10 THE MECHANICS OF A THESIS

10.1 Overview

In the preceding chapter, it was noted that a thesis or dissertation is composed of two ingredients - body and soul. The body of the thesis is contained within the text and the soul is contained within the sub-text. However, in the preceding chapter, the primary emphasis was upon the soul of the thesis. In this chapter, the emphasis is upon the body.

Although a thesis has both body and soul, its primary function is as a document which demonstrates a learning of the "business of research" - as such, a thesis is not necessarily intended to be a work of art but, if both functions can be achieved, then so much the better.

A thesis can be structured in any number of ways and still achieve the desired end results. In this text, however, the emphasis is on only one particular form of thesis structure, which is based upon the division of the research documentation into seven chapters. The approach put forward here is not presented as a definitive one and nor is it suggested that it is better than any number of other approaches. However, the approach adopted here is both comprehensive and systematic and should, at the very least, produce a well-structured document.

For many research students, the research dissertation is their first

attempt at creating a lengthy document, which can range from 100 - 300 pages. In the absence of any previous writing experience, it is difficult to produce such a document and maintain:

- A sensible flow of arguments
- A systematic writing and sectioning style
- A detached perspective which ensures comprehensive subject coverage.

It is therefore useful to begin by using a well-proven template and then make variations to that template, rather than by creating an untried presentation style which may ultimately need to be completely revised. Research students seldom have the time luxury of being able to experiment with a thesis style and then completely rewriting the thesis in another style if the first has been inappropriate. It must be remembered that a dissertation can take several months of full-time writing for a novice writer - a complete rewrite is therefore highly undesirable.

The objective of this chapter is to provide a template style which is particularly well suited to theses involving design, implementation or study, and analysis of experimental results - that is, theses in engineering, medicine, the sciences, social studies and so on. A similar template style, with variations, may also be suitable for research in other disciplines.

It also needs to be noted, prior to adopting this style, that each university has its own peculiar list of requirements in terms of the mechanics of a thesis, specifically:

- The order and style of preliminary pages, including titles, tables of content, acknowledgments, dedications, index, etc.
- The layout of the thesis, including margins, headers, footers, font types, etc.
- The referencing styles required by the university, research institute or department.

The template provided herein is based upon the assumption that the final thesis will need to fit into such university-specific requirements.

10.2 The Seven Chapter Structure

In this text, the thesis is treated as a historical document that needs to be written in a timeless fashion so that it can remain as a permanent reminder of the sorts of research and thought processes that were applied at a particular period in time. In a research program, which involves the investigation and testing of a methodology, a thesis can be developed with a main body which is composed of seven chapters. The overall structure of the thesis is shown in the template in Table 10.1.

Each chapter, within the template structure shown in Table 10.1, has a specific function in terms of conveying, to the reader, the basic steps that were involved in the student "learning how to conduct a systematic investigation". These basic steps include:

(i) Establishing a clear purpose for the research (Introduction)

(ii) Documenting how a student learnt from others (Literature review)

(iii) Putting forward an idea in detail (Methodology)

(iv) Documenting how the boundaries of the idea could be tested without bias (Experimental Design)

(v) Presenting information/data by which others can judge the limitations of the idea (Experimental Results)

(vi) Discussing how the research outcomes can be critically interpreted in a broader arena (Broad Context Discussion)

(vii) Identifying the relationship between the original objectives, the final experimental results and the overall contributions of the work (Conclusions and Recommendations).

A study of the seven chapters reveals that the structure of the thesis is largely independent of the specifics of the research itself because, regardless of the subject matter, the process of learning about systematic investigation, is essentially a constant.

Chapter or Section Title	***Purpose***
Abstract	A short piece of text that summarizes the research program and its findings. The abstract is used by others for library cataloguing and literature search purposes
1 Introduction	A chapter designed to overview the purpose and background of the thesis, together with the proposed methodology and testing techniques. The introductory chapter needs to summarize what existed prior to the research; the specific contributions of the research and what existed after the research was completed. The chapter should also provide an explanation of how a defense of the research is presented within the remaining thesis structure
2 Literature Review	This chapter summarizes the mechanisms by which the research student identified key researchers and the major forums for publication of work. The research student needs to demonstrate, in this chapter, how he/she developed a research methodology and experimentation scheme based upon the work of peers.
3 Methodology	The methodology chapter details the proposed ideas and concept that form the basis of the investigation
4 Experimental Design	This chapter is critical to the research student because it demonstrates how he/she was able to develop unbiased, systematic procedures for testing the validity of the proposed methodology
5 Experimental Results	The results chapter provides a forum for the research student to systematically present and summarize the data arising from the experiments/studies that were performed.
6 Broad Context Discussion	It is particularly important for the research student to take the experimental results and provide a discussion of their broader context - how they compare with other researchers and published work; how significant the results are to society, industry or a broader field of study.
7 Conclusions and Recommendations	The final chapter which summarizes, in an unbiased manner, the findings of the research, relative to the stated objectives in the first chapter. The concluding chapter should also highlight the deficiencies of the research and how these could be remedied through further investigation.
Appendices	The appendices are used as an area for storing information which is important to the arguments raised in the thesis but, because of its length, detail or complexity, would otherwise interrupt the flow of arguments in the thesis.
Bibliography / References	A detailed listing of the sources from which knowledge and specific information was acquired.

Table 10.1 - The Seven-Chapter Thesis Template

It goes without saying that, given a basic thesis structure is largely independent of the specifics of the research, then the thesis can be written during the course of the research program and, at the very least, before its conclusion.

As a general rule, once a comprehensive initial literature review has been completed and a detailed methodology (or proposal for investigation) has been put forward, then all of Chapters 1 - 4, as outlined in Table 10.1, can be completed to final draft form. However, many research students prefer, instead, to wait until the research has been completed before commencing the preparation of their thesis. This is a particularly naive and ill-informed method of attack because:

(i) In addition to being a historical document of research, a thesis is also a detailed blueprint for research and experimentation - it is the student's professional responsibility to be the first person to test the validity of the writing in the thesis by following his/her own experimental procedures, outlined therein. This ensures that the work can be reproduced by others who subsequently read the thesis.

(ii) The various chapters included in a thesis are not there as a mere formality. The introduction sets the simple theme of the research. The literature review presents the supporting theory, upon which the simple theme is justified, and the detailed methodology describes an investigation that follows on from the review. The experimental design, by necessity, shows how a series of experiments follow on from the review to substantiate the simple theme. All of the physical research work must tie together as seamlessly as the thesis.

(iii) Many students labor under some illusion that it is a simple task to reverse-engineer a thesis after the research has been completed. Inevitably, the seamless linkages, described in (ii), cannot be found; experimental procedures prove inadequate to justify the simple research theme, and so on.

In summary, to an experienced professional researcher in the field, a reverse-engineered thesis looks like an unconvincing reverse-engineered thesis, and not as a seamless and fluent professional document.

One could go further and state that the entire first draft of a thesis should be written ***prior*** to the conduct of the very first experiment. Indeed, in many cases, this would greatly enhance the quality of the research work. How is this possible? Firstly, because a person who writes the early

chapters of a thesis, in the absence of any experimental results, will more likely write in an open-minded sense and without any predisposing statements that highlight a bias. Secondly, because, at the commencement of the program, the outcomes of the research work should genuinely be unknown as far as experimental results are concerned and, hence, the thesis writing should be such that it can handle any number of scenarios emerging from the experimental results. On the other hand,- a thesis which is written after the event, tends to display a bias in the writing style that suggests that the work was always predisposed to achieving particular outcomes. In the absence of any physical experimental results, a broad discussion could therefore focus, in a balanced manner, on the positive and negative attributes of any achieved outcome scenario.

Writing an open-ended draft of an entire thesis, prior to the conduct of any experiments, takes a considerable amount of discipline and a focus upon what is ultimately to be achieved from the research program - many students would say that the ultimate goal is the "correct set of results" - a professional researcher would say that the ultimate goal is a correct and open-minded research procedure. The seven-chapter template format for thesis is particularly useful because it enables students to look at the ultimate goals of their research from the perspective of the professional researcher. In other words, to step back from the trees and see the woods.

10.3 Complexity Flow

A common fault of research students is the construction of thesis sentences and paragraphs which are completely incomprehensible to a reader because of the:

- Number of large words that are not in common usage
- Number of technical terms and acronyms
- Amount of mathematical or chemical formulae that are employed
- Amount of jargon.

Given that the objective of the thesis is for the writer to convey a message to the reader, it would be all too easy to believe that many research students are desperately endeavoring to achieve the exact opposite effect.

Rule 8:

A cardinal rule of thesis writing is that if one cannot explain something in simple terms, then one does not understand what is to be explained. All subjects, regardless of their technical complexity, can be broken down into explanations that are written in simple English, and which are comprehensible to the lay-person. Those who cannot do this are not ready to begin the thesis writing process.

