7

The Literature Review

Read this chapter if you would like to have the following questions addressed:

- *What is the purpose of a literature review in the context of postgraduate research?*
- *What is the most systematic way of conducting and presenting a literature review?*
- *What are the characteristics of good and bad reviews?*

7.1 The Objective of a Literature Review

As a diligent search or inquiry, the professional research process self-evidently requires that a researcher be capable of learning from existing knowledge and experts in a particular field. In the modern world, however, the difficulty is often associated with the enormity of the existing knowledge base and, worse still, the fact that this knowledge base is manifested a vast array of publications, dissertations, websites, and so on.

From a pure research perspective, the purpose of a literature review is to provide a basis upon which to make critical decisions regarding the directions of a research program. In other words, in undertaking a diligent search, one must demonstrate a firm grasp of existing knowledge and its implications and then, having evaluated the current boundaries, seek to use, extend or enhance that knowledge. From the pragmatic perspective of a research student, the requirement to demonstrate a logical progression of thought, from the review of literature, through to the development of a research methodology or strategy, is a critical component of the postgraduate assessment process.

It needs to be clearly understood that professional research, at postgraduate level, is about systematic procedures that lead to the application or extension of knowledge - it is not about unbridled, curiosity-driven or opportunistic discovery. In understanding this, it then follows that, in a postgraduate research program, the student needs to demonstrate a number of elements about the field of study - specifically, that:

(i) The key researchers/seminal authors in the field have been identified

(ii) The review has uncovered the key forums for presentation in the field in question

(iii) The review is "comprehensive" with respect to the time limitations imposed by the research program - in other

words, that there is a logical basis for concluding that the review fairly represents the existing body of knowledge

(iv) There is a sound basis for the currently proposed methodologies or theorems, which has been derived from a detailed reading of other researchers' work

(v) The field of study has been comprehensively reviewed from broader historical and general perspectives as well as those specifically related to the proposed research

(vi) The proposed research is a logical derivation, continuation or extension of the work that has already been undertaken by others or, if the proposed research is a deviation, then that there is independent support for such a deviation.

A common error, in postgraduate study, is that students (particularly Doctoral level students) feel the need to put forward some theorem or methodology which is revolutionary in nature and enormous in scope. In taking such an approach, the subsequent error that arises is that such students tend to use the literature review as a means of discrediting existing work through personal opinion and, later, pursuing their own preferred methodology without support from existing researchers. The more appropriate course of action is to:

- Learn from others
- Use that knowledge as a platform for extending the existing knowledge base.

The danger for those who endeavour to be "revolutionary" in their research project (in the sense that they do not follow or extend the directions set in existing literature) is that, regardless of the merits of what they achieve, they tend to have by-passed the basic tenets of professional research. One must always remember that postgraduate research programs are about systematic process and rigour more than they are about indulgent creativity. The luxury of creativity is

normally only extended to those researchers who have already demonstrated an ability to be thorough, rigorous and systematic.

An important element of the literature review process is to be able to sort through a wide variety of data, and to determine which elements of that data are validated facts, and which are opinions or discredited or disproven theories. This evaluation and validation has to be achieved while maintaining an impartial perspective.

7.2 What are the Facts?

Research students submitting dissertations or research papers tend to present evidence from previously published work as facts – obviously this is not always the case. So, what are the facts in the context of a postgraduate research program?

Literature is presented to us in many different forms. These include:

(i) Encyclopedias
(ii) Websites
(iii) Books
(iv) Refereed journal papers
(v) Conference proceedings
(vi) Trade journals
(vii) University research publications
(viii) Professional information (documents/websites) produced by bodies such as specialist medical groups, etc.
(ix) Consumer magazines
(x) Promotional materials
(xi) Trade technical data publications (e.g., pharmaceutical, electronic or mechanical equipment catalogs)

Clearly not all of what is presented in these publication forums is factual. So, how is a research student expected to determine the facts?

To begin with, students can look at the motivation behind each of the publication forums, the benefits to the originators in presenting facts, and the penalties for misrepresenting information.

For example, trade journals and technical data publications are motivated by the need to sell specific products. For this reason, one would naturally expect those presenting products to present them in the best possible light – not necessarily through misrepresentation but more likely through omission of relevant negative information. In these sorts of publications, on the other hand, the penalties for directly

misrepresenting information could be severe. If, say, a pharmaceutical company misrepresented data pertaining to a product, then it could face litigation or even criminal charges. So, one could generalise and say that trade/technical publications present a myopic view of products but that the technical information regarding the products is likely to be accurate if not entirely complete.

