CHAPTER

5

Literature searching and literature reviews

Aims:

To introduce the skills needed to undertake 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.

- This chapter is particularly relevant for research degree projects.
- The chapter is also appropriate for taught degree projects – especially those that are research-based.
- This chapter provides useful material for all taught degree projects.

5.1 Introduction

In virtually all computing projects (especially at research degree level), you are assessed on what you submit at the end, be it a written report, a working program, a specification, detailed system designs, test plans or whatever. However, it is often your initial investigative work 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 has two main components; a *literature search* and a *literature review*. The literature search represents the mechanics of looking for, sorting, managing and digesting the available research material. 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 will be discussed in Chapter 8.

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

- It justifies your project – i.e., it shows that your project is worth doing; the area that you are investigating is recognised and meaningful. At research degree level you will also be identifying 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 (undergraduate or postgraduate) of 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.

5.1.1 Justification

The importance of a literature survey within academic projects cannot be over-emphasised. For example, Figure 5.1 helps to illustrate a literature survey's contribution within the context of a computing project by analogy to building a block of

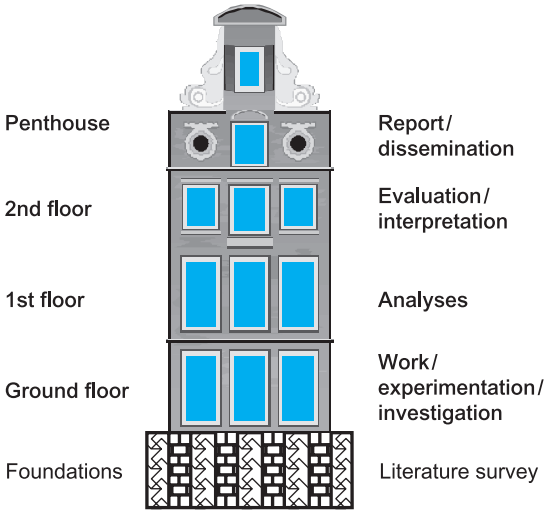

Figure 5.1 The importance of the literature survey

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 investigations are narrow, conclusions are weak, influences of other relevant issues are ignored, and you may just be repeating the work of others.

5.1.2 Context

It is very important for any academic project to justify its content by identifying how it fits into a broader context. Figure 5.2 shows two potential student projects; one at taught degree level and one at research degree (PhD) level (contributing to world knowledge). This is an alternative viewpoint to that shown in Figure 2.1, which aimed to show your own understanding within world knowledge. Figure 5.2 represents a somewhat simplified interpretation of world thinking, knowledge, understanding, theories and philosophies (and a taught degree 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 the dashed lines. Conversely, contractions in world understanding might also occur as historical skills are forgotten. However, although Duell (Commissioner of the U.S. Office of Patents) stated in 1899 that 'Everything

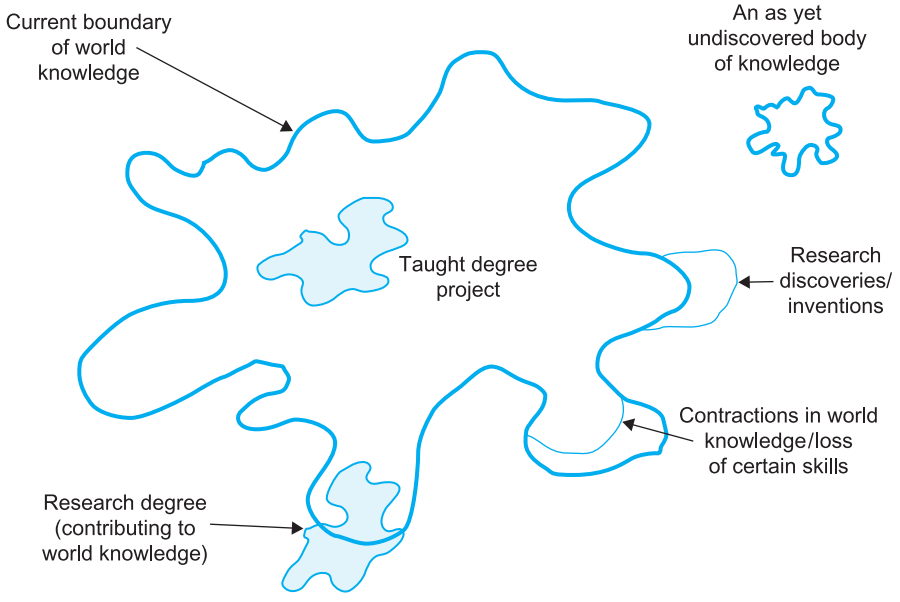

Figure 5.2 Projects within their wider context

that can be invented has been invented', on the whole, world knowledge continues to expand as new discoveries are made.