A large document, whether it be a thesis, a novel or a report, needs to have a writing style which draws the reader in, rather than pushes the reader away. Any thesis chapter, section or subsection which begins with complex concepts or sentences will push the reader away because it creates a mental impediment to the communication process. The objective is to make it easy for the reader to follow the first sentence so that the reader will naturally want to take in the second, and so on.

Another important issue with a large document is that, after a reader has been led in to a number of complex arguments and statements, the polite (astute) writer will gradually lead the reader out by a series of statements that become increasingly more summative and generic in nature.

Rule 9:

The complexity of arguments, that are put forward in a thesis, needs to migrate from simple, through to elaborate, and back to simple in order to draw the reader into the work and ease the reader out of the work.

The basic flow of complexity within a thesis is schematically shown in Figure 10.1. In summary:

- The introductory chapter should be written in simple terms, that can be comprehended by an intelligent lay-person. The introduction conveys the simple theme of the research to the reader.
- Gradually, the reader should be drawn in, by following the student's learning experience, in the literature review, and coming to terms with the current state of knowledge in the field.
- Once this has been achieved, the complexity of arguments and details in the methodology and experimental design sections increases to the leading edge of knowledge in the field.
- As experimental results are presented, the complexity of arguments should decrease because experimental results are designed to draw the reader back to the simple research theme elucidated in the first chapter.
- The broader context discussions should again be intelligible to the lay-person, and the conclusions should be concise and, in simple terms, relate all that has been achieved, back to the originally-stated objectives in the introduction.

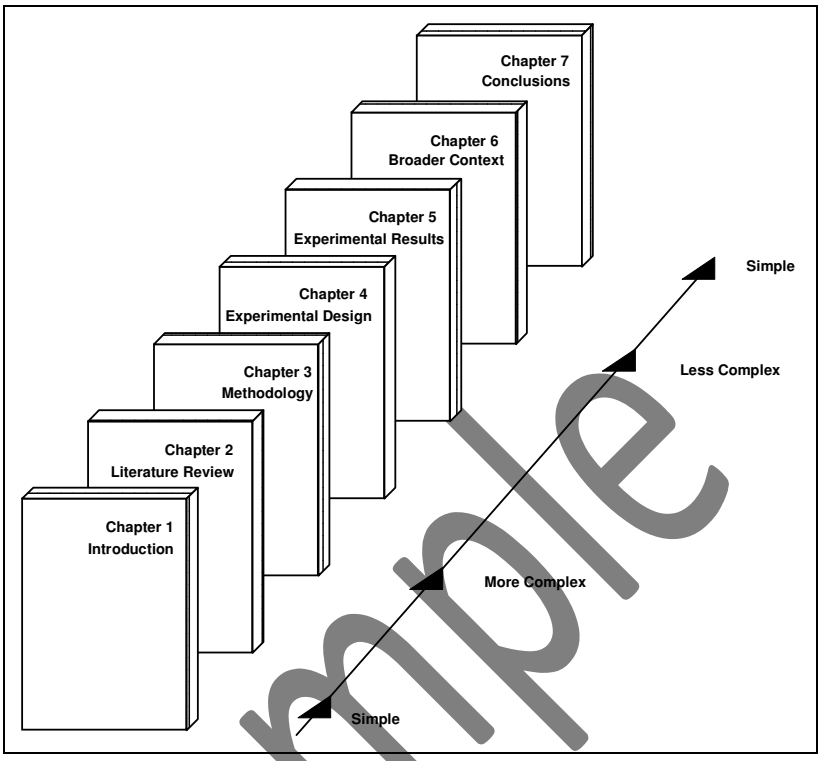

Figure 10.1 - Flow of Argument Complexity in a Thesis

The same flow of argument complexity should be applied within each thesis chapter and then section and sub-section. Each chapter should commence with a simple statement of what is to be achieved and each chapter should end with a summation of what has been achieved and how it relates to the initial objective. The only difference between the overall thesis, an individual chapter, or a section or sub-section, is the pace at which the complexity of arguments increases or decreases. In a chapter, arguments may move from simple to complex within one section. In a section, the change may be from one paragraph to another and, in a sub-section, arguments may move from simple to complex within one or two sentences.

Within the confines of the seven-chapter template, each chapter in the thesis needs to be subdivided to reflect the changing complexity of arguments. Table 10.2 provides an outline of section headings which fits

into the seven-chapter format and enables this to occur. Again, it becomes evident that the subdivision of thesis chapters can be largely independent of the specifics of the research program. The key factor in the thesis structure is ensuring that the reader learns in the same manner as the research student - in other words by moving from simple concepts, through progressively more detailed arguments and then by summarizing what has been achieved. It is also important to note that complex thesis structures are notoriously difficult to convert into documents that have a natural progression from simple arguments to detailed arguments and back to simple arguments. The choice of a complex thesis structure makes the task of both the research student and the reader considerably more difficult. Example 10.1 shows a typical example of a complex thesis structure, where a series of case studies or experiments form the basis of individual chapters.

Example 10.1 - A Complex Thesis Structure

Chapter 1 - Introduction

Chapter 2 - Literature Review for Case Study 1

Chapter 3 - Methodology and Experimentation for Case Study 1

Chapter 4 - Literature Review for Case Study 2

Chapter 5 - Methodology and Experimentation for Case Study 2

Chapter 6 - Literature Review for Case Study 3

Chapter 7 - Methodology and Experimentation for Case Study 3

Chapter 8 - Conclusions

The end result of such a structure is that the flow of argument complexity, from the beginning of the thesis to the end, oscillates between simple and complex - to the extent where the reader cannot elicit a simple set of conclusions from the work. The important lesson is to always ensure that the thesis structure is suited to the required flow of arguments.

Chapter	*Section*	*Title*
1		**Introduction**
	1.1	Overview of the Research Program
	1.2	Background
	1.3	Overview of Proposed Methodology
	1.4	Overview of Experimental Procedures
	1.5	Perceived Specific Contributions of the Research
	1.6	Thesis Structure
2		**Literature Review**
	2.1	Overview of the Literature Review Process
	2.2	General Theory
	:	More Specific Theory
	:	Detailed Theory
	2.N	Summation and Resulting Research Directions
3		**Methodology**
	3.1	Overview of the Methodology
	3.2	General Theory
	:	More Specific Theory
	:	Detailed Theory
	3.N	Summation
4		**Experimental Design**
	4.1	Overview of Experimental Design
	4.2	General Theory
	:	More Specific Theory
	:	Detailed Theory
	4.N	Summation
5		**Experimental Results**
	5.1	Overview of Experimental Results
	5.2	General Results
	:	More Specific Results
	:	Detailed Results
	5.N	Summation of Results
6		**Broad Context Discussion**
	6.1	Overview of Significance of Experimental Results
	6.2	More Specific Discussions of Context
	:	Detailed Discussions of Context
	6.N	Summation of Significance and Context
7		**Conclusions and Recommendations**
	7.1	Overview of Research Findings
	7.2	Perceived Research Contributions
	7.3	Limitations of Research
	7.4	Recommendations for Further Research
	7.5	Concluding Remarks

Table 10.2 - Sectioning Chapters to Ensure the Flow of Argument Complexity

Rule 10:

The thesis structure must be able to support a logical flow of arguments, commencing with a simple concept and migrating towards detailed ideas and then back to simple summations. Without such a structure, the likelihood of an inexperienced author convincingly conveying a message to a reader is greatly diminished.

It should now become evident that one of the reasons the seven-chapter approach to thesis preparation is put forward in this text is that this structure is based upon the smooth flow of arguments.

A common error, however, is the belief that a smooth flowing series of arguments can be superimposed upon a thesis structure that is not designed to sustain such a flow. This error tends to occur subconsciously, in the sense that many students do not consciously think about the flow of arguments in a thesis - preferring, instead, to view the thesis as a set of independent chapters, from which a reader can somehow assemble a perspective on the research. In other words, the error is that students focus on "*what*" is to be said, rather than upon "*how*" it is to be said. Having studied the flow of arguments, it should be clear that without a focus on the "*how*", the "*what*" can be altogether lost in the context of a long document.

10.4 Thesis Balance - Body and Appendices

The logical flow of arguments in a thesis can often be interrupted by large quantities of:

- Mathematics
- Chemical equations
- Computer program source code
- Raw experimental data.

Each of these elements may play an important role in enabling a reader to reproduce the work in the thesis but none may be necessary in order to understand the research student's flow of arguments - in many cases, their inclusion may be counterproductive to the presented arguments. For this reason, a thesis is divided into a main body and a series of appendices. The main body presents a series of reasoned arguments, and the appendices provide the supporting details.

Unfortunately, many research students have come to regard appendices as a repository for computer source code listings, vast quantities of unprocessed raw data, and so on. The naive belief is often that a reader will believe that the dissertation is all the more impressive because it is thicker as a result of the appendices (the corollary being that an otherwise mediocre document might be mistakenly be viewed as a landmark piece of research). Needless to say, the reality is that intelligent readers are capable of discerning between supporting documentation and mere "padding" of work. For this reason, it is important that research students understand the significance of appendices in a thesis.