In the case of websites, the credibility depends upon the originator of the site. What are the ramifications if an individual with a free website presents incorrect data? Probably none at all. So, one needs to look at websites in terms of their originators and then assess each on a case by case basis. This is discussed further in Section 7.5.

The real problem for students comes in terms of assessing the validity of information that is presented in journals, conference proceedings or other scholarly publicatons. Many students would appreciate that there are screening proceses governing entry into such publications – some would then naively assume that this guarantees the integrity of the information. This is not the case. There have been numerous instances of falsified research outcomes, fraudulent claims, etc. that have been published in some of the world's most highly regarded journals. The penalty for the journals in publishing such work is a loss of reputation and prestige and, yet, such instances still occur. So how can students determine the facts, assuming that the journal itself does not guarantee the integrity of the published information?

Of all the work that has been published in all the world's publications, we know that at least some of it is factual and valid – because others have used it and have proven it to be so. We also know that some of what has been published is neither factual nor valid because others have been unable to substantiate it, or because the researchers have admitted falsification of results, or because people simply published theories (in good faith) that were subsequently proven incorrect. The difficulty is that there is no data that tells us how much of what is published is factual and how much is fiction or fraud. It would be useful if someone could provide us with data that said 70% of the work published in journals is factual

and 30% is fictional or fraudulent – at least then we could identify the scale of the problem – unfortunately, such data doesn't exist. We only know that, of the totality of what exists in scholarly publications, some of the information is factual and some is fictional. We also know that researchers, around the world, are increasingly pressured into publishing more and more material – one assumes that this, of itself, increases the level of invalid research publications in the marketplace.

In research terms, the mechanisms that we use to determine the validity of information are citation and time –an idea or theorem which is simply published in a journal, no matter how eminent, does not, of itself, make it factual.

Citations in isolation are not a fool-proof approach and neither does do they guarantee that information presented in a publication forum can be 100% validated. They simply give us an indication of the support for an idea or theorem. If a theory is espoused and, say, experimentally validated by a researcher, and then published, it is the response of other authors that guides us towards the facts. If a research paper is cited by other authors, because those other authors have:

- Reproduced the work
- Extended the work
- Re-validated the outcomes in a different manner
- Applied the work to produce a tangible outcome

Then we can have a higher degree of confidence in the initial publication than we might otherwise have if it were not cited at all.

When research students undertake a literature review, they need to demonstrate to a reader that they have considered the balance of probabilities for each pivotal theorem/concept they have uncovered. On balance is there evidence to suggest that the work is valid? If a work is highly cited for the reasons listed above, then it is, on balance, likely to be valid. However, it must also be remembered that a work which is uncited is not necessarily invalid – it merely has

not been subjected to independent scrutiny beyond the publication process.

Ultimately, the true indicator of the validity of research is time, and this time could be years, decades or centuries. The longer an idea or theorem has been in existence, and the longer that other researchers have applied it, tested it and extended it, the more likely it is that the original work was valid.

7.3 The Structural Process of the Literature Review

Many research students find the literature review the most tedious aspect of a postgraduate research program, particularly in engineering, medical and scientific areas, where such review requires the reading of large numbers of complex papers. It is also important for students to understand that, while computer-based technologies and networking have made access to papers somewhat more convenient, the ever-expanding number of publications and papers has made the researcher's task much more difficult. Moreover, the nature of postgraduate research has changed as a consequence of the enormous amount of research that is undertaken around the world. A typical 19th Century research dissertation might have focused upon a revolutionary discovery but have been based upon a very limited knowledge base (i.e., very little published literature). However, a 21st Century research program is far more likely to focus upon a minor extension of existing knowledge but be based upon an enormous knowledge base.

In undertaking a literature review in the 21st Century, it is also important for students to recognise that the likelihood of finding uniqueness in research methodologies and ideas is very small. It must be remembered that, each year, many hundreds of thousands of dissertations and research papers are produced around the world and, given the propensity to follow the systematic path of learning and extension, many research programs, in a particular field, can independently end up proposing and developing the same methodologies - despite the fact that they are undertaken in completely different research environments.

Given the complexities of the modern literature review process, many research students have great difficulty in even structuring such reviews in their theses, much less arriving at a logical stream of thought which leads them to a particular research direction. A simple way of looking at the literature review process is as a funnel that is used to draw out the proposed course of action for the research. This is shown schematically in Figure 7.1

The width of the funnel represents the number of publications that are available and the depth represents increasing or decreasing specialisation or relevance. At the top of the review funnel, there are publications that cover the general area of the research in "lay" terms - these can be general text books, encyclopedias, and so on. Normally, there are many such publications available because of their generality. Next, there are the historical and seminal research papers which broach the general field of study - again, because such papers are more general, and because they tend to have initiated at an earlier period, there tend to be numerous examples. However, as one moves down the review funnel, towards one's specifically chosen field of endeavour, then the number of available papers decreases because specialisation has increased.

