9

The Fundamentals of a Thesis

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

- *What is the purpose of a thesis?*
- *What are the difficulties involved in conveying knowledge, through a thesis, and how can these issues be addressed?*
- *What can be done to ensure that a thesis leaves a positive, lasting impression with a reader?*

9.1 Basic Objectives - The Research Story

A thesis is composed of two parts - body and soul. The body of the thesis is contained within the text and the soul is contained within the sub-text. In this chapter, in which thesis fundamentals are examined, the primary focus is upon the soul of the thesis and the way in which the sub-text needs to convey information to the reader.

One of the fundamentals of writing is to phrase sentences in a positive context and so it is ironic that the first of two chapters in this text, dealing with the development of a dissertation, begins with what a thesis should not be. It is particularly important, here, to begin in a negative sense because many research students labour under a number of misunderstandings about the nature of a dissertation. Hence, it must firstly be noted that a thesis or dissertation is not intended to be:

- A weighty volume, which is made as thick as possible to demonstrate the skills of the research student
- Composed of long and incomprehensible sentences, technical phrases, acronyms, mathematics, formulae and jargon
- A consultant's report, which makes dogmatic assertions about the facts presented therein, and in which the research student appears to be an expert

However, this is what some research students produce, in a naive hope that they will impress prospective readers.

Having established what a thesis is not, it is necessary to move into a positive sense and establish what a thesis should be. In particular, a thesis should be:

(i) A historical record of a series of events that took place at a particular place and in a particular period of time

(ii) A timeless document that is composed in such a way that events and results are recorded with a view to perpetual relevance

(iii) A simple story about the manner in which a research student conducted a diligent search for knowledge, in order to learn how to become an impartial investigator

(iv) A document, objectively written by a humble learner, rather than an expert, and a document assessed by a subjective expert

(v) A document in which complex theories, mathematics, formulae, etc. are presented in the simplest possible light, by the research student, in order to demonstrate that the student understands the theories and their place within the research

If one accepts the above objectives for a thesis, then one can move away from the pretentious and move towards the accurate, the meaningful and the timeless. The starting point for this process needs to be an understanding that experts are more impressed by those who can express complex ideas in a simple manner than those who can express simple ideas in a complex manner. Moreover, given that many researchers begin their careers by endeavouring to impress with long, complex sentences and equations, it is not surprising that they are sometimes amused (rather than impressed) when they see the same traits in their aspiring successors.

All of the above points (i) to (v) can be summarised in a simpler form in order to clarify the central objective of a thesis - that is:

For a research student to demonstrate, in a written form, that they have been able to learn how to systematically learn, by investigating a particular problem...

It is not the problem that is the core of the thesis but the student's method of tackling the problem that is the central hub, around which the other issues must revolve.

Ironically, research students have generally completed some two decades of schooling and reading before they endeavour to write their first postgraduate dissertation and yet, the moment that they do commence, many forget every basic that they have learnt in an attempt to impress through pretentiousness. In this chapter, therefore, we seek to annotate the fundamentals of the thesis and to highlight these in the context of the examination/assessment process.

9.2 A Simple Theme

For many research students, a thesis is the first lengthy document that they have ever authored and, so, in the absence of any previous experience, it is not surprising that they make fundamental errors of judgement. The first error of judgement is the assumption that a reader can comprehend and store dozens of complex ideas and theorems and somehow assemble their implications into a single instrument, by which the document can subsequently be assessed. This assumption is particularly rash given that many thesis readers will have never seen the environment in which the research was conducted, the equipment that was used in experimentation, and so on. In some cases, the end result is that the thesis reader becomes confused and unable to extract the significance of the work or the findings - a particularly serious situation if the reader also happens to be the examiner of the research.

If one considers, on the other hand, any well-respected novel, regardless of whether it be fact or fiction, and regardless of whether it was written in the 17th Century or the 20th Century, then one element becomes clear - a reader can summarise the entire document in his/her own mind with one or two simple sentences. The lasting impression that is left with the reader is not the word-by-word content of the novel but, rather, the simple summation that is derived from it and the meaning that was derived from the novel. The reason that this occurs is because the writers have very skilfully created a work which, in its complex entirety, devolves into a simple thought that is artfully communicated.

Research students, as novice writers, tend to believe that it is possible to convey complex ideas because the readers of theses tend to be experts - this is a fallacy. The very nature of written communications is such that it is generally difficult to forcefully convey even a simple idea from writer to reader because each has his/her own particular interpretation of the universe of discourse. Figure 9.1 highlights the problem in a graphical sense. The first point in understanding the problem is to recognise that each individual has developed his/her sense of understanding of the "universe of

discourse" from a different perspective and that there may be little or no overlap between a writer's perspective and a reader's perspective.