In Section 10.3, the importance of establishing a smooth flow of arguments in a thesis was highlighted. This is the key factor in facilitating the flow of ideas and concepts from the writer to the reader. However, it is also important to remember that a reader is, in the first instance, just a reader - even when the reader is an examiner. In other words, the first objective of a thesis reader is to come to terms with what has been achieved in the research program, and the nature and quality of the defense that has been put forward. Normally, this means that the thesis reader is not interested in understanding and verifying every mathematical and chemical equation, or in compiling every piece of presented computer source code to ensure that it is bug-free. The reader's assumption is that the researcher and his/her supervisors have already checked all of these elements.

It is also important to remember that a thesis is not a 10th Grade school assignment that needs to be embellished with unnecessary mathematics, chemistry and so on, in the belief that it will impress the reader. For this reason, the presentation of mathematics, chemistry and computer programming in a thesis needs to be carefully considered, as does the balance between the body of the thesis and the appendices.

As a rule-of-thumb, the appendices in a well-balanced document (whether it be a thesis or a report) should be no more than 10-15% of the size of the main body. Appendices which represent a large proportion of the main document body suggest that the author is incapable of summarizing information and concepts and presenting them in a smooth-flowing document - or, worse still, that the author is padding a document in order to make it appear more impressive.

Research students often have severe reservations about curtailing their entries into appendices because they feel that they should present everything that has been done, during the course of the research, so that an examiner might appreciate the scope of the work. This is a somewhat misguided approach that inevitably fails to achieve the desired outcomes because it tends to muddle the arguments that are presented and because it suggests that the author is confused about what is to be presented. With this in mind, one needs to consider the important primary role of appendices, in providing supporting information for work in the body of a thesis.

The first issue that needs to be addressed is the presentation of mathematical or chemical equations within the body of a thesis. Although these issues are debatable, two factors that need to be considered are as follows:

- Mathematical and chemical equations should only be included in detail when they are absolutely central to a particular argument - for example, when the argument specifically relates to a mathematical or chemical problem. In other instances, only the summarized results need to be presented.
- If mathematical or chemical equations are used in a thesis, it is important for the author to explicitly summarize their purpose so that the reader does not need to interpret (decode) the work.

Consider the following example of how mathematics can ruin the flow of an argument.

Example 10.2 - Mathematics Interrupting the Flow of an Argument

The magnetic field intensity was initially defined in the cylindrical coordinate system by:

$$\underset{\sim}{H} = \frac{1}{\mu}\left(J \times \left(\underset{\sim}{\hat{r}} A_z \cos\theta - \underset{\sim}{\hat{\theta}} A_z \sin\theta \right) \right)$$

but

$$J \times \underset{\sim}{A} = \underset{\sim}{\hat{r}} \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}\left(A_\phi \sin\theta\right) - \frac{\partial A_\theta}{\partial\phi} \right] + \underset{\sim}{\hat{\theta}} \frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial A_r}{\partial\phi} - \frac{\partial}{\partial r}\left(rA_\phi\right) \right] + \underset{\sim}{\hat{\phi}} \frac{1}{r}\left[\frac{\partial}{\partial r}\left(rA_\theta\right) - \frac{\partial A_r}{\partial\theta} \right]$$

$\therefore$

$$\underset{\sim}{H} = \frac{1}{\mu}\left[\underset{\sim}{\hat{\phi}} \frac{1}{r}\left[\frac{\partial}{\partial r}\left(-rA_z \sin\theta \right) - \frac{\partial}{\partial\theta}\left(A_z \cos\theta\right) \right] \right]$$

$$= \frac{\underset{\sim}{\hat{\phi}}}{\mu r}\left[\frac{j\beta \sin\theta Idz}{4\pi r} e^{-j\beta r} + \frac{Idz\sin\theta}{4\pi r^2} e^{-j\beta r} \right]$$

$\therefore$

$$H_\phi = \frac{Idz}{4\pi} e^{-j\beta r}\left[\frac{j\beta}{r} + \frac{1}{r^2} \right] \sin\theta$$

A more meaningful discussion could be presented by reducing the mathematical content in the body of the thesis, as shown in Example 10.3.

Example 10.3 - Smoothing the Flow of an Argument

The magnetic field intensity was initially defined in the cylindrical coordinate system by its relationship with orientation (θ) and current (J):

$$\underset{\sim}{H} = \frac{1}{\mu}\left(J \times \left(\underset{\sim}{\hat{r}} A_z \cos\theta - \underset{\sim}{\hat{\theta}} A_z \sin\theta \right) \right) \qquad \text{...(9)}$$

From this relationship, the magnitude of the intensity of the field in the ϕ direction could be extracted:

$$H_\phi = \frac{Idz}{4\pi} e^{-j\beta r}\left[\frac{j\beta}{r} + \frac{1}{r^2} \right] \sin\theta \qquad \text{...(10)}$$

This derivation is presented in detail in Appendix C.

In Example 10.2, the reader is expected to analyze the intermediate steps of a mathematical derivation with no clues provided as to the significance of those steps. In Example 10.3, only the important relationships are presented and even these are summarized in English for the benefit of the reader. If the derivation is of significance to the research presented in the thesis, then it can be placed into an appendix and referred to accordingly. On the other hand, if the derivation is merely a conventional mathematical process (e.g., algebraic manipulation or basic calculus), which has no intrinsic value to the research direction, then perhaps it need not be included at all.

In each instance, whether it be mathematical or chemical, the research student therefore needs to determine the significance of the inclusion to the thesis. If the only purpose of the mathematics or chemistry is to impress the reader, then it should not be in the thesis body.

Mathematical and chemical equations are not the only problems that are encountered in the balancing of the thesis body and the appendices. The

other common problem relates to the presentation of computer software. This is a more complex problem to resolve and there are differing opinions on what need or need not be presented in a thesis. In this text, which represents only one opinion on the subject, a particular viewpoint is adopted and, in order to understand this viewpoint, one needs to have an understanding of how it is justified.

Firstly, one needs to consider an analogous problem in order to highlight the reasoning associated with the presentation of computer software. Consider then, a thesis which is based upon some form of chemical experimentation. Consider the level of detail that is required in explaining the experiments and the apparatus. Is it necessary to detail, in the thesis, the composition and geometric shape of every test-tube and beaker that is used in the research? The answer is clearly no. The reason is that the test-tubes and beakers are merely common tools in the experimentation process, which can readily be reproduced by other researchers (because they are a commodity item) without any specialized knowledge. The basic rules of thumb that can be derived from this example are as follows:

Rule 11:

Details that should be included in a thesis are those that enable another researcher, who already has access to general technical or professional skills, to reproduce the experimental conditions and tests in a thesis so that the work can be verified.

Rule 12:

Details that can be excluded from a thesis are those that describe items which can be produced by a technician or professional practitioner without any specialized knowledge of the purpose of the research.

Hence, in a thesis, there is no need to describe the metallic composition of tweezers, or the elasticity of the graphite that was in the pencil which was used to record results. There is no need to explain how long division is performed or the meaning of the word "percentage". In order to make the

writing of a thesis practical, some assumptions must therefore be made about the reader. These assumptions apply more clearly to areas such as mathematics, chemistry and physics than they do to theses about software.

In the case of research, software can appear in many forms - for example, commercially-acquired application packages, which the researcher has used to extract results, or purpose-developed software that has been created by the researcher. In this text, the following perspectives are therefore applied in regard to software in a thesis:

(i) Software and software applications are no different to test tubes or beakers in the scheme of a thesis unless the specific objective of the research is to enhance the software development process (e.g., the research is in computer science and the purpose of the research is to develop a new computer language).

(ii) If the software or software applications are used as tools in a thesis (e.g., to simulate some physical phenomenon) then the level of detail involved in documenting them should be on the basis that the software is only a means of establishing some experiment - and that it is the experiment which is the central theme of the thesis.

(iii) In situations where a researcher has used a commercially-available software package to achieve research outcomes, the level of detail included in the thesis should relate to the strategic issues that another researcher would have to address in order to reproduce the work with a similar package - the level of detail should not be a step by step user guide for a specific software package.

(iv) In situations where a researcher has developed software, from first principles, the level of detail included in the thesis should relate only to the strategic issues associated with the development - that is, the "specification" or "flow chart" or "object structure" or "block diagram" of the software, from which any professional software developer should be able to develop his/her own version of the software.

(v) The development of conventional source code, within the context of a research program, is a technical issue that could justifiably be transferred to an outside contractor without affecting the integrity of the research work - hence, the detailed listing of conventional source code is as unnecessary as the detailed listing of the procedures required to make a wooden bench for a laboratory experiment.