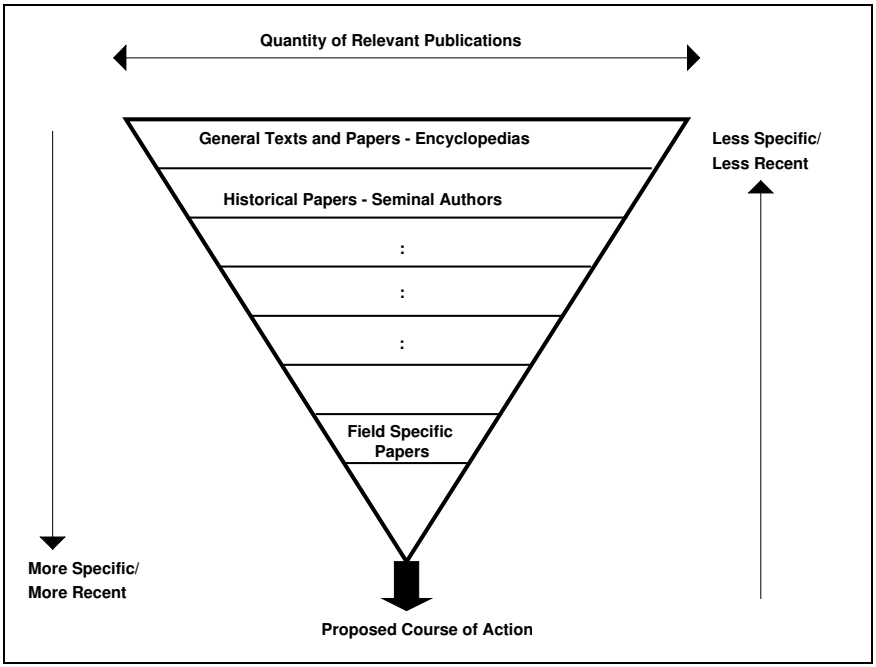

Figure 7.1 - The Literature Review Funnel

One of the most straightforward and effective means of structuring the literature review section of a dissertation is to create a textual adaptation of the review funnel. Typically, a review should commence with generalities and history and, gradually, work its way through to more and more specific issues that, ultimately, lead to the directions proposed for the research program.

Many research students tend to be overwhelmed by the scale and complexity of previously published work and become paralysed with the fear of tackling a literature review. Within such paralysis, simple, common-sense approaches tend to be neglected and the process stalls. The simple rule-of-thumb is that, when approaching a field of research, for the first time, there is a logical sequence of reading that needs to be pursued. A typical sequence is as follows:

Encyclopedia or Web-Based (Internet) Search
⇩
General Text Book
⇩
Specific Text Book
⇩
Journal and Conference Papers
⇩
Trade Journals and Marketing Literature.

A high-quality encyclopedia is often a far better starting point for a research program than a text book or a journal paper. Why? Because credible, professionally-edited encyclopedias cover a subject to a low depth but with a large breadth – various sections in such encyclopedias are generally written by people who are chosen because they are internationally regarded in their field. Several pages of an encyclopedia can often reveal the entire spectrum of key words, phrases and related areas of study that can subsequently be examined through text books and journal papers. Encyclopedias also tend to provide historical time-frames and backgrounds that can be used to search for seminal papers during the course of a literature review. Better still, an encyclopedia will often place an entire field of study

into an appropriate context - for example, a specific field of medical research will be covered relative to the entire area and history of medical research. This form of coverage gives the research student a starting point for placing his/her own research work into perspective before being overwhelmed with the technical complexities of the subject matter at hand. Encyclopedias are therefore a critical and, often, overlooked part of the literature review process.

Each subsequent step in the review process should take the researcher closer to his/her specific area of study and, not surprisingly, as one moves through the review funnel, the depth and complexity of the published work increases and the breadth and availability decreases. In some instances, research students will be unable to uncover any papers that directly relate to their chosen research. In many areas of science, medicine and engineering, the final step in the review process should also include a review of technical journals and trade magazines. This step is particularly important because journals and texts tend to predominantly represent work that is undertaken in universities and research institutes - a large proportion of industry research remains unpublished. Often, however, it is possible to determine the state of industry research from an examination of equipment or services that are promoted through trade journals in a field - for example, production machinery or biomedical equipment.

In structuring a literature review, one also has to be aware of the differing levels of confidence that one can place upon the information that is derived from the various sources, as outlined in Section 7.2. For example, one would generally ascribe a high degree of confidence to work which was published in an eminent international journal, which is refereed by recognised experts in the field. One would ascribe a lower level of confidence to an article in a trade journal because it is likely to be an advertorial piece which is edited into the journal because of advertising space that has been purchased elsewhere in the same journal. This does not necessarily mean that work which is presented in an international journal should be accepted at face value, nor that work which is presented in a trade journal should be dismissed as advertorial. It does, however, require

the research student to be judicious in the manner in which information from such sources is derived and presented.

Moreover, the age of the sources can have an enormous bearing upon the significance of the cited work. Typically, books and refereed journal papers can report upon events that occurred several years ago. Conference proceedings tend to report upon work that was still current/ongoing at the time the conference presentations were made. Trade journals provide information upon the latest commercially-available technologies. The research student's ability to judge how much academic research work is converted into commercial systems or products, at a particular time, can often provide a useful insight into the practicality or usefulness of the various technologies.

Regardless of the sources of information, the ultimate problem that needs to be addressed, by every research student, is how to convince a peer that a review is systematic, comprehensive and a sound basis for the proposed course of research action. This is particularly difficult in an absolute sense because one can never be certain of having reviewed all the published work in a particular field - in many cases, active research is not published at all because of commercial confidentiality provisions. Part of the solution to this problem rests in the structure of the review. The funnelling approach is systematic and should lead to a reasonable coverage of the field at hand. The other part of the solution rests in the manner in which the review is presented. To this end, it is particularly important for a research student to remember that he/she is unlikely to have made a complete (total) coverage of a subject area since this is generally impractical.

Example 7.1 provides a sample outline of a literature review chapter that could form a chapter within a postgraduate research dissertation. A good starting point for the literature review, submitted in any research dissertation, is an overview, containing a detailed and honest statement of the process that was used to conduct it, and the potential limitations of that process - in other words, a discussion of which potential sources may not have been addressed and why. The second point that needs to be made within the overview should relate

to the funnelling process that was used to extract publications of increasing relevance to the study at hand. The third point that needs to be made should relate to the means by which key researchers, seminal authors and reliable publication sources were identified.

The subsequent sections of a literature review should gradually lead a reader towards the direction of the research program, as it has evolved as a result of the review. Example 7.1 demonstrates how the funnelling process (that is used as the basis of the review) can also be used as the basis for the presentation of the review, with increasing detail and decreasing breadth being a feature of the process. The final section of a review should provide a summation that draws the links between the knowledge that has been obtained from others and the work that was performed during the course of the student's specific research program. Again, it needs to be stressed that work which does not naturally flow from the context of a review is always difficult to substantiate from a research student's perspective.

The first section of a literature review should be written in lay-terms and readily comprehensible to the lay-reader - its objective is to demonstrate how a logical system of analysing the current status of knowledge could lead to the advancement of knowledge. The final section (summation) should equally be in lay-terms and provide a bridge between what existed before the student's program and what would exist after.

Example 7.1 - Sample Literature Review Chapter Format

2. Literature Review

2.1 Overview of the Review Process

The literature review for this research was conducted over a period of several years, from 2000 - 2002. The objective of the review was to acquire an understanding of the current state of knowledge in the field in which this research was undertaken and to identify key research groups, seminal authors and forums where such research was presented and subjected to peer review. The review process involved an examination of numerous texts, refereed journal publications, conference proceedings, Internet-sourced publications and trade journals. The mechanism by which the review was conducted...

2.2 Historical Background

Although this research was purely scientific in nature, the impetus for the work that was to be conducted could be traced back to the work of the historian Langridge (1921) whose theories suggested...

2.3 General Theory

:

:

2.M Theories Providing Specific Impetus to this Research

:

2.N Summation - Influence of Review Upon Research Directions

The research findings, presented by each of the authors cited in this chapter, were balanced against one another in order to establish a sound basis for this research and to provide a reference by which any contributions to knowledge, presented herein, could be measured. Specifically, the authors, and their influence on this research are summarised as follows...

7.4 Identification of Landmark Research

A key part of the review structure is the identification of seminal authors and key researchers - not necessarily one and the same. Many published works are prepared by multiple authors - for example, a research student and his/her supervisors. Some traditional senior researchers insist upon being cited as first-named authors in publications, even when it is their research students that are, in practice, the primary research workers in a project. In other cases, the senior researchers will regularly appear as second and third-named authors in publications and their research students will appear as the first-named authors. Although, in principle, the first-named author should be the researcher who has contributed the greatest amount to the research paper, in practice, there tend to be differing opinions on to whom that title should be bestowed. Supervisors adopting the master/apprentice relationship sometimes feel that they are the principal researchers and the students are the helpers. Supervisors adopting the laissez-faire relationship with the students generally feel that the students are the principal researchers.

From a literature review perspective, one needs to recognise that both practices exist and a research student often needs to assess who are the "doers" and who are the "supervisors" in order to sensibly comment upon the key researchers in a particular field. A citation index (e.g., ISI Web of Knowledge or Scopus Database), that can be accessed on-line through university library facilities, is designed to identify authors and the number of times that they have been cited by other researchers in a field. This index enables students to trace backwards and identify seminal papers, upon which many others have based their research work. Patterns can often be identified.

For example, a researcher may (as a research student) initially co-author a paper (which ultimately becomes a well-cited/seminal document). The researcher then goes on to become a senior researcher and research supervisor - ultimately, a stream of co-authored papers emerges wherein the original researcher is a supervisor and the other co-authors are his/her research students. Such patterns of publishing

behaviour can sometimes provide an insight into the depth of knowledge that an author has about a particular field.

During the course of a literature review, it is also important to note that many research papers are published but never cited (and, presumably, never read by others). Often, papers are only cited by the original authors which means that the findings may not have been used as a basis for other work. Some authors only publish one or two papers in a field and then no longer appear in published work - this is often the case when the authors are research students who cease to publish after they have completed their studies. The general rule-of-thumb is that a paper, which has been well-cited and used as the basis for many other research programs, is likely to be significant because:

- Other researchers may have tested the original research in detail and often pass judgement upon it in their own research papers

- The original research may have been pioneering in nature and a landmark in the particular field.

The level of confidence that a research student can place in such work is therefore significantly higher than that which can be placed in a paper that has never been cited elsewhere. An uncited paper may well be a high-quality piece of research - perhaps better than a seminal paper (i.e., the paper may be a landmark paper of the future) but, in the absence of widespread testing and adaptation, by other research groups, such papers need to be treated with greater caution.

The other factor that a student needs to consider in identification of landmark research is the quality of the research publication in which the work is published. The quality of a publication is a function of the peer review process that is used to judge the work and the relevance of the reviewer backgrounds to the work that is published therein. It also needs to be remembered that many conferences, whether refereed or not, are financial (if not profit-making) ventures and recover their costs by having attendees, many of whom are the presenters/authors. In the modern world, far from

paying professionals to author and present papers, many conferences insist upon authors paying for registration fees and, hence, conference proceedings and publications need to be treated with care because of the financial links between a paper's acceptance and the benefits to the conference. On the other hand, if attending a conference, one can listen to the open peer review process of a paper in action when attendees question a presenter - this can often provide a significant insight into the various opinions of the quality of the work.

It must also be remembered that conference proceedings provide a more immediate representation of the current state of research than do international journal publications. Often, the time between the authoring of a paper, and its subsequent refereeing and publication can be several years. Adding to this the original time taken to actually conduct the research, prior to publication, one can readily envisage that the finally published work may be up to five years of age. Conference proceedings may be only a few months or a year of age.

Conference proceedings are not the only form of publication in which financial links are involved in the publication process. Some journals also charge "page" fees for the publication of research papers - in the extreme case, this may mean that a journal is little more than a commercial fee-for-service publishing agency, rather than an impartial publication. Other journals may impose a voluntary publication fee but have a policy of publishing, regardless of whether or not the fee is paid - provided that the paper is of a sufficiently high standard. Generally, research students need to study the editorial and refereeing policies of a journal or set of conference proceedings before making a final assessment of the work presented therein. It also needs to be noted that the financial aspects to publication of work do not necessarily demean the standard of the presented research - they are merely an element to be used by researchers in assessing the nature of various publication forums.

Trade journals often fall into the category of fee-for-service publication mechanisms because they are intended as profit-making activities. A typical arrangement is that a company, paying for

advertising space within the journal (for, say, a piece of equipment), is given the opportunity of submitting a technical article in association with the advertisement. In other words, the cost of an advertisement in such journals includes provision for several pages of an "advertorial" article. This is particularly attractive from the publisher's perspective because it means that the technical "fill" between advertisements does not need to be provided by paid authors but, rather, is part of the advertising. As long as one is aware of this practice, there is nothing wrong with the citation of advertorial articles in a thesis - provided that they are identified as such and their findings are treated with caution. Such articles provide a very current statement of commercial trends and products (albeit with a reasonable potential for bias in the writing style) that often give a partial reflection of reality, as it is perceived by particular product/service providers.

In determining landmark research, and the consequences of it, one generally needs to sift through the spectrum of potential publication sources and endeavour to form a perspective by balancing different opinions and facts, and allocating weightings to their significance and age.

Needless to say, in some cases, the age of a published work may have as much bearing on its credibility as the refereeing process. For example, an unrefereed paper, which is openly published on the Internet, and is on the subject of a dynamically changing field (e.g., the ability to process human genetic information as a result of computer processing and memory limitations) may be far more significant than one published in an international journal and which is, by nature, several years behind the current technology.

In other cases, the very fact that a piece of work has been commercialised may give it greater significance than work which is highly esoteric in nature and published in international journals. Hence, a trade journal paper, which describes the development of some system or machine, may reflect a higher degree of technical merit than one which is published in a more academic forum.

Finally, in determining landmark research, it must always be remembered that the majority of published research arises from academic sources and that, in many cases, high-level industrial research is never published. It may be that, in practice, the unpublished industrial work is the landmark research and the academic work is outdated and irrelevant. Hence, the literature review can never be complete, and can never have more significance ascribed to it than is merited by the fact that published work is only a partial reflection of the status quo of a particular field at a particular time.

7.5 Internet-Based Searching

Research students are generally more comfortable with the idea of using Internet-based search engines to uncover information than they are with journals and conference proceedings. The Internet has significantly changed the way in which research and information is presented and accessed but students need to be aware of the pitfalls of blindly relying upon Internet-based information.

The Internet has increased the amount of data available but the proportion of noise and fiction in the data is also considerably greater than it was with traditional publication methods. The key issue here is that the benefit of rapid access to data has to be offset with the time now required to screen for the validity of the accessed data.

As a starting point, the fundamental problem with the Internet is that individual websites can convey a false sense of credibility. For example, the website for a souvenier shop on a tropical island may look more professional than one for a world renowned university. The danger that this presents is that all information appears to have the same level of validity – whether indeed it has or has not. Many students cite information from the Internet without interpreting the level of credibility that one can ascribe to the individual source.

For example, if one looked at the web-page of a senior medical researcher, in an internationally renowned medical faculty, located in an internationally renowned university, and it provided information about a particular medical treatment, then one would ascribe it a greater degree of credibility than information derived from an obscure individual's website. Of course, the fact that something is published on the website of an internationally renowned university does not necessarily make it valid, and the fact that something is published on an obscure individual's website does not necessarily make it invalid.

Students tend to rely heavily upon the Internet for initial stages of their literature review. To a large extent, the Internet appears to act as an on-line encyclopedia of knowledge. The Internet also contains numerous actual on-line encyclopedias and, while potentially useful,

these also need to be treated with care. Some on-line encyclopedias are actual encyclopedias which have been edited and contributed to by people with expertise in various fields. A more recent trend is the creation of user-based on-line encyclopedias. These allow any Internet user to add, change or update the information on any particular subject – the idea being that any inaccuracies in presented information will ultimately be corrected by the millions of site users.

The problem with this is that, as far as these user-based on-line encyclopedias are concerned, "reality" or "facts" are whatever the last user has defined them to be. So, if a malicious 12-year old, for his own amusement, decided to change the information on complex medical conditions, then the apparent facts on that condition, as far as the on-line encyclopedia was concerned, would be whatever the 12-year old entered. Again, the theory is that the next qualified user would correct this. However, anyone who logs on to the site prior to correction would end up getting fiction rather than facts.

In the context of postgraduate research, while research students should look at any sites they wish, and read widely, credible sources of information should be derived from:

- University websites
- Professionally edited encyclopedia websites
- Research institute websites
- Websites produced and maintained by international professional bodies.

This does not guarantee the validity of anything that is presented but at least it provides a sound starting point.

In addition to general websites, most research students will also make use of modern citation software systems, such as the widely used "Web of Knowledge / Web of Science" system which is licenced by many universities around the world. This powerful tool enables research students to search for subjects, authors, key-words, etc. and, importantly, to check the number of citations. Even more importantly, students can follow the "web" of a publication by cross-linking to

papers that have cited the paper under consideration – thereby enabling students to determine the nature of the citations that have been made.

There are numerous other on-line software packages, licenced by various universities, which provide similar search and investigation facilities – for example, the Scopus system, which focuses upon engineering and technology areas. Students should check with their university librarians for the most appropriate on-line search systems to employ for their particular field of research.

The advent of on-line search systems for journals is also coupled to the advent of on-line publication of refereed journals and conference proceedings. Again, it needs to be understood that these trends add significantly to the amount of data that is available but they also add to the burden of checking validity. Any individual is able to establish an on-line journal because the cost of entry into the marketplace is significantly less than it would be for a physical paper-based journal – the issue is the level of credibility that can be ascribed to that journa.

In summary, on-line Internet-based searching provides access to more data but carries with it a burden of greater scrutiny and checking on the part of the student. Do not blindly cite web-pages and websites without first checking the authenticity of the originators.

7.6 The Researcher as an Impartial Learner

A literature review, as its name suggests, is intended to provide an analysis of the work produced by other research groups, with the end objective of providing some stimulus to the research at hand. It is the research student's task, as an impartial learner, to report, weight and balance the differing views on a specific field in such a way as to present the most honest reflection of reality. Ultimately, because of the range of differing opinions in some subjects, it is possible for two different reviewers to derive two diametrically-opposed conclusions from a review of the exact same set of publications, by ascribing different weightings to each of the opinions.

It generally takes a great deal of skill to provide a literature review as an impartial observer, and to avoid the biases with which human beings tend to be naturally endowed. A good starting point for a literature review is to avoid expressing personal opinions on the merits of other researchers' work. There are two reasons for this:

- A research student's opinions are of limited value within postgraduate research because the student needs to demonstrate humility and impartiality

- The purpose of the complete review is to help shape the researcher's opinions - a researcher should not shape a review to suit his/her own opinions.

It also needs to be remembered that a literature review is not merely an information dump that is used to store information on what various research groups are doing. It is intended as a means of reaching some end objective in terms of a research outcome. Hence, each reference that is cited within a review needs to be qualified by some articulation of how it related to (or changed) the methods and end objectives of the current research. However, one of the most common failings in literature reviews is that they are an information storage dump, rather than a funnel, which has shaped the opinions of the researcher. A typical example of poor reviewing follows:

Example 7.2 - A Biased and Unproductive Review

"Jones and Orwell (1978) originally adapted the principles of electromagnetic induction to crude but intelligent linear motors. In my expert opinion, which is unlikely to be disputed, given the level of industrial experience that I have had, the Jones and Orwell paper was one of the most appalling that I had ever encountered and appeared to be utter nonsense in terms of the achieved results. Franz and Hortence (1991) applied their advanced control theories to a range of different microprocessor-controlled linear motors. Courtney et al. (1999) used intelligent control techniques to vary the flux patterns in several different linear drives..."

Example 7.2 is little more than a catalogue of different paper abstracts and adds no value, over and above that which could be derived by any reader who performs a computer-based index search of publication abstracts in a library. Worse still, it contains personal opinions which imply that the writer is not a humble and impartial learner.

A review needs to contain far more than reporting. For each cited reference, the review needs to provide an important sequence of information to the reader, including:

- The work that was performed by a researcher/s
- The relevance of the published work to the current research program
- Research which correlated with that published work
- Research which contradicted the findings of the published work
- The overall balance of published opinion on research findings.

In this context, the review in Example 7.2 needs to be completely rewritten with the above elements in mind. A better representation could be as shown in Example 7.3.

Example 7.3 - A Balanced and Relevant Review

"In this research program, it was necessary to study the evolution of control strategies that were applied to linear motor drives. The earliest work that was uncovered during the course of the review was by Jones and Orwell (1978), who originally adapted the principles of electromagnetic induction to crude but intelligent linear motors. In the context of this research, the Jones and Orwell research was thought to be particularly significant because it formed the basis of numerous citations and developments by other researchers. Some researchers, such as Osborne (1981), questioned the validity of the presented results in the Jones and Orwell paper, while others, such as Sethi (1981) Franks (1982), were able to reproduce the original findings but suggested that further work was both warranted and necessary.

The natural progression of development in linear motors drives, which emanated from the Jones and Orwell research, culminated in the development of a motor drive system which was ultimately the basis for this research. Franz and Hortence (1991) applied their advanced control theories to a range of different microprocessor-controlled linear motors and these theories were evaluated, during the course of this research, as a means of controlling flux patterns in linear drives. In more recent work, which was close in scope to this research program, Courtney et al. (1999) used intelligent control techniques to vary the flux patterns in several different linear drives. The research, documented herein, contained similar experimental procedures but undertaken on a different series of drives..."