Figure 5.2 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 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 5.2. World knowledge has now expanded to accept this understanding/belief within its boundaries. In addition, as world knowledge expands, not only do we find out things we did not know but we also find out how little we know about certain subjects and perhaps identify a whole new set of questions that need to be asked and answered.

Some interesting examples where world understanding has changed over time are highlighted by the following two quotes:

> *'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)

5.1.3 Research degrees versus taught degree projects

If you are pursuing a PhD or an MPhil, your project should be at the boundaries of world understanding in your particular field of study (see Figure 5.2). 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, on the other hand, would not necessarily make a major contribution to knowledge, but it would be involved with an investigation into potential developments to world knowledge and be concerned with work at the boundaries.

At taught degree 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 taught degree 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 5.3 focuses more on the context of an individual taught degree 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 fields on their own, but uses material from them to identify the broader context in which the project lies. An example would be a project that looked at the application of artificial intelligence methods to predicting breast cancer rates in patients.

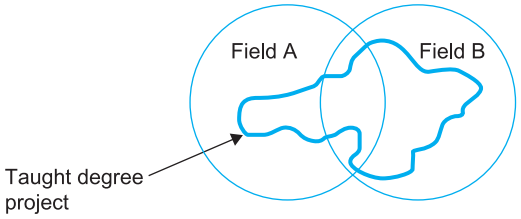

Figure 5.3 A taught degree project in context within two subject areas

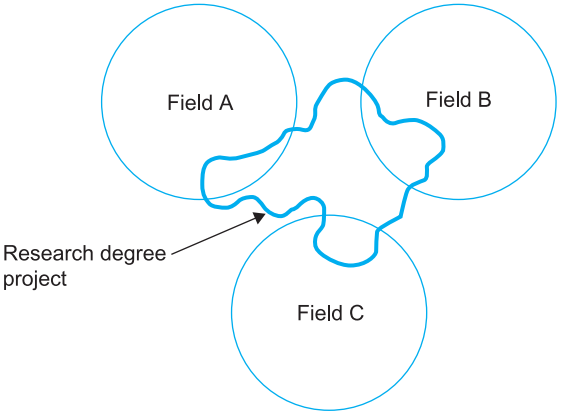

Figure 5.4 A research degree that draws together three previously unrelated subject areas

Figure 5.4 shows a potential PhD project along similar lines. This time the project might draw on three currently unrelated fields and contributes 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.

5.1.4 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 provide other researchers with a starting point for their studies and provide anyone wishing to develop your project work further with a comprehensive literature base.

5.2 The literature survey process

In Chapter 4, when project planning was discussed, the literature survey was split into two distinct, concurrent stages of *search* and *review*. For planning purposes it might well be acceptable to define the literature survey in this simplistic way to aid clarity. Although these two components represent the bulk of the work involved in performing