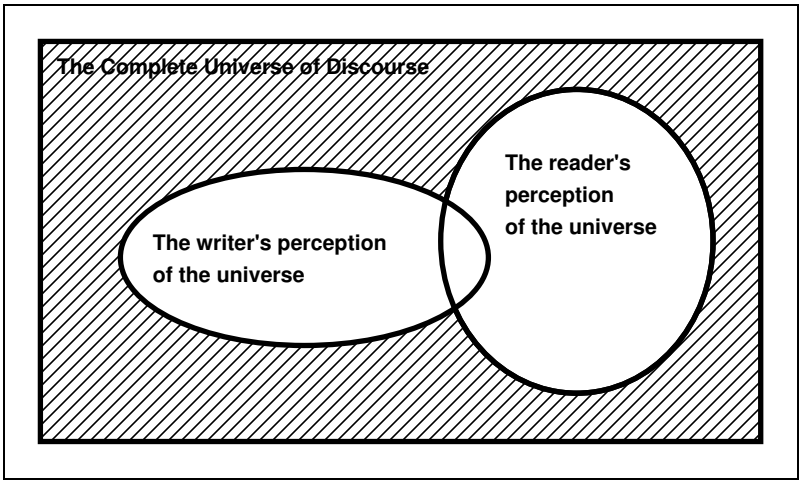

Figure 9.1 - Different Perspectives on the Universe

The skill of a writer is manifested in his/her ability to maximise the overlap between the communicated ideas and the manner in which they are interpreted by the reader.

From a research student's perspective, however, there are two things that can be done in order to make the task of communicating with the examiner more straightforward:

(i) Ensure that the student has an absolutely clear picture in his/her own mind of what is to be communicated

(ii) Ensure that the student has a clear picture in his/her own mind of who the reader is intended to be and what their view of the universe is likely to be.

The above points appear to be trivial but many students have considerable difficulty with them - worse still, many students begin

writing a thesis before having an absolutely clear picture of what is to be communicated.

When a research student is unable to form a clear and simple picture, in his/her own mind, about what is to be communicated, it becomes extremely difficult for him/her to convey meaningful information to a reader. Confused ideas tend to lead to complicated and directionless sentences. Complicated and directionless sentences ultimately lead to an incomprehensible thesis. Consider the disastrous beginnings of a thesis, shown in Example 9.1.

> ***Example 9.1 - The Pretentious Introduction***
>
> *"The investigation of heterarchical societal control structures (HSCSs) has been widely documented in a number of colloquial quasi-complementary tomes in the sphere of sociology which draw succinct but peripheral analogies from the intrinsic behavioural patterns..."*

The researcher's muddled view of the research program has resulted in a series of long-winded, complicated sentences, which have some obscure meaning that can only be decoded after several readings. It is clearly evident that a researcher, such as the one cited in Example 9.1, is not ready to write a thesis. After some thought, however, the researcher has been able to develop a simple theme for his research and has produced the introduction shown in Example 9.2:

> ***Example 9.2 - The Enlightened Introduction***
>
> *"The objective of this research was to answer a single question. That is, what are the factors that influence the controlling structures in a society..."*

This simplicity of purpose needs to extend to engineering, medicine and the sciences as much as it does to the softer research

fields of arts, sociology and history. In fact, it is in the hard sciences where such ability tends to be most lacking, and the desire to obscure meaningful communication with mathematics, technical detail and acronyms tends to be greatest.

Generally, research students, in engineering, medicine and the sciences, argue that they cannot simplify their work into one or two simple sentences which are devoid of technical definitions, mathematics, etc. This is almost universally because they are unable to understand the broader context of their own research. Until such a level of understanding is achieved, then the challenges of writing a thesis, which can meaningfully communicate the research, are enormous. Complex and muddled introductory pieces evolve into complex thesis structures with convoluted logic, from which a reader literally needs to decrypt the actual extent and nature of the work that was performed. All too often, the end result is that the reader, unable to decipher the encrypted information, makes inaccurate assumptions about the level of the performed work and its relevance - more likely to the student's detriment than benefit.

The typical problem faced by students, in engineering, medical or scientific research, is that they see their own work in a very introverted manner - in a complex and excessively detailed form that masks its generic significance and the research methodologies that need to be demonstrated. In Example 9.3, the typical scientific approach to a thesis introduction is provided to demonstrate the introversion that tends to occur.

Example 9.3 - The Pretentious Technical Introduction

The photonic emissions, emanating from intrinsic semiconductors doped with Group V impurities, were modelled using Schrödinger's equations in order to verify that

$$\overline{E} = \frac{\sqrt{\varepsilon^2 - \lambda/\pi^3}}{\Phi^{j\omega\alpha} \pm \eta^{N/2}} \ldots$$

Minutia, mathematics and technical terms hide the fundamental story from the reader, rather than highlight it. The approach in Example 9.4, on the other hand, emphasises the research story that is to be told within the thesis.

Example 9.4 - The Enlightened Technical Introduction

"The purpose of this research was to investigate the relationship between an applied stimulus energy and the emission of light, in a range of different materials..."

Mathematics, technical terms, and so on, may well be important to the arguments raised in the thesis but they are not, in themselves, the central core. These devices are only tools which need to be carefully and selectively applied to support the central story that is told within the thesis.

A key factor in writing a substantial document, such as a dissertation, is to clearly understand the message that is to be conveyed. If this message cannot be encapsulated in one or two simple sentences, without resort to the tools of mathematics, technical jargon, etc., then the message is too complex, and the chances of a novice writer conveying it to the reader are minimal.

Another key factor in communicating the research story in the thesis is to ensure that the reader has a complete set of details about the:

- Where?
- When?
- Why?
- How?

of the research program as early as possible. This makes it easier to place any following discussions into the appropriate context. Consider Example 9.5, which is an enhanced version of Example 9.4, and which now has some basic background elements incorporated into it.

Example 9.5 - Comprehensive Introduction

This thesis is the documentation for a Doctoral research program that was undertaken at the New England University in Vermont, USA, between the years of 1999 and 2002. This Doctoral research program was part of a larger program of research, undertaken in collaboration with a semiconductor manufacturer (Zytex) over the same period. The overall research program was composed of five postgraduate researchers, and its objective was to investigate the potential applications of light-based semiconductor memory devices for computers. The specific purpose of this Doctoral research was, however, to investigate the relationship between an applied stimulus energy and the emission of light, in a range of different materials.

The objective of conducting this research was to determine whether or not a range of high-speed, low-cost data storage devices could be developed for the computer industry...

Example 9.5 continues to build upon the simple theme, established in Example 9.4, by including some fundamental background statements that frame the context of the research for the benefit of the reader.

In this text, in order to highlight the salient points extracted from the presented examples, a number of basic rules are put forward for consideration in each of the two chapters that relates to the development of a thesis. The purpose of these rules is to highlight those points that are critical to the development of a thesis and which can powerfully communicate a theme from writer to reader. The first three of these rules pertain to the focus of the thesis:

Rule 1:

Before writing a thesis, summarise the purpose and contribution of the research program in one or two sentences which are devoid of technical terms, mathematics or jargon. This is the simple theme for the thesis. Keep the simple theme in plain view at all times when writing the thesis.

Rule 2:

Highlight the simple theme as a starting point for the thesis introduction.

Rule 3:

Each thesis section and chapter that follows on, after the simple theme is presented, needs to either implicitly or explicitly link back to it - otherwise the theme will be lost.

Without the simple theme, and the progressive reminders of how a sentence, section or chapter relates to it, a thesis loses focus. The end result is a document which highlights elements in which the research student is particularly adept or interested or, perhaps, elements in which the student has devoted the greatest proportion of time. However, these are not necessarily the elements that are of most importance in aligning the student's domain of perception to that of the reader. The end result is that the reader loses track of why the student is making particular arguments, reviewing particular pieces of work, or conducting a particular set of experiments.

Let us assume that a thesis is to be written around the simple theme expanded in Example 9.5. Consider what happens when Rule 3 is ignored during the course of a literature review:

> ***Example 9.6 - Omission of Links Back to the Simple Theme***
>
> *This literature review was conducted over a period of 18 months, commencing in December 1999. A key finding was the work of Clements (1992) whose theories on the photonic emission of ....*

In Example 9.6, the reader is left to find the relationship between the presented text and the original theme of the thesis - while this may appear to be self-evident while the thesis is short, the links are lost in a larger work, where details are separated by several chapters or numerous pages. Example 9.7 provides a link back to the central theme:

> ***Example 9.7 - Inclusion of Links Back to the Simple Theme***
>
> *This literature review was conducted over a period of 18 months, commencing in December 1999. The objective of the literature review was to acquire an understanding of the previous research that had been conducted to determine the relationship between an applied stimulus energy and the emitted light, in a range of materials. A key finding was the work of Clements (1992) whose theories on the photonic emission of ....*

Notice how, in Example 9.7, the linking sentence not only makes the subsequent text more relevant and interesting to the reader but it also reinforces the simple theme of the research. The more times that the central theme is reinforced, the more readily the reader will be able to recall it and the more clearly he/she will see the relationship between the conducted work and the theme.

The research student's ability to focus the research program and the writing back to the simple theme is critical to the process of communication. The other key factor is the reader and this is discussed in Section 9.3.

9.3 The Thesis Reader and Examiner

A thesis is unlike a novel in the sense that it is written for a relatively narrow audience. As a general rule, the broader the reading audience, the lower the level at which the work has to be pitched - the corollary is that the narrower the audience, the higher the target for the work. A question that many students have, however, relates to how high or low to pitch the work and what assumptions to make about the reader.

There are three issues associated with the writing of a thesis in terms of the reading audience. The first issue is that the thesis needs to be pitched at the research assessor - the expert peer reviewer. The second issue is that many theses cross disciplinary boundaries and, yet, the reviewer is likely to be a reader from only one discipline - hence, a thesis that endeavours to satisfy multiple disciