mailing lists are provided by *list servers* and are established to deal with particular subjects or special interest groups. By submitting your email address and subject interest(s) to a list server you will be added to the mailing list. You will then receive mailings from people on your particular subject of interest. This works by people submitting comments, questions, discussion points and so on to the list server, which are then forwarded to everyone on the mailing list. The messages that are forwarded are either moderated (checked by a human beforehand) or unmoderated (all messages are forwarded).

One such list server is Mailbase provided by the University of Newcastle upon Tyne. To find out more about this service, and the subject areas that are available, you can access the Mailbase web site at:

http://www.mailbase.ac.uk/

Newsgroups are similar to bulletin boards or notice boards. They cover an enormous range of topics from specific academic subject areas to general-interest 'chat' groups. The most common way to access newsgroups is through your own web browser. Your Internet Service Provider or university computer services department will be able to advise you on what groups are available locally and how this facility is supported.

OPAC

Most institutions these days have an OPAC (Online Public Access Catalogue) which you can use to perform searches for material held in your library. OPAC provides a far more efficient way of performing searches (be it on author's name, title, keywords and so on) than older, manual paper-based or microfiche-based systems. If your library has one of these systems you should learn how to use it.

You can also access OPACs at other institutions via the Internet. For example, the British Library OPAC can be accessed at:

http://opac97.bl.uk/

Most university OPACs can also be accessed via:

http://copac.ac.uk/copac/

or

http://www.niss.ac.uk/

BIDS

BIDS (Bath Information Data Services) is a database that contains up-to-date abstracts and article details from a number of scientific journals and conferences. The service is available by subscription and is usually provided on an institutional basis. It can be accessed via the Internet at:

http://www.bids.ac.uk/

The BIDS service also provides an index to scientific and technical conference proceedings.

The following sources are also useful for tracing information:

- British National Bibliography: this provides a list of all British books published and deposited at the British Library each year. It is available in printed format and as a CD-ROM.
- British Books in Print: a microfiche listing all British books *currently* in print.
- American Books in Print: a microfiche listing all American books *currently* in print.
- Global Books in Print: a CD-ROM containing information on all books recently published in the USA, the UK, continental Europe, Africa, Asia etc.
- ASLIB: an index of PhD theses completed in the UK each year. It provides abstracts and is arranged in subject order.
- Current Research in Britain: a catalogue that presents, in institution order, research activity that is ongoing within UK universities. Computing research is covered within the physical sciences volumes. It is published annually.
- Index to Conference Proceedings: provides an index of conference proceedings received by the British Library. It is available in printed form or via the British Library web page.
- Computer Abstracts: a printed catalogue that provides abstracts and details of articles published from a number of computer journals, published every six months. It is also available via the Internet at:

  http://www.anbar.co.uk:compabs/

- Computer Select: a CD-ROM that contains complete articles published monthly in a number of computer journals.
- ULRICHS: an international periodicals directory in printed format which provides details of journals published throughout the world.

Inter-library loans

Although your search can provide you with a comprehensive list of material that will support your project, there is no guarantee that your local library will stock the items you require. This is when you need to make use of the

inter-library loans system. Your institution will be able to obtain material for you from other institutions using this system. However, the system has three potential drawbacks:

- It is expensive and often undergraduates will have to pay for this service.
- It can take some time before you receive an article you have ordered – possibly too long in some cases.
- You can be severely limited on how long you may keep the material (for example, one or two weeks when you may want a book for two or three months).

Having said this, the system is well worth using if you require pertinent articles and books for your project that are not available locally.

Some tips for performing a literature search

- Note interesting quotations and their reference as you go along.
- Use review articles and books to help your search.
- Reference correctly from the start (covered in Chapter 6).
- Know when to stop – or at least when to move on to the next stage of your project. You will know this from your project plan and the research boundaries which you have set yourself.
- Have a system to organise and catalogue the material you read – see below for a discussion on how to manage your information.
- Read recognised leaders and original theorists in your field.
- Start with a broad search before you focus in – don't jump straight into the most complicated recent article on your subject: you may be put off by its apparent complexity.

4.4 Managing information

Collecting a large number of articles and books relating to your subject is all very well but, depending on the size of your project and the breadth and depth of your literature search, you may soon find yourself swamped under paperwork and books. Some people manage to work well under these conditions, able to put their hands on a particular piece of paper under a pile of 'debris' on their desk. For the rest of us it makes sense to have some means of managing and controlling the literature and information gathered to avoid losing sight of important articles or losing references that are later needed. This section briefly introduces some tips and ideas to help you manage the articles, books and references you obtain from your literature search. For a more detailed discussion on managing research material you can read Orna and Stevens (1995).

The best way to begin managing your research is by using the conceptual

model you have created of your subject area (using your RTM, relevance tree or spider diagram). Use this model to identify the topics in which you are interested and how these topics link together. You can use this model to sort articles and books that you obtain into some sort of order. Some articles may cover broad issues while others may draw together two or three important topics. Arrange photocopied articles and your own notes into plastic wallets or folders suitably labelled. In this way you will quickly and easily be able to draw together relevant information as you tackle different parts of your project.

Another important strategy to follow is to set up an index system of some kind that includes information on every article and book that you read. Some books that discuss literature searching will recommend that you set up a manual index system on cards. These days, however (and especially for computing students), it is better to use a computer to do this. It is quicker, less bulky, the information is readily available in a format which you can use (paste) in your final report, and it can be updated easily. You can use a word processor to record details of your references – such as title, keywords (for quick searching for similar topics), brief overview etc. Alternatively, there are software packages available that manage references for you. Examples of shareware packages include *References Manager 1.5* for the Apple Macintosh, *Nineveh* for Windows, and *REFLIST 2.0* for DOS. These packages are available via Internet archive sites such as HENSA at *http://www.hensa.ac.uk*. In addition there are commercial packages available, such as Reference Manager for Windows 98 (refer to *http://www.risinc.com* for more details).

Also, try to record references in the correct format from the start – this will enable you to use them directly when you complete your project later on. It is also a good idea to note the primary reference of each article you obtain; i.e. how did you discover that article in the first place? Was it referred to by another article you read or did you just come across it by chance as you searched the library shelves?

When you are reading articles highlight key phrases, sentences and paragraphs by underlining or using a highlighter pen. You may set up a system whereby you use a green pen to highlight useful quotations, orange to highlight explanations to key topics, pink to highlight new ideas or contributions, and blue to highlight contradictions or arguments with your way of thinking. In books you can use Post-it notes to quickly identify important pages and also enable you to make brief notes on the book at key points.

Another useful idea is to make brief notes on the front page of articles and within the papers themselves. This might provide an explanation to yourself of what the author is trying to say or to note another reference you feel is related to this particular point (whether it supports or contradicts the argument). You might like to provide your own brief summary of the paper at the start as well. This will save you having to reread the entire paper six months later when you have forgotten what it was all about and you are trying to incorporate it into your report.

These ideas will not provide you with a comprehensive information management system. This is something only you can develop based on your own way of working and your own feelings and ideas. However, the approaches discussed above will provide you with a useful basis, having introduced you to the key skills used by researchers to manage information.

4.5 Critical evaluation

You have gathered some articles and books together, have read them to some extent and have an idea of what each one is about and what the author is trying to say. How do you critically evaluate them?

Normally when people hear or read the word 'criticise' they think of it in a negative sense, i.e. finding fault with the object in question. However, to critically evaluate an article means far more than looking for faults – this is certainly not the aim of critical evaluation.

When you read an article or a book you should consider the following points. This is not to say that you should apply these points as a 'tick list' but you should be thinking about these ideas implicitly as you read the article. You should also try to think how the article can contribute to your own work.

- What kind of article is it – a review paper, an evalulatory paper, a theory paper, a practical paper, a case study etc.?
- What can you gain from the article – ideas, techniques, useful quotations etc.?
- Is the author well recognised in his or her field? Is he or she an authority in this area?
- What contribution is being made by the article? What kind of contribution is it? Can it make a contribution to your own project? If so, how?
- How does the article fit within its context? How does the article fit into and support the context of your project? How important is the article in its field and your own? Does the paper classify and summarise its field in a clearer or more logical way than has been done before?
- Do conclusions follow logically from the work that has been presented? Are the arguments logical? Do they follow one another? Are they supported or contradicted by the work of others? Are alternative conclusions consistent with the discussion?
- Can you differentiate fact from unsubstantiated opinion? If there are opinions in the article do you agree with them? Are these opinions supported by logical arguments or other authors?
- What do you feel about what has been written? Do you agree with statements that are made? Are there any counter arguments?
- Does the article contradict other viewpoints or support the status quo? How does the article relate to other literature in the field?

- What references does it use? Are these appropriate, relevant, up-to-date? Which references can you use? Is the article referred to by other authors?
- Are there limits to what the author is suggesting? Is his or her argument only applicable in certain cases?
- Can you use the results from the article in your own work? How do these results contribute and fit into their field and your own?

Rudestam and Newton (1992: 50) suggest some additional points that should be considered when reading and critically evaluating articles. They break their points down into five key areas: *conceptualisation, theoretical framework and hypotheses, research design, results and discussion*, and *summary*. Those that supplement the points made above and are applicable for computing projects can be summarised as:

- What is the major problem or issue being investigated?
- How clearly are the major concepts defined/explained?
- Is there a clear research question/hypothesis that can be, and is, tested?
- What type of research design/methodology is employed? Is it suitable and reliable?
- Have algorithms and statistical techniques been used appropriately? Can you apply them in your own work? What are the limitations of these techniques?
- Is the choice of measures, sample sizes and data appropriate? Have extraneous factors/variables been considered?
- Can generalisations be made from these results? What are the limitations of these generalisations?
- Are the implications of the results discussed?
- What is your overall assessment of the study in terms of its adequacy for explaining the research problem and the contribution it is making?

Taking all of these points into consideration, you will see that critical awareness of your chosen subject means a lot more than just understanding it and being able to regurgitate parts of it. Reading and understanding what you have read is really only the first part of the process. You should be aware of its boundaries, its limitations, contradictions, developing areas and dead ends. The main point of critical evaluation is that you *think* about what you are reading. This *critical reading* is defined by Blaxter *et al.* (1996: 106) using a number of points, some of which are listed below.

A critical reading is:

- 'one that goes beyond mere description by offering opinions, and making a personal response, to what has been written';
- 'one that relates different writings to each other';
- 'one that does not take what is written at face value';

- 'one that views research writing as a contested terrain, within which alternative views and positions may be taken up'.

Using these pointers as you read and interpret the material you obtain will ensure that you develop a deeper (not superficial) understanding of your subject area. You will be developing the depth of knowledge that will be expected on your degree course.

4.6 Writing literature reviews

You are now critically aware of your subject area and the literature in your chosen field. How do you present your understanding of your field and set the foundation for your project using the literature you have obtained as a literature review?

As a starting point for discussion, Borg and Gall (1989, cited by Saunders *et al.* 1997: 39) identify the purpose of a literature review as, among other things:

- to refine your research question and objectives;
- to highlight research possibilities that have either been explicitly identified by other authors or have possibly been overlooked in the past;
- to avoid repeating the work of others;
- to identify research methods and strategies that may be usefully applied in your own research.

Building on these points, a literature review should provide 'a coherent argument that leads to the description of a proposed study' (Rudestam and Newton 1992: 47). This is achieved with reference to past and current literature in your field(s) and will involve a discussion of current omissions and any biases you may have identified (Saunders *et al.* 1997). You will have great difficulty achieving these aims if you merely read and digest a number of articles and books related to your project. It is through your critical evaluation (discussed in the previous section) and critical understanding of the relevant literature that your literature review will develop.

You will not be able to write a literature review without reference to other material in the field. References should, therefore, be used to support your arguments *where appropriate*. They should not be used to pad out your report and 'prove' that you have read (or, at least, have obtained) a number of key texts.

There are no specific, infallible rules you can apply to write the perfect literature review. It is something that improves with practice and something that you can get a feel for by reading examples within the varied literature you will come across. However, at a 'mechanistic' level within project reports, Saunders *et al.* (1997: 40) identify three common ways for presenting literature

reviews:

- as a single chapter;
- as a series of chapters;
- subsumed within the report as various issues are tackled.

For an undergraduate project it is unlikely (unless your entire project is a literature review) that you will dedicate a series of chapters to your literature review. Not only will you not have enough time to do this, but you will also not be expected to gather sufficient material to fill several chapters. It is more common for your report to contain an introductory chapter dedicated to a literature review or for you to subsume your review within each chapter of your report where you discuss different elements of your project. Quite clearly the approach you adopt is up to you and is something about which your supervisor should advise you.

When writing your literature review remember what it is not:

- It is not a report that lists all the papers and books you have read whether they are relevant or not. You must be selective about that to which you refer.
- It must not dedicate a page or paragraph to each article in turn, merely reporting on their content. Haywood and Wragg (1982: 2) refer to this as 'the furniture sales catalogue, in which everything merits a one-paragraph entry no matter how skilfully it has been conducted'.

Perhaps the best way to explain the presentation of a literature review is through a small example. The box represents a short introduction to an academic paper. Quite clearly, academic papers of only two or three thousand words are much shorter than an entire project report. However, the example shows how the scene is set for the rest of the paper and its context is justified with respect to other literature in the field.

An artificial neural network approach to rainfall-runoff modelling

The United Nations General Assembly declared the 1990s the International Decade for Natural Disaster Reduction with the specific intent to disseminate existing and new information related to measures for the assessment, prediction, prevention and mitigation of natural disasters (WMO 1992). A prominent element within this programme has been the development of operational flood forecasting systems. These systems have evolved through advances in mathematical modelling (Wood and O'Connell 1985; O'Connell 1991; Lamberti and Pilati 1996), the installation of telemetry and field monitoring equipment at

critical sites in drainage networks (Alexander 1991), through satellite and radar sensing of extreme rainfalls (Collier 1991), and through the coupling of precipitation and runoff models (Georgakakos and Foufoula-Georgiou 1991; Franchini *et al.* 1996). However, in practice, successful real-time flood forecasting often depends on the efficient integration of all these separate activities (Douglas and Dobson 1987). Under the auspices of the World Meteorological Organisation (1992) a series of projects were implemented to compare the characteristics and performance of various operational models and their updating procedures. A major conclusion of the most recent intercomparison exercise was the need for robust simulation models in order to achieve consistently better results for longer lead times even when accompanied by an efficient updating procedure.

The attractiveness of Artificial Neural Networks (ANNs) to flood forecasting is threefold. First, ANNs can represent any arbitrary non-linear function given sufficient complexity of the trained network. Second, ANNs can find relationships between different input samples and, if necessary, can group samples in analogous fashion to cluster analysis. Finally, and perhaps most importantly, ANNs are able to generalise a relationship from small subsets of data while remaining relatively robust in the presence of noisy or missing inputs, and can adapt or learn in response to changing environments. However, despite these potential advantages, ANNs have found rather limited application in hydrology and related disciplines. For example, French *et al.* (1992) used a neural network to forecast rainfall intensity fields in space and time, while Raman and Sunilkumar (1995) used an ANN to synthesise reservoir inflow series for two sites in the Bharathapuzha basin, S. India.

The use of artificial neural networks for flood forecasting is an area which has yet to be fully explored. Up until now the majority of work in this area has been mainly theoretical; concentrating on neural network performance with artificially generated rainfall-runoff data; for example Minns and Hall (1996). However, these theoretical approaches tend to overlook the difficulty in converting and applying actual data to artificial neural network topologies. Hall and Minns (1993) go some way to address this criticism by applying neural networks to a small urban catchment area. However, their discussion is limited to the performance of a neural network on a small number of events.

This paper goes one stage further by discussing how artificial neural networks may be developed and used on 'real' hydrological data. It discusses the problems that need to be addressed when applying neural networks to rainfall-runoff modelling and demonstrates the effectiveness of artificial neural networks in this particular domain. By applying a neural network to flood simulation in two UK catchments, the prospects for the

use of ANNs in real-time flood forecasting are evaluated. Finally, suggestions are made concerning necessary refinements to the existing ANN prior to transfer to operational use.

Source: reproduced in part from Dawson and Wilby (1998)

Notice how this introduction/literature review begins by justifying the content of the paper with reference to a WMO report. It continues by showing how the subject area has evolved over the years. Literature reviews often employ this kind of approach – focusing on the topic of interest through a chronological discussion of literature in the field. This approach generally leads to a natural focus on the topic of concern. The review then moves on to explain a little bit more about the area of study, setting the scene for the reader, before focusing more precisely and discussing some recent developments in research within the field. The literature review concludes by highlighting current limitations in the field, once again justifying the relevance and importance of the paper by showing how it aims to fill these gaps.

In summary, literature reviews evolve over a period of time. They cannot be written as one-offs, after you have read a few articles on your chosen subject. Although you will not split your literature review into specific sections your review should, implicitly, justify the existence of your project (by critically evaluating past and current research in the field), identify your project within a wider context, and discuss and arrange relevant literature in the field. In other words, your literature review forms the *foundation* of your project.

4.7 **Summary**

- Your literature survey will help to place your project within a wider context and justify its presence within a particular field (or fields) of study.
- Your literature survey consists of two main components: the literature search (supported by an ability to manage the information you gather) and the literature review (which requires a critical understanding of material which you obtain). These components are performed repetitively over a period of time and (probably) in parallel with one another.
- Although you will eventually need to move on to the main investigation/development work of your project, your literature survey will continue to be performed throughout the lifetime of your project to some extent, as you refine and consolidate the information you gather, ensuring that your project remains up-to-date.

4.8 Further reading

Blaxter, L., Hughes, C. and Tight, M. (1996) *How to Research*, Open University Press, Buckingham.

Campbell, D. and Campbell, M. (1995) *The Student's Guide to Doing Research on the Internet*, Addison-Wesley, Wokingham.

Gash, S. (1989) *Effective Literature Searching for Students*, Gower, Aldershot.

Rudestam, K.E. and Newton, R.R. (1992) *Surviving Your Dissertation*, Sage, London.

Saunders, M., Lewis, P. and Thornhill, A. (1997) *Research Methods for Business Students*, Pitman, London.