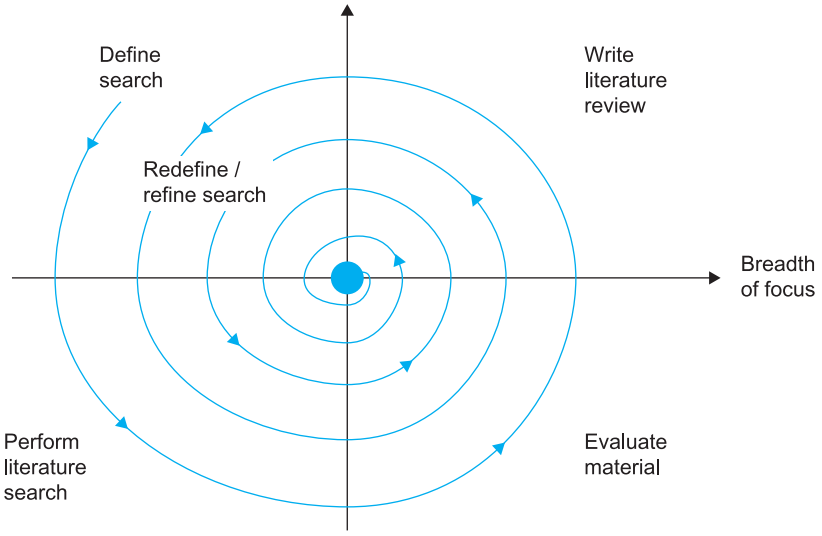

Figure 5.5 The literature survey process

a literature survey, there is more to a survey than just this. Figure 5.5 provides a far more accurate representation of 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 5.5. This definition begins to identify the boundaries of your literature search and the topics you are interested in and provides 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. However, you may 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 3, 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 5.5; 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 office, 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 ordered 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 with. You may feel other issues 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 5.5 represents your increased focus on the particular *topic* of interest. This is not to say that your search draws in consistently over time as indicated in Figure 5.5. 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 the like, 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 to 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.

Berndtsson *et al.* (2008: 59) discuss the idea of *completeness* with respect to a literature review. They highlight the point that it is difficult to know when to stop – how do you know when you have collected sufficient material? While it is probably impossible to read every single artefact that has been published in your area, Berndtsson *et al.* point out that 'by undertaking a systematic process, which can be conveyed to the reader, the validity of the resulting study will be enhanced'. They go on to state that the reader (examiner) should understand why certain material has been covered and why certain material has been omitted.

5.3 Literature searching

5.3.1 Introduction

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 everything you come across will eventually become 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 opinion you happened across through a conversation in a corridor, or a block of un-refereed 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. Using only material from sources on the Internet (such as Wikipedia) will undermine the legitimacy of your project. While such sources can provide useful background information and overviews, you should try to extend your literature search to peer reviewed sources.

Bearing these two points in mind, there are 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 7) and steer clear of 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 because you won't waste time trying to remember precise details of articles you have read but have since lost or returned to your local library. It is also important to avoid plagiarising the work of others (plagiarism is covered in Section 8.5). 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 vast array 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 her/his 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 other publications by now? Read the abstract and keywords, look at the list of references at the back (are 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 useful 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.

5.3.2 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 list is 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.* (2006), Dochartaigh (2007) and Saunders *et al.* (2007).

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 out-dated 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 areas of a particular topic. You may find 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 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.

CDs and DVDs

Increasingly these days material is being presented on CDs and DVDs. CDs and DVDs generally present information from other sources in a more easily accessible format. For example, CDs and DVDs 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 represent the work of a research degree and provide a contribution in their particular field. Not only will they provide 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 research degree student, an idea of the scope and requirements of a research 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 loans or sometimes downloaded from the Internet.

Manuals

Within technical computing projects, manuals may prove to be a valuable source of information. For example, it might 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 Resource requirements in Section 3.3.3) 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 IEEE, the Project Management Institute and so on) often have *special interest groups* in particular areas and they 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.

The Internet

The Internet is a valuable source of information but it must be treated with 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, un-refereed 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 accessing academically sound material, company information and software. You can often find articles published elsewhere 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.

Some points that you should consider when evaluating the quality of material on the Internet include (some of these points are adapted from Ohio State University Library, 2008):

- What is the purpose of the site – is it to provide information or to sell a product?
- When was the site updated? How up-to-date is the material on the site? Is it still relevant?
- Is the site part of (or related to) an official organisation (a professional body, government department or academic institute or research group)? For example, the IEEE, the Project Management Institute, British Computer Society, etc.?
- Are there any copyright issues associated with the material? Will you be able to use the material without breaching copyright?
- Is there an author for the material? Is the author qualified to provide the information? Are they presenting opinions rather than facts? Are they biased?
- Is the site recognised from other sources? Is it a recognised body? Are there other links to the site and is it reviewed anywhere?
- Is the material biased? 'Does the author have a "vested interest" in the topic' or an axe to grind?

For more detail on how to use the Internet wisely for research purposes, refer to Dochartaigh (2007) and Munger and Campbell (2006), who have written entire books devoted to this topic.

In addition to the above media, you may also find material in forms such as video/DVD 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 DVD on your subject area may provide you with as good grounding in your topic as an introductory textbook.

Other sources of information that should be treated with more caution include letters and memos, newspaper articles, computing magazines, 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 quotes from key orators for use in your report. Letters, memos and company sales literature will provide limited material and they are likely to be quite biased.

5.3.3 Tracing the information

You now know the format in which literature is presented, 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 staff for other search material they might have.

Internet

Although 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 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. Three such engines can be accessed at:

- http://www.google.com/
- http://www.yahoo.cm/
- http://www.lycos.com/

Wikipedia (http://www.wikipedia.org/) is a useful starting point for tracing general information about a subject and identifying references. However, like most Internet sites, Wikipedia is not academically refereed and you should use the information you obtain there with caution. Having said this, for a general overview of a subject or as an introduction to a new area, it is a valuable tool.

Through the Internet you will also be able to access *mailing lists* and *news groups*. 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 their mailing list. You will then receive mailings from people on your particular subject of interest. This works by people submitting comments, questions, discussion points, etc. 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 before hand) or un-moderated (all messages are forwarded).

One such list server is JISCmail provided by Janet (UK). To find out more about this service and the subject areas that are available, you can access the JISCmail web site at: http://www.jiscmail.ac.uk/.

News groups 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 news groups is through your own web browser. Your Internet Service Provider (ISP) or university computer services department will be able to advise you on what groups are available locally and how this facility is supported.

The following links provide some useful resources and sources of information on the Internet for those undertaking research in computer science and information science. These sources were compiled in October 2008 so be aware that new sites may now be available and some may have moved.

Intute (http://www.intute.ac.uk/sciences/). Intute is a free service that provides access to information in engineering, mathematics and computing. According to the Intute web site it provides 'access to the very best Web resources for education and research'.

ISI Web of Knowledge (http://wos.mimas.ac.uk/). A database for UK education that covers engineering and science publications (both journals and conferences). It indexes over 57,000 journals across 164 scientific disciplines. It provides a full search facility and ability to download abstracts but you (or your institution) must subscribe to this service.

Research Navigator (http://www.researchnavigator.com/). This site is maintained by Pearson and provides a useful starting point for students undertaking research in a number of disciplines. It provides access to the *New York Times* archive and EBSCO's ContentSelect, which provides access to lots of computing journals.

Berndtsson *et al.* (2008) identify a number of other useful Internet resources. Some bibliographies they identify include:

ACM Association of Computing Machinery (http://www.acm.org). Contains a digital library of all material published by the ACM and a guide to computing literature.

The Collection of Computer Science Bibliographies (http://liinwww.ira.uka.de/bibliography/). According to the site this 'is a collection of bibliographies of scientific literature in computer science from various sources, covering most aspects of computer science. The bibliographies are updated weekly from their original locations such that you'll always find the most recent versions here. The collection currently contains more than 2 million references (mostly to journal articles, conference papers and technical reports)'.

IEEE Computer Society (http://www.computer.org). The IEEE's online bibliographic database, where you can search for journal articles

and conference proceedings. Note that you will have to pay for most of the articles you want to download from this site.

Lecture Notes in Computer Science (www.springer.de/comp/lncs). Springer's online database containing literature from this series of publications.

DBLP bibliography (http://dblp.uni-trier.de). According to the site 'The DBLP server provides bibliographic information on major computer science journals and proceedings'. It was originally focused on database systems and logic programming (hence the acronym) but it has since expanded to other areas of computer science.

HCI Bibliography (http://www.hcibib.org). Dedicated to Human Computer Interaction research. The site is maintained in Canada.

IngentaConnect (http://www.ingentaconnect.com/). 'IngentaConnect offers one of the most comprehensive collections of academic and professional research articles online – some 20 million articles from 30,000 publications, including 10,000 online'.

Neuron AI directory (http://www.neuron.co.uk/). Provides links to academic and commercial publications and those primarily within the field of artificial intelligence (expert systems, neural networks, fuzzy logic, etc.).

Intute (2008) also provide a comprehensive list of Internet resources for computing. You can download a booklet that details these resources from http://www.intute.ac.uk/sciences/booklets/. The booklet is split into sections covering (amongst others) *Journals and Magazines*, *Programming and Software*, *Organisations and Societies*, *Subject Gateways*, *Learning and Teaching* and *Other Interesting Sites* (publishers for example). Amongst the sites they reference are:

Free on-line dictionary of computing (http://foldoc.org/). Based at Imperial College London, it does what it says.

IBM Systems Journal (http://www.research.ibm.com/journal/sj/). Provides access to papers published within this journal.

Journal of Digital Information (http://jodi.tamu.edu/). A free service that allows you to download papers on 'the management, presentation and uses of information in digital environments'.

OPAC

Most institutions have an OPAC (Online Public Access Circulation) that you can use to perform searches for material held in your library. OPAC provides an efficient way of performing searches (be it an author's name, title, keywords and so on). Your library will invariably have one of these systems and you should learn how to use it.

You can also access OPACs at other institutions via the Internet. For example, over 50 UK institutions OPACs can be accessed via: http://copac.ac.uk/copac/, which is a merged online catalogue.

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.

Global Books in Print	A CD-ROM containing information on all books recently published in America, 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. It is available on line at: http://www.hull.ac.uk/lib/infoskills/aslib.html.
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 and it is published annually.

5.3.4 Inter-library loans

Although the search material detailed above can provide you with a comprehensive list of material that will support your project, there is no guarantee that you can download the material you need from the Internet or 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 taught degree students will have to pay for this service.
- It can take time before you receive an article you have ordered – possibly too long in some cases.
- You can be severely limited on the duration for which you can 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.

5.3.5 Some tips for performing a literature search

We finish this section with a few tips on undertaking a literature search:

- Note interesting quotes and their **full** reference as you go along. This will be invaluable later when you write your report and try to trace your references.
- Use review articles and books to help your search.
- Reference correctly from the start (covered in Chapter 8).
- 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. The following section provides a discussion on how to manage your information effectively.
- Read recognised leaders and original theorists in your field.
- Start with a broad search before you focus; don't jump straight into the most complicated recent article on your subject. You may be put off by its apparent complexity.

5.4 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 needed later. 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 (2009), a book devoted to 'Managing information for research'.

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 arrange 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 sort that includes information on every article and book that you read. You should use a computer to do this as 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, useful quotes, etc. Alternatively, there are software packages available that manage references for you – for example, Reference Manager (refer to http://www.refman.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 Internet or 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 quotes, 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-type notes to quickly identify important pages and also 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 explanation to yourself of what the author is trying to say or to note another reference you feel is related to this particular point (be it supporting or contradicting 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 as they cover the key skills used by researchers to manage information.

5.5 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; that is, 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, 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 could contribute to your own work.

- What kind of article is it – a review paper, an evaluative paper, a theory paper, a practical paper, a case study, etc.?
- What can you gain from the article – ideas, techniques, useful quotes?
- Is the author well recognised in his/her field? Is the author an authority in this area?
- What contribution is the article making? 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? How does it fit into your conceptual understanding of the field?
- 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 and up-to-date? Which references can you use? Is the article referenced by other authors?
- Are there limits to what the author is suggesting? Is his/her argument applicable only 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 (2007: 67–68) suggest some additional points which should be considered when reading and critically evaluating articles. They break their points down into five key areas: *Conceptualization*, *Theoretical Framework and Hypotheses, Research Design*, *Results and Discussion* and *Summary*. Those which 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.* (2006: 117) using a number of points, some of which are listed below. They define a critical reading as one that:

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

5.6 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, Gall *et al.* (2002, cited by Saunders *et al.*, 2007: 57–58) identify the purpose of a literature review as, amongst 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, 2007: 63). 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 might have identified (Saunders *et al.*, *loc. cit.)*. 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.

Figures 5.6 and 5.7 help to illustrate how a literature review should be presented. Figure 5.6 shows a particular research field that a student wishes to discuss as part of their literature review. The world's understanding of this field is covered by numerous books, articles, papers, documents, knowledge in people's minds, etc. The 'furniture sales catalogue' approach (Haywood and Wragg, 1982) would explain this field in a literature review by discussing each article (source of information) in turn as a separate paragraph or section – for example:

Book A: Covers . . . ,

Book B: Discusses . . . ,

Paper A: Introduces . . . ,

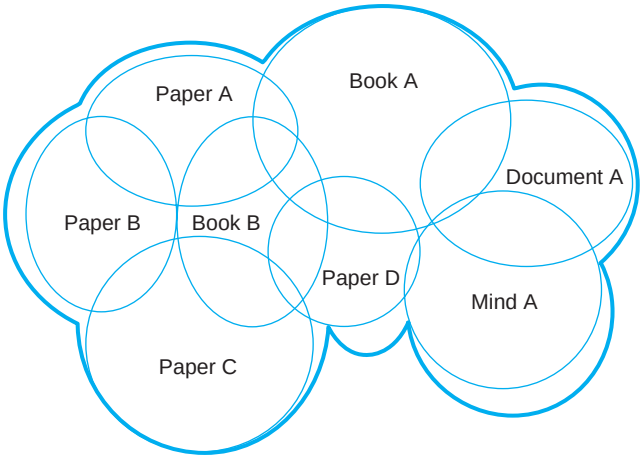

Figure 5.6 A research field made up of a number of articles, books, documents, etc.

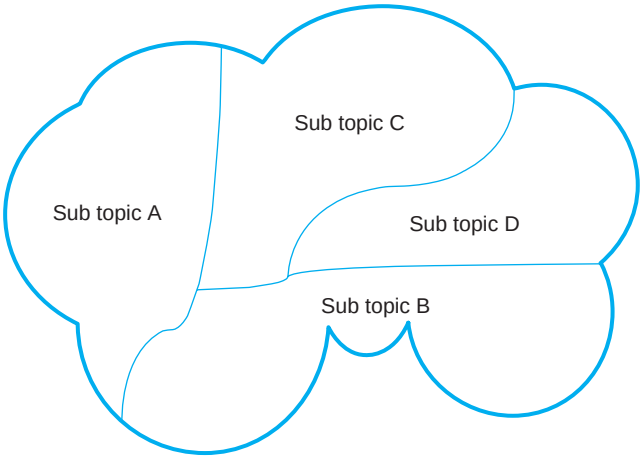

Figure 5.7 How the research field shown in Figure 5.6 might be structured and presented in a literature review

Person A: Thinks . . . ,

and so on.

A better way of presenting this material is to view the field as a series of inter-related subtopics (your own interpretation and understanding of that field and how it is made up). Figure 5.7, as an example, shows how the field in Figure 5.6 might be interpreted. The field can now be discussed in a literature review from this alternative perspective **using** references where appropriate to support the arguments made and explain the topics covered.

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 (2007: 61) identify three common ways for presenting literature reviews:

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

For a taught degree 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 not be expected to gather sufficient material to fill several chapters. It is more common that your report will contain an introductory chapter dedicated to a literature

review or that you will 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' (see Figure 5.6).

Perhaps the best way to explain the presentation of a literature review is through a small example. The following example 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.

Example – 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

Example (*continued*)

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.

(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 in on the topic of concern 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 focussing 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, your literature review forms the **foundation** of your project. Remember, 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) and although you will not split your literature review into specific sections your review should implicitly cover the following four points:

1. Arrange relevant literature in the field.
2. Critically evaluate past and current research in the field.
3. Identify your project within a wider context.
4. Justify the existence of your project by identifying a gap in the field and showing how your project will fill that gap (particularly important at research degree level).

5.7 Summary

- A 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 that 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 part 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.

5.8 Further reading

Blaxter, L. Hughes, C. and Tight, M. (2006) *How to research* (3rd Edition), Open University Press, Maidenhead, UK.

Dochartaigh, N.O. (2007) *Internet research skills: How to do your literature search and find research information online* (2nd Edition), SAGE Publications, London.

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Orna, E. and Stevens, G. (2009) *Managing information for research,* Open University Press, Buckingham, UK.

Rudestam, K.E. and Newton, R.R. (2007) *Surviving your dissertation* (3rd Edition), SAGE Publications, London.

Saunders, M. Lewis, P. and Thornhill, A. (2007) *Research methods for business students* (4th Edition), Prentice Hall, Essex, UK.

5.9 Action points

- Consider how you will undertake your own literature review. Try to identify the boundaries for your search.
- Put in place an information management system that will enable you to manage the literature you obtain effectively.
- Speak to your supervisor and library staff about sources of information for your project. Search the Internet for relevant material.