In order to understand the significance of the above perspectives consider Example 10.4 and Example 10.5:

Example 10.4 - Frivolous Explanation of a Software Application

In using the Xylog mathematical simulation package, the following steps were used:

(a) The computer was turned on and the screen was allowed to warm up before pressing the enter key several times

(b) In order to execute the simulation package it was necessary to move the mouse to the top left hand corner of the screen where an icon, representing the software package, was displayed

(c) The mouse button was clicked two times and after a pause the opening screen of the software appeared

(d) The opening screen had ten possible menu options, and in response to each of these the following numbers were typed in (followed by pressing the Enter key on the keyboard, which had 101 keys)...

Example 10.5 - Professional Explanation of a Software Application

In order to model the relationship between the magnetic and electric field intensity, it was necessary to employ a computer-based mathematical simulation package, which was commercially available at the time this research program was conducted. The package was produced by the Xylog Corporation and was typical of a number of similar packages available at the time. The key elements involved in modeling the relationship included:

- *The establishment of the mathematical relationship within the software application*
- *The definition of boundary parameters for the modeling...*

The level of detail provided in Example 10.4 tends to make the software the focus of the research dissertation, which is clearly inappropriate. In Example 10.5, the software is presented in its true light – that is, one of a number of packages that could be used to facilitate the experimentation process that was the focus of the research.

Examples 10.6 and 10.7 highlight various treatments of source code in theses. In Example 10.6, the frivolous "padding" approach is adopted, where the researcher endeavors to impress by diverting attention away from the central argument of the thesis. Moreover, the software in 10.6 represents only one possible implementation of the software in one particular language. In Example 10.7, the software is again professionally presented as a "means to an end", rather than the "end" in itself. In other words, the software is placed into the context of the research program, which has a broader agenda than just software development. Additionally, in Example 10.7, the assumption is made that any professional software developer, given the block diagram of the modular structure, and the flow-chart for the specialized routine, could reproduce the software in any high-level language.

Example 10.6 - Frivolous Inclusion of Source Code in Theses

In this research it was necessary to develop a routine that could be used to count the number of radio-active pulses emanating from the specimen. The code that was used was as follows:

```
Procedure Count_Radio_Active_Pulses;

Var
Counter, Pulse_Count : Integer;
Pulse_Matrix:  Array [1..10] of Byte;
Begin {Count_Radio_Active_Pulses Procedure}
For Counter := 1 to Max_Count do
  Begin {For Loop}
  Pulse_Count := Pulse_Count + 2;
  Pulse_Matrix [Pulse_Count] := Counter + Pulse_Count;
  End {For Loop};...
```

Example 10.7 - Professional Explanation of Software Development

In this research, it was necessary to develop software that could be used to count the radio-active pulses emanating from the sample. The key elements of the software were composed of a number of modules which are shown schematically in Figure 3.9, which highlights the relationship between the modules. Most of the modules were achieved through a conventional high-level language. However, one routine, which was used to count high-level pulses, required some specialized algorithm development and the flow chart for this routine is provided in Appendix D...

Note also that, in Example 10.7, lengthy discussions on the software are avoided, and items which disrupt the flow of the thesis are relegated to the appendices, provided that they are necessary for outsiders to reproduce the work.

10.5 A Unitary Document - Chapter/Section Linkages

A thesis may be composed of a number of chapters but it is intended to be more than the sum-total of the individual chapters.

Within a thesis, there needs to be a flow of ideas from chapter to chapter and it is particularly important to note that chapters are not independent. This is in contrast to many text books (including this one) where it is possible to read chapters as individual modules. However, it is unwise to extend the modular concept to the development of a thesis because the strength of the central argument can be lost through modularization. In other words, a literature review is not just a literature review - it is a review that is undertaken to advance a simple research theme (i.e., idea) into a methodology. A methodology is not just a methodology, it is a detailed proposal, based upon a literature review, that needs to be tested through experimentation, and so on. Hence, within the seven-chapter thesis template, introduced in this text, each chapter is a sub-set of a central argument and, hence, each chapter needs to connect to the following chapter. The final chapter (i.e., the Conclusions chapter) needs to connect back to the central theme of the research that was put forward in the first chapter (i.e., the Introduction chapter).

The concept of chapter linkages is shown Schematically in Figure 10.2. However, some clarification is required in the context of the thesis section structure which was originally presented in Table 10.2. As a starting point, it needs to be remembered that each chapter of a thesis is divided into sections - the first section provides an overview of the chapter and the last section provides a summation of the chapter. In achieving the required linkages between chapters, it is therefore important that the text in these sections provides the required connections. Consider Example 10.8 and 10.9:

Example 10.8 - Literature Review Summation with Linkages

2.8 Summation

The findings of this literature review were used as the basis of the methodology, which is presented in detail in Chapter 3. In particular....

Example 10.9 - Methodology Overview with Linkages

3.1 Overview

The methodology, which is detailed in this chapter, was based upon the work of Summers (1968) who was one of the seminal authors in the field. His research, which was summarized in the literature review in Section 2.4, was critical to the determination of...

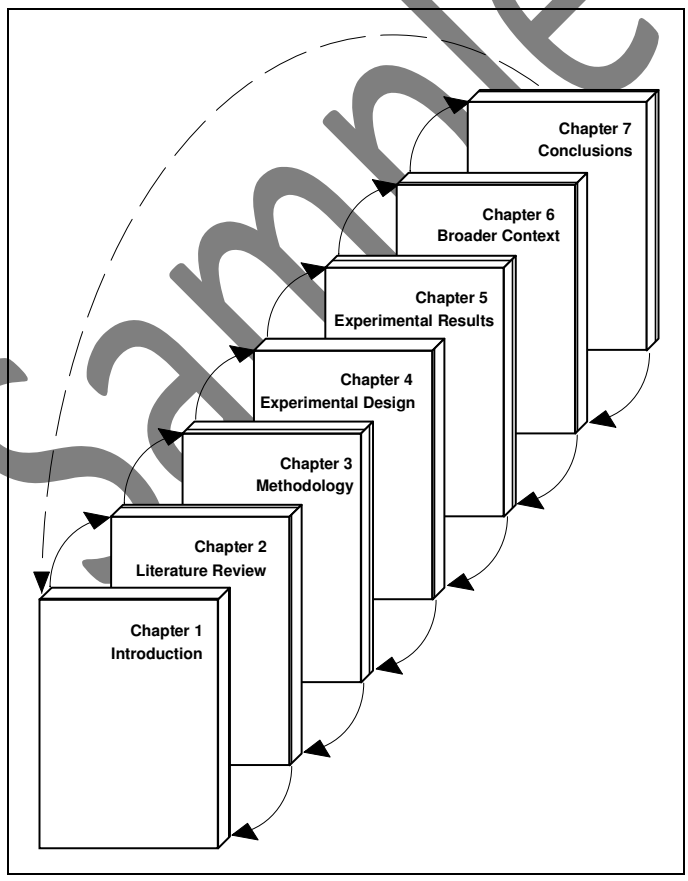

Figure 10.2 - Logical Chapter Linkages in a Thesis

Despite the fact that it is the final chapter, the concluding chapter of a thesis also needs to link backward and forward via a number of mechanisms:

- A backward linkage is made to the preceding chapter, explaining why the conclusions follow on from the broad context discussion of the preceding chapter
- A backward linkage is made to the introductory chapter, where the originally stated research objectives are related to the research findings, and where the contributions are restated in the light of the research outcomes
- A forward linkage into the unknown is provided by a reference to further work that needs to be undertaken by other researchers, in order to address any existing deficiencies in the work, or to enhance the work through further contributions of knowledge.

Once the basic linkages between chapters, from the introduction through to the conclusion, are recognized then the same process has to be applied to sections and sub-sections. The process of linking portions of a thesis applies as much to sections and sub-sections as it does to chapters. Sections and sub-sections need to link together as smoothly as chapters in order to preserve the integrity and flow of arguments.

10.6 Consistency in Sectioning, Style and Labeling

Rigor in research is not solely confined to the technicalities of the subject matter. Self discipline is also required in the editorial format of the thesis in order to convey a portrait of a careful and systematic writer to the thesis reader.

A common problem area with theses relates to ambiguities and inconsistencies in sectioning and labeling of work. Hence, as a starting point, it is important that a systematic approach is adopted to dividing chapters into sections and sub-sections. The basic rule is as follows:

Rule 13:

If a thesis chapter X is divided into Y sections, then all text must logically fall under Sections X.1 - X.Y in order to maintain consistency of numbering - there should be no floating text - the same approach applies mutatis-mutandis to sub-sections.

The following examples highlight different sectioning techniques that can be adopted:

Example 10.10 - Incorrect Sectioning of a Thesis Chapter

2. Literature Review

The literature review was conducted over a period of 18 months and, during that time, a number of landmark research papers were uncovered....

2.1 History

:

:

2.9 Summation

Example 10.10 has some text which is left floating without a section number - even though it could be implicitly assumed that this section was intended to be 2.0, the technique is inconsistent. Clearly, the sectioning of the chapter implies that the chapter is divided into nine sections (2.1 - 2.9) and yet ten sections of text are included therein. Example 10.11 shows the correct approach where all text is bound under an appropriately titled section.

Example 10.11 - Correct Sectioning of a Thesis Chapter

2. Literature Review

2.1 Overview

The literature review was conducted over a period of 18 months and, during that time, a number of landmark research papers were uncovered....

2.2 History

:

:

2.10 Summation

The overall objective of ensuring that a thesis comes together as a unitary document, rather than as a collection of independent chapters, therefore needs to be met by three linking mechanisms:

- Formal argument flow - which ensures that the presented arguments are consistent and sequential from one chapter to the next
- Explicit editorial linkages - where the overviews and summations of chapters form the seams between the chapter boundaries
- Implicit editorial linkages - where section, sub-section, paragraph and object (i.e., diagrams, tables, etc.) numbering is consistent throughout the document to create a unified

appearance.

The editorial aspects of the thesis should not be overlooked because they create a sub-text that reflects the author's ability to maintain consistency and logic. Although it may appear to be a trivial issue, the presentation of poorly selected (or ambiguous) numbering schemes for paragraphs (or other objects) can mar the appearance of the final thesis. Some representative examples illustrate the issues that arise from editorial inconsistency.

Example 10.12 - Poor (Ambiguous) Paragraph Numbering

2. Literature Review

2.1 Overview

The literature review was conducted over a period of 18 months and the major elements were divided into three categories:

1. *Historical Aspects*
2. *General Theory*
3. *Specific Papers Related to the Research Theme.*

These three elements served to provide...

In Example 10.12, the author has chosen to number three paragraphs within a sub-section. However, the purpose of paragraph numbering is to enable subsequent backward references to be made to those paragraphs. Unfortunately, in Example 10.12, the paragraphs have been numbered with numerals which correspond to chapter numbers in the thesis. This makes any future references ambiguous. The correct approach is shown in Example 10.13, where the paragraphs are numbered with lower-case Roman numerals.

Example 10.13 - Correct Paragraph Numbering

2. Literature Review

2.1 Overview

The literature review was conducted over a period of 18 months and the major elements were divided into three categories:

(i) Historical Aspects

(ii) General Theory

(iii) Specific Papers Related to the Research Theme.

These three elements served to provide...

Using Example 10.13 as a base, it is evident that subsequent backward references can be unambiguously made to the numbered paragraphs. For example:

"...This corresponds to the category previously listed in 2.1(ii)..."

Another common error in identification of paragraphs tends to occur as a result of having non-unique numbering ascribed to paragraphs within an individual section. In Example 10.14, the author wishes to numerically identify two, different sets of paragraphs within the same thesis section. However, as the example shows, the same numbering scheme has been applied to both sets, so that subsequent references to, say, 2.1(ii), would be completely ambiguous. The basic rule is as follows:

Rule 14:

Any items (e.g., paragraphs, list items), within a thesis section or sub-section, which are to be numbered for subsequent reference, must be uniquely numbered within that section or sub-section. If multiple sets of items need to be numbered,

then differing numbering schemes must be applied to avoid ambiguity.

Example 10.15 shows how the problem of Example 10.14 can be resolved by using upper-case Roman numerals for the second set of paragraphs - alphabetic labeling (a) - (d) could also have been applied.

Example 10.14 - Incorrect (Duplicate) Paragraph Numbering

2. Literature Review

2.1 Overview

The literature review was conducted over a period of 18 months and the major elements were divided into three categories:

(i). Historical Aspects

(ii) General Theory

(iii) Specific Papers Related to the Research Theme.

These three elements served to provide the basis for analyzing four different aspects of the research program:

(i) Microprocessor functionality

(ii) Data transfer rates

(iii) Microprocessor clock speed

(iv) Input/output bottle-necking

This led on to...

Example 10.15 - Correct Paragraph Numbering

2. Literature Review

2.1 Overview

The literature review was conducted over a period of 18 months and the major elements were divided into three categories:

(i). Historical Aspects

(ii) General Theory

(iii) Specific Papers Related to the Research Theme.

These three elements served to provide the basis for analyzing four different aspects of the research program:

(I) Microprocessor functionality

(II) Data transfer rates

(III) Microprocessor clock speed

(IV) Input/output bottle-necking

This led on to...

10.7 Writing Style - Tenses and Grammar

The writing style in a thesis is generally an issue of individual preference, and what may please an author may not please a reader – or vice-versa. However, there are some basic issues of writing style that need to be considered in order to improve the cohesiveness of the thesis and to ensure that it remains as a timeless document, to which reference can be made after many years or decades.

As a starting point, it is important to note that the authoring of a lengthy dissertation is, for a novice author, a demanding task. For many research students, the only experience with a lengthy document has generally been an undergraduate thesis, which may have been considerably shorter than one which is expected for a postgraduate research dissertation. For other research students, English is often a second language and the intricacies of the language become all the more apparent when a long document needs to be prepared.

There are four issues, associated with the preparation of a thesis, that generally cause concern. These are the:

(i) Tense in which the thesis needs to be written

(ii) Use of personal pronouns

(iii) Use of punctuation

(iv) Length of sentences.

It is important to note that what will be put forward herein is only one person's opinion on the above issues. There are contradictory views which also have validity and, in some cases, individual universities make provision for some of these issues in their research guidelines. The objectives in presenting one viewpoint here are to demonstrate the reasoning that needs to be used to justify a particular course of action and to facilitate the establishment of a consistent thesis writing style. Those who follow the arguments, expressed herein, may either elect to abide by them or to generate their own set of writing principles, and to adhere to those throughout the course of the thesis.

Issue (i) (i.e., *thesis tense*) is quite complex, and how it is handled depends upon the skill of the writer. A well-skilled writer can move from one tense to another and still maintain a smooth flowing set of arguments throughout the course of the document. However, a novice writer tends to confuse past, present and future tenses and the end result is an equally-confused

reader. Therefore, a good rule-of-thumb is as follows:

Rule 15:

A novice writer should always write each sentence in the thesis in the past tense. The only exception that should be made to this rule is when reference is made to "perpetual" truths - that is, mathematical/chemical expressions, references within the thesis itself, and so on.

The rationale for adopting this rule is that the thesis should read as a timeless document. Hence, each statement in the thesis should remain valid, whether it is read on the day it was written, or a century later. Secondly, the thesis is a historical document that describes events which took place at some earlier point in time - therefore, the past tense is generally the valid tense even on the day that the document is written. Consider the Example 10.16 and 10.17:

Example 10.16 - Confusing (Mixed) Tenses

The apparatus ***is*** *composed of an Ultrascan storage oscilloscope, coupled to a probe that* ***is*** *used to measure the induced voltage on a cell membrane. The Ultrascan oscilloscope* ***is*** *a high-bandwidth device that* ***is*** *capable of storing images of up to 7mS in duration. ...This* ***is*** *analogous to the work that Medlock (1958)* ***initiates*** *in his research into cell responses. ...The resulting voltages* ***were*** *transferred to the oscilloscope and then to a Unidex personal computer and the results* ***were*** *analyzed. The results* ***were*** *printed out and* ***are*** *shown in Figure 4.2. ...It* ***is*** *anticipated that these results* ***will*** *lead to significant advances in the observation of cell responses to chemical stimuli that...*

Example 10.17 - Past Tense Form of Program Description

The apparatus ***was*** *composed of a storage oscilloscope, coupled to a probe that* ***was*** *used to measure the induced voltage on a cell membrane. The oscilloscope* ***was*** *produced by Ultrascan Limited and,* ***at the time this experimentation was conducted****,* ***had*** *the highest bandwidth of any commercially available device. The oscilloscope* ***was*** *also capable of storing images of up to 7mS in duration. ...This experimentation* ***was*** *analogous to the work that Medlock (1958)* ***initiated*** *in his research into cell responses. ...The resulting voltages* ***were*** *transferred to the oscilloscope and then to a personal computer (commercially-****acquired*** *from Unidex). The results* ***were*** *analyzed and printed. The outcomes* ***are*** *shown in Figure 4.2. ...****At the time this research was conducted****, it* ***was*** *anticipated that these results* ***would*** *lead to significant advances in the observation of cell responses to chemical stimuli that...*

In Example 10.16, the author commences in the present tense and, subsequently, has difficulty in deciding how to continue in the same tense. The first stumbling block is a reference to previous work (by Medlock) which is, again, incorrectly cited in the present tense (i.e., the work by Medlock is actually a past event). Subsequently, the present tense no longer appears valid and the author reverts to the past tense and, ultimately, to the future tense. If the above tense changes are confusing at the time the document is written, consider how much more confusing the text will become a century later if it needs to be referred to at that time. Moreover, when an author uses a muddled combination of tenses, he/she often fails to recognize that many of the devices, to which references are made, may no longer exist or perform at the same level at some future time. To highlight the problem, consider a less-subtle example statement (10.18) that could have been written in the 1950s:

Example 10.18 - The Present Tense Can Rapidly Date Research

"It is not possible to calculate the stresses in the material, using a computer, because the task requires that more than 50,000 bits of data are stored. It is anticipated that such storage capacity will never become available..."

As in Example 10.16, Example 10.18 fails to address the fact that the thesis only represents results, equipment, knowledge and speculation that existed at a particular point in history. It is not simply a question of whether the technical aspects are correct but, rather, an issue of whether the grammar has correctly expressed the technical status at a point in time.

In Example 10.17, the original text has been rewritten from the perspective that the thesis may be read at some distant time in the future. All the text is in the past tense, with the exception of the reference to a thesis diagram which will exist "in perpetuity" with the text. The text in 10.17 also places speculation into its appropriate context by noting that the speculation was only valid at the time the research was conducted - this is not to say that the statement will necessarily become invalid, only that it may later be proven so. Another issue that is tackled in Example 10.17 relates to the perpetuity of apparatus used in a research program. In this example, it is assumed that the thesis will be read at some distant time and that, hence, there may need to be some explanation as to what particular names imply (e.g., a commercial producer of oscilloscopes).

Once the tense of the thesis is established, the research student generally needs to consider whether or not to make the thesis "personal" or "impersonal" through a selection of pronouns and phrasing. Opinions differ on this issue, with some reviewers preferring the use of personal pronouns and others denouncing their usage in theses and research papers. In this text, it is suggested that personal pronouns be avoided in a thesis for two reasons:

- While the thesis reports on historical events that centered around the research student, the generated knowledge should universally apply to others
- In as much as most of the work reported in a thesis is undertaken by a research student, the use of the personal pronoun becomes rather monotonous - further, if the personal pronoun is used then it is altogether reasonable that other contributors be given equal consideration.

Consider Example 10.19 and 10.20:

Example 10.19 - Personal Pronouns Lead to Monotonous Writing

I combined the samples in a ratio of 4:1 so that my test-case solution was more dilute than my reference solution. I then heated my test-case solution until my thermometer showed that my fluid temperature had reached 321K. My laboratory technician then transferred my test-case solution to his spectrometer which I subsequently calibrated with my reference solution.

Example 10.20 - Impersonal Writing Can Be More Interesting

The samples were combined in a ratio of 4:1 so that the test-case solution was more dilute than the reference solution. The test-case solution was then heated until the thermometer showed a fluid temperature of 321K. The test-case solution was then transferred to a spectrometer which was subsequently calibrated against the reference solution.

Example 10.20 essentially contains the same technical content as Example 10.19 but the minutia of "who did what" at a low level is eliminated, thereby enabling a reader to focus on the research procedures rather than the "doers" in the experiments. Of course, Example 10.19 is an exaggerated sample of what can happen but, nevertheless, over the course of a lengthy dissertation, the end result of a novice writer applying personal pronouns is often rather dull, if not verbose.

The issue of punctuation in theses is also a regular cause for concern, particularly because many authors in the sciences and engineering are notoriously poor in a grammatical sense. Moreover, many thesis authors have English as a second language and, hence, the additional task of adding commas, semicolons, colons, apostrophes, etc., causes considerable confusion. Given the complexities of the English language, it is often infeasible for potential thesis authors to master the grammatical idiosyncrasies of the language within the confines of a research program. One obvious solution is to appeal to others for assistance and support in the editorial aspects of the work - some universities provide professionals to advise on grammar and to edit theses. However, it is difficult for such professionals to assist unless the research student makes a reasonable

attempt at the punctuation in the first instance. Some basic rules may assist in this process:

(I) A useful starting point is to write a complete sentence, without punctuation marks, and to only add a full stop at the end of the sentence.

(II) Check the sentence for any "asides" (i.e., pieces of text that can be removed without changing the flow of the sentence). Insert commas before and after the asides.

(III) If a list of adjectives precedes a noun, then a comma should be inserted between adjectives which have equal rank (i.e., where the order of adjectives can be rearranged – coordinate adjectives). Commas do not need to be placed between adjectives in which the order has to be in a particular sequence (i.e., subordinate adjectives).

(IV) Read the entire sentence, from beginning to end, inserting any pauses where they should naturally occur. Commas should be inserted at the natural pauses.

(V) Insert colons before any lists of items to be presented.

(VI) Use semicolons to separate items on a list, if the list is within a continuous sentence structure.

(VII) Re-read the sentence and, if additional pauses are required in the final reading, add the necessary commas.

These rules will not make a poor writer into a great writer but, at least, they may serve to make a poor writer into a consistent writer – and one who will be better served by language support services in the university when final drafts of the thesis need to be generated. The basic rules are applied, step by step, to a lengthy sentence in Example 10.21

Example 10.21 - Punctuating a Sentence

(I) *The experimental apparatus was composed of a long thin glass pipette which had been commercially acquired and this was used in order to infuse saline solutions the test-case iodine solution an ammonia solution and the chlorine mixture.*

(II) *The experimental apparatus was composed of a long thin glass pipette**,** which had been commercially acquired**,** and this was used in order to infuse saline solutions the test-case iodine solution an ammonia solution and the chlorine mixture.*

(III) *The experimental apparatus was composed of a long**,** thin glass pipette**,** which had been commercially acquired**,** and this was used in order to infuse saline solutions the test-case iodine solution an ammonia solution and the chlorine mixture.*

(IV) *The experimental apparatus was composed of a long**,** thin glass pipette**,** which had been commercially acquired**,** and this was used in order to infuse saline solutions the test-case iodine solution an ammonia solution and the chlorine mixture.*

(V) *The experimental apparatus was composed of a long**,** thin glass pipette**,** which had been commercially acquired**,** and this was used in order to infuse**:** saline solutions the test-case iodine solution an ammonia solution and the chlorine mixture.*

(VI) *The experimental apparatus was composed of a long**,** thin glass pipette**,** which had been commercially acquired**,** and this was used in order to infuse**:** saline solutions**;** the test-case iodine solution**;** an ammonia solution and the chlorine mixture.*

(VII) *The experimental apparatus was composed of a long**,** thin glass pipette**,** which had been commercially acquired**,** and this was used in order to infuse**:** saline solutions**;** the test-case iodine solution**;** an ammonia solution**,** and the chlorine mixture.*

A novice writer, or a person for whom English is a second language, would have difficulty in punctuating a lengthy, complicated sentence, such as the one shown in Example 10.21. Ironically, however, in reading theses, it is often the case that such writers are the ones who generate the lengthiest sentences. In some theses, the reader is subjected to page after page of lengthy sentences that need to be interpreted. Given that the text within these sentences is generally technical and complex, the reading process becomes both difficult and monotonous. The other extreme occurs when novice writers string together a collection of short sentences. This staccato writing style is equally annoying for the reader and, often, makes it difficult to follow the theme of the research. As a general rule-of-thumb, it is therefore sensible for the thesis author to vary the length of sentences in order to maintain a reader's interest. In other words, a long-short sequence of sentences can be much more appealing to a reader than long-long or short-short sequences.

Example 10.22 - Long-Long Sentence Sequences

The taxonomy, adopted in this dissertation, was the subject of considerable discussion with the National Science Foundation's Phylogeny Department, which devoted a significant amount of time to the process of classifying various nomenclatures and allocating them to identified specimens, in some expectation that such nomenclatures would ultimately form a systematic basis for a generic classification schema. On completion of these discussions, it was necessary to revert back to some of the classical nomenclatures that had previously been adapted by both the National Science Foundation and the American Centre for the Study of Fossilized Remains, in the hope that this would resolve the discrepancies that has arisen during the course of the investigation...

Example 10.23 - Short-Short Sentence Sequences

The sample was heated. The heated sample was then agitated. The resulting temperature was measured. An additional sample was then heated. This time, no agitation was applied. The resulting temperature was again measured. The results were compared.

Example 10.24 - Long-Short Sentence Sequences

In this research program, a key objective was to investigate a range of fluid-flow phenomena associated with a micro-valve structure which was to be applied in a range of different biomedical applications. It was anticipated that this would lead to significant advances in the use of the valve. However, the practical implementation of the valve provided numerous challenges that had to be addressed in order for the valve to even be made functional, let alone suitable for the anticipated biomedical applications.

Another useful rule-of-thumb that can be applied to thesis writing, in order to improve both the readability and the interest value of the work, is to make use of bullet points and numbered lists, whenever more than one element needs to be highlighted within a sentence. These tend to make the elements more prominent and help to reduce the monotony of long sentences. The sentence, previously shown in Example 10.21, is reproduced in Example 10.25, using a numbered list.

Example 10.25 - Making Use of Numbered Lists

The experimental apparatus was composed of a long, thin glass pipette, which had been commercially acquired, and this was used in order to infuse:

(i) Saline solutions

(ii) The test-case iodine solution

(iii) An ammonia solution

(iv) The chlorine mixture.

Bullet points and numbered lists are particularly useful when technical terms (e.g., chemical compounds) or acronyms need to appear within a paragraph. The use of bullet points and numbered lists has the effect of separating the technical items from the grammatical arguments, thereby making the text more readable. Consider Examples 10.26 and 10.27.

Example 10.26 - Sentence Without Bullet Points

A range of different manufacturing technologies, including servo drives, PLCs, CNCs, FMS, MRP, MRPII and the MPS, were investigated in regard to their placement in the CIM environment...

Example 10.27 - Sentence with Bullet Points

A range of different manufacturing technologies, including:

- *Servo drives*
- *PLCs*
- *CNCs*
- *FMS*
- *MRP*
- *MRPII*
- *MPS*

were investigated in regard to their placement in the CIM environment...

The bullet point and numbered-list mechanisms are particularly useful for those who have difficulty in expressing themselves in English because they provide a very simple means of minimizing punctuation problems and improving the clarity of arguments.

None of the techniques, introduced in this section, are a replacement for the acquisition of good grammatical skills but they do provide simple mechanisms by which the clarity of presented work can be improved.

10.8 Format - Diagrams, Equations, Tables, Acronyms

Many universities have a specific set of guidelines which are used for the presentation of a postgraduate dissertation. This enables all theses emanating from a particular university to maintain a particular style. Sometimes, the provided specifications are relatively loose while, in other cases, the specifications detail the referencing techniques, character fonts, line spacing, nomenclature, and so on.

In this section, a brief summary of suggested formatting techniques, that can be applied to common editorial problem areas in theses, is provided in order to serve as a guide when no other formal guidelines exist. The suggestions herein are neither universally adopted nor the "correct" set - they are merely one means by which consistency can be maintained throughout a long and complex document. Many universities and learned journals adopted their own guidelines which may differ from these but have equal validity.

In this text, in regard to formatting, three basic rules of thesis mechanics are proposed:

Rule 16:

All non-textual items (e.g., Equations, Tables, Figures) within a thesis must be labeled so that references can be made to them. Non-textual items should only appear in the thesis after a textual reference is made to them - otherwise they should be excluded.

Rule 17:

All references to textual and non-textual items in a thesis should be by means of Section/Sub-section/Paragraph numbers or by labels. References by page numbers or by the expressions "above" or "below" should not be used.

Rule 18:

Acronyms and technical expressions, which are uncommon in the parlance of the profession in which the thesis is written, should only appear after an explanation of their meaning has been presented (or in conjunction with footnote explanations)

With these rules in mind, a set of working specifications for thesis formatting is put forward in Table 10.3 as a guide:

Item	***Format***
Line-Art Diagrams/ Figures	Each diagram or figure should be labeled with both a number and a short explanatory description (e.g., Figure 6.2 - Pressure/Temperature Chart) which appears beneath the item. References to diagrams and figures should be by their labels and these labels are treated as proper nouns (e.g., The chart in Figure 6.2 shows...). The numbering scheme for diagrams should be chapter-dependent (e.g., Figure 7.9 in Chapter 7) in order to minimize changes during thesis development and editing
Tables	Each table should be labeled with both a number and a short explanatory description (e.g., Table 3.9 - Temperature Readings at Various Time Intervals) which appears beneath the item. References to tables should be by their labels and these labels are treated as proper nouns (e.g., The results in Table 3.9 show...). The numbering scheme for tables should be chapter-dependent (e.g., Table 4.2 in Chapter 4) in order to minimize changes during thesis development and editing
Equations	Each Equation should be labeled by a number which appears in parentheses on the right-hand side of the page beside the item (e.g., ...(6.2)). References to Equations should be by their labels and these labels are treated as proper nouns (e.g., The expression in Equation 6.2 defines...). The numbering scheme for equations should be chapter-dependent (e.g., Equation 3.1 in Chapter 3) in order to minimize changes during thesis development and editing
Photographs	Photographs can either be treated as normal line-art diagrams/figures or can be labeled as plates (e.g., Plate 7.1), with the basic rules applied *mutatis mutandis* as for line-art diagrams.

Table 10.3 continued overleaf…

Item	*Format*
Acronyms	Acronyms should only be applied after the full-spelling of the appropriate term is provided on the first usage *in each chapter*. The acronym should appear in parentheses beside the full-spelling and, thereafter, only the acronym should be used (e.g., computer integrated manufacture (CIM)). The full spelling of the term should be in the normal sense and proper nouns should not be applied unless they are normally associated with the words in the term (i.e., **C**omputer **I**ntegrated **M**anufacture (CIM) is incorrect). A table of acronyms should be provided in the thesis as a guide.
Latin/ Foreign Phrases	Latin/Foreign phrases, which are normally applied in academic and common parlance, should be incorporated into the text in italics to remind the reader of the language change.
Common Latin Acronyms	Common Latin acronyms "n.b.", "i.e." and "e.g." should be applied with a full stop after each abbreviation. When used to supplement text, a comma should also follow their usage (e.g., "n.b., the test results in Table 4.1 were...")
Numbers in Sentences	The numbers one to ten are written in words. Numbers greater than ten are written in numeral form. When a number range is included in a sentence, then the boundaries of the range are written in numerals (e.g., 10-100).

Table 10.3 - Basic Thesis Formatting Guide

10.9 The Abstract

An abstract is intended as a means of summarizing a documented research program so that it can be catalogued in order to facilitate library access by other researchers. As its name implies, an abstract draws (abstracts) work from the main dissertation and places it into a short, concise form, from which a reader should be able to deduce the nature of a research program. The abstract in a research dissertation is particularly important for two reasons:

- It enables a researcher to develop and phrase a simple research theme for the work, and to précis the entire program. This highlights any logical flaws that may exist and enables corrective action to be taken
- It is generally also the first piece of text that is encountered by a thesis reader and it leaves a lasting impression for the reader.

These reasons make the abstract a key factor in the preparation of a research dissertation. However, for many research students, an abstract is an afterthought that is hastily assembled, after the final draft of the thesis has been completed (thereby negating one of the potential benefits).

One of the principal reasons why people tend to write poor research abstracts is because they do not have a clear understanding of their own research work and its purpose in the world. Herein, one of the basic tenets is that a research student must be able to summarize his/her own research work and its contributions, within one or two non-technical sentences, prior to preparing the dissertation - this is cited as Rule 1 in this text. However, if Rule 1 has been violated, then the chances of writing a good abstract are particularly small. On the other hand, if a researcher has a clear vision of his/her research, then adhering to a few basic rules can make the preparation of an abstract considerably more straightforward:

Rule 19:

The abstract should be used as a mechanism for providing a short, sharp picture of the research program, and its contributions, to the reader. Generally, the shorter the abstract, the clearer the picture. One or two paragraphs should be adequate for a postgraduate dissertation.

Rule 20:

The abstract should focus upon the broader issues of the research program and its findings. The abstract should be devoid of minute details unless those details are an integral part of the broader picture of research.

Rule 21:

The abstract is a mechanism by which a lay-reader can be introduced to the documented program of research and to the key words that describe the research and its contributions.

In the final analysis, the abstract is a junction point at which future readers decide whether or not to pursue further reading of the document that follows. The abstract should therefore serve the purpose of attracting specific types of readers to the work and repelling other types of readers for whom the work will not be relevant.

10.10 The Introductory Chapter

The introductory chapter of a thesis is the first formal textual piece within the main body of the work. It is the chapter in which the author needs to convince a reader that he/she is:

- Humble
- Impartial
- Knowledgeable
- Thorough
- Rigorous
- Open-minded
- Competent
- Systematic.

If the author fails to achieve these ends, then the result will be that all the subsequent chapters of the thesis will be subject to a greater level of scrutiny by the reader.

Achieving the required outcomes, from the first chapter of a thesis, is not a simple task. To begin with, many of the required outcomes appear contradictory. For example, the author must appear to be knowledgeable but, at the same time, humble. The author must appear to be thorough and rigorous (suggesting a narrow focus) but, at the same time, open-minded (suggesting a broad focus). For these reasons, the first chapter of a thesis is one that generally needs to be subjected to a number of revisions, through an iterative and consultative process. Following on from Figure 10.1, showing the flow of argument complexity, it is also apparent that the first chapter of the thesis should be able to draw in, and hold the attention of, a lay-reader while, at the same time, holding the attention of the learned peer.

Table 10.2 shows a suggested a generic (section-by-section) structure for the introductory chapter of a thesis which facilitates the buildup of progressively more complex arguments. The basic objective of this structure is to provide an introductory chapter that contains:

- A simple overview of the research and its contributions
- A background discussion of where the research fits in a historical and technical sense, and why the pursued course of

action was perceived to be relevant

- An overview of the concepts that were put forward in the research and the methods that were used to assess their boundaries
- A specific statement of the contributions of the research
- A cogent argument that explains the ensuing thesis structure and the reasons supporting it.

A basic rule that should therefore be adopted in regard to the preparation of the first chapter of a thesis is:

Rule 22:

The introductory chapter of a thesis needs to appeal to the lay-person and the learned professional. It must therefore be subjected to two, different types of review in the iterative drafting process - firstly, by a lay-person with no knowledge of the research program and secondly, by a knowledgeable peer who was not directly involved in the research. This provides a testing ground for both the arguments and the technical explanations.

10.11 The Literature Review Chapter

The literature review chapter is the chapter in which a research student endeavors to convince a reader that:

- He/she has conducted an impartial evaluation of other learned peers' work
- The review is sufficiently thorough to uncover relevant landmark research, key publication forums, seminal papers, and so on
- There was a justification for the pursued course of research action based upon the work that had been reviewed (in other words, alignment between the review and the research program)
- The review genuinely contributed to the course of the research program.

In order to achieve these ends, the review chapter has to be more than a collection of abstractions from the works of other researchers. It needs to be a carefully structured filtering process, from which some alignment between past and future work is drawn.

It also needs to be noted that it is generally unacceptable for a research student to pursue a course of action which does not have some form of peer support. The general ethos, which needs to be followed, is that the research student must learn how to humbly learn from other experts - the research student is not an expert consultant. Hence, any deviations from courses of action, outlined by expert peers, need to be very carefully considered in terms of how they can be justified by a humble learner. Ultimately, the humble learner does not have the luxury of conducting a peer review and then altogether dismissing its findings. The following rules should be adopted:

Rule 23:

The research program, pursued by a research student, needs to be in alignment with the findings of the literature review in terms of the interpretation and extension of the previous findings of other learned peers. Deviations from courses of action, proposed by learned peers, can only be justified by the student in terms of the quest for further knowledge and, even then, this quest needs to satisfy the basic principles of a systematic investigation which has a sound theoretical basis.

Rule 24:

The structure of the literature review section should be such that it demonstrates the research student's techniques for systematically uncovering relevant work in comparable fields (i.e., landmark research, seminal papers) and also provides a balanced analysis of the uncovered research.

The literature review chapter needs to follow a smooth flow of argument complexity, commencing with an overview that explains how the review was undertaken, and culminating in a summation that aligns the work in the current program with the review. The generic structure is shown in Table 10.2. The literature review chapter is the most challenging of all the thesis chapters to write and it needs to be completed at an early stage of the research program to ensure alignment between the program and the review.

10.12 The Methodology Chapter

The methodology chapters tend to be the best written of all the chapters in submitted dissertations. The reason for this is that a methodology chapter relates to the details of the project which was the core of the research program, and it is the work with which students are most familiar. Ironically, a thesis examiner may place less emphasis on the reading of such a chapter, because it is assumed that the methodology will be well presented by the student.

It must, however, be remembered that the core of a research program is the systematic investigation, rather than the project in itself. For this reason, the methodology chapter needs to be carefully written to ensure that it remains in line with the objective of a systematic investigation. The following rule should be applied:

Rule 25:

The methodology chapter of a thesis should be written in such a way as to ensure that the project description and the details of an implementation do not dominate the work at the expense of the documentation of a systematic investigation. The process of a research student learning how to learn must remain at the core of the research program.

Following on from the generic chapter description in Table 10.2, the key factors that need to be considered in the preparation of a methodology chapter are:

- To ensure that the descriptions do not become detailed to the point of being a distraction from the main objective of the dissertation
- To ensure that the methodology aligns with the simple research theme put forward in the introductory chapter.

10.13 The Experimental Design Chapter

A proposed methodology or concept has boundaries and it is generally the purpose of a research program to identify those boundaries and to report upon the positive and negative attributes of the methodology.

The hallmark of a good research program is the ability to establish a series of experiments or studies that can push a concept to its operational limits and, thereby, expose those limits. The experimental design portion of a thesis is therefore a critical element that explicitly demonstrates the researcher's impartiality and willingness to explore boundaries, rather than to just get "the correct answer".

A common flaw in theses is that a weak set of experiments is designed by a research student in order to minimize the chances of exposing negative attributes in a proposed concept. Sometimes, this is manifested in small (statistically irrelevant) sample sizes, or atypical or restrictive experiments that do not provide a full investigation of the related phenomena. The end result is a weak thesis that adds little to knowledge of the field at hand. A cardinal rule that should be exercised in relation to the experimental design chapter of a thesis is as follows:

Rule 26:

The experimental design chapter should provide a detailed description of the procedures that were used to test the boundaries of a concept. The chapter should also present a detailed description of how reliable and valid these test procedures are; how they relate to the simple theme of the research, and what inferences (if any) can be drawn from the results.

In some research programs, a valid outcome may be that no inferences can be drawn from the results because it is infeasible to conduct a sufficiently large number of experiments or because it is impractical to create conditions that may cause a concept to fail. The key factor here is that only those inferences which are absolutely honest, and supported by appropriate data and statistical analysis, should be drawn from the results of the research program. The following rule should apply:

Rule 27:

If the experimental procedures, applied to test the boundaries of a concept, are believed to be inadequate, and it is not feasible to create a more comprehensive set of testing procedures, then the experimental design chapter should focus upon how much value can be derived from the limited set of results and what further inferences can be drawn.

From a structural perspective, the experimental design chapter needs to lead the reader through from basic concepts to detailed experimental designs and then summarize the significance of the designs in a summation section. This is shown in the structuring guide of Table 10.2.

10.14 The Results Chapter

The results chapter of a thesis tends to have analogous problems to the methodology chapter in the sense that students tend to naively believe that "more is better" - the more results that are presented, the better the thesis will be.

The results chapter should not be a repository for every measured result that was derived during the course of the research program, and the following inclusion rule should apply:

Rule 28:

The purpose of the results chapter is to present only those tabulated and graphed data sets that are explicitly related to testing the boundaries of the concept which is put forward in the simple research theme of a thesis. For each set of presented results, a statement needs to be made which links the results back to the theme in simple terms.

With the above rule in mind, it is also important that the results chapter of a thesis follow a theme which begins with an overview and simple supporting results, then gradually moves on through more complex results - finally ending with a summation that ties the individual results back to the research theme. The generic structure is shown in Table 10.2.

10.15 The Broader Context Analysis Chapter

Research students sometimes have difficulty in understanding the significance of their research work within a broader context. By nature, most postgraduate research programs focus on a narrow section of what is, sometimes, a narrow field of study in itself. In other words, a postgraduate research program contributes a small amount to a narrow field which contributes a small amount to a broader field, and so on. However, in order to master the principles of research, it is often important for a research student to understand that individuals in the modern research environment cannot generally change the face of a discipline (much less that of society) by their research contributions.

For these reasons, it is incumbent upon students to demonstrate to readers that they understand the scope of their work and its results in the context of the broader field of study and, if applicable, to industry or society. Some basic rules can be applied in order to present an accurate depiction of the research within a broader context:

Rule 29:

In order to present an accurate picture of the research program. within the broader context, it is important that the literature review has been sufficiently thorough to trace the field of research to its origins. It is also important that the review examines the impact of field of study up to the time of the research program so that, when the results are finally extracted, they can be compared with precedents in terms of their impact.

Rule 30:

Historical texts or encyclopedias should be used to determine the relationship between research in the broader field of study, and its impacts upon society or industry. The inclusion of the current research program within the historical context helps to demonstrate an awareness of the significance of the research.

A thesis chapter which is designed to frame the current research program within the broader context must, by nature, be legible to the lay-person. The results which have been aggregated during the course of the research work can be summarized in relation to the initially stated research objectives and then framed within the broader research context and, ultimately within a broader historical/societal context. This discussion enables a reader to assess the level of the research contribution and the author's understanding of it. The generic structure for this chapter, shown in Table 10.2, provides scope for a range of arguments ranging from overview to detailed analysis of implications and back to summative issues.

10.16 The Conclusions Chapter

The final chapter of a thesis needs to be a reflection of the research findings, in light of the broader context analysis, and in relation to the originally stated research objectives. Given that knowledge is ever-expanding, it is also important that the concluding chapter of a thesis explicitly recognizes the limitations of the current research and makes recommendations as to how further developments and contributions can be made. The following rule should be applied:

> *Rule 31:*
>
> *The concluding chapter of a thesis should be composed of several parts. The first should summarize the relationship between what was achieved and what was initially proposed; the second should explicitly highlight the perceived contributions and limitations of the work, and the third should make recommendations for how future researchers could build upon the existing research.*

The generic structure for the concluding chapter is shown in Table 10.2. In terms of its target complexity, the concluding chapter should, like the introductory chapter, be legible to the lay-person. In theory, a lay-person should be able to read the introduction and conclusion chapters and have a good broad understanding of the research and its contributions - without having been exposed to the specifics of the concepts or the experimental test procedures.