Notice how, in the revised review section, that the researcher does not directly criticise the work of others - the researcher is an impartial learner. The critique is a product of the researcher's balancing of views and findings, leaving a natural evolution of

thought for the reader to follow and absorb. Notice also that each reference citation is explicitly tied back to the objectives of the current research program - the reader is not left to interpret and make sense of loose, vague and implicit linkages.

With the above points in mind, research students need to address some commonly asked questions in regard to a literature review - that is:

(i) How do I get my opinions across?

(ii) Can I be critical of other researchers' work?

(iii) Do I need to tie every single reference back to the objectives of the research?

(iv) What if there is no similar work in my particular field?

The answer to question (i) is relatively straightforward. The objective of a review is *not* to get one's own opinions across to the reader - the researcher's opinions should be a product of the review. If the strength of presented evidence (from other credible researchers) is insufficient, then there is little to be gained by injecting personal opinions into the debate (as in Example 7.2). If a research student chooses to divert from a body of professional opinion, then, in the absence of other hard scientific data (mathematical proofs, experimental results, etc.) the only credible line of argument is an honest endeavour to explore through curiosity - for example:

Example 7.4 - Substantiating Deviations from Established Practice

"Although none of the literature, uncovered during the course of this search, proposed or recommended the course of action that was ultimately pursued, it was felt that, as an apparently unexplored area, an exploration was justified purely on the need to seek new knowledge. On balance, the literature suggested that the probability of such an approach being successful was somewhat limited for the following reasons..."

The answer to question (ii) is also straightforward. The research student, as a humble and impartial observer, cannot criticise other learned professionals work through personal opinion. The work of others should only be criticised (in a balanced manner) through the research of others, or through hard scientific data - for example:

Example 7.5 - Balanced Critiques from an Impartial Observer

"Bertaut's work (1994) was extended by several other research groups with mixed results. Jones and Langtonn (1995) were unable to substantiate the claims originally made by Bertaut. Lawson and Douglas (1996) identified a number of positive attributes in Bertaut's work but were also unable to reproduce the findings. In this research, Bertaut's experimental conditions were reproduced and the experiments repeated but, again, it was not possible to achieve the same performance figures reported in his paper..."

The answer to question (iii) is somewhat complex. The need to link each cited paper back to the central objectives of the research is important. However, this requirement can be relaxed in portions of the literature review that demonstrate general trends in regard to a body of knowledge - for example:

> ***Example 7.6 - Review that Demonstrates a Researcher's Learning***
>
> *"An understanding of the interaction between social, economic and political factors that contributed towards the collapse of a number of Asian dynasties was gleaned from a number of historians, and set the scene for this research. Lofti and Davis (1934) were amongst the first to observe the linkages between social, economic and political factors and their relationship with the collapse of various civilisations. Jane and Zbar (1936) made similar observations but found that there were instances in which economics could be ruled out as a causative factor in...."*

Example 7.6 highlights a portion of a review which demonstrates the research student's learning process, and enables a reader to follow in the researcher's footsteps - in doing so, the reader can then judge whether or not the sequence of learning was logical.

Question (iv) is a question that often arises in the context of a postgraduate research program - a research student feels that he/she has uncovered some revolutionary theory and believes that no other similar work has ever been conducted. Generally, this arises less because of the uniqueness of the research and more because the student has difficulty identifying the appropriate string of key research words that assist in uncovering appropriate papers. However, when such a problem does arise, the solution is to revert back to the review funnel and digress back to a general discussion on the broader subject. The review should focus on funnelling and increasing the depth of knowledge to the apparent cut-off point. Once key researchers (and those who have conducted research closest to the chosen field) have been identified, the next stage in the process is to personally contact such researchers and seek their advice on whether or not similar work has been conducted elsewhere. If such researchers do respond in writing, it is then advisable to include their written responses in the appendices of the thesis and to quote their correspondence as a meaningful form of reference.

In the final analysis, literature reviews tend to demonstrate that professional research is more about systematic investigation than it is about making remarkable discoveries that others have never countenanced. The key factor is in ensuring that an accurate picture of the current research environment is portrayed without resort to bias or the injection of personal opinion.

It should also be noted that, in this chapter, despite the focus upon referencing, there has been no discussion of specific referencing techniques (or the semantics of referencing). The reason for this is that there are numerous techniques that are adopted in various journals and universities around the world. Although only several are in widespread usage (e.g., the Harvard - author name and publication year technique), many universities provide an open specification for referencing in theses - the end objective being only to ensure that references are systematic and unambiguous. On the other hand, referencing techniques are specified in detail in individual journals, conference proceedings, etc. However, regardless of the adopted format, these are only the semantics of the review process, the actual mechanics of which require a great deal of consideration on the part of a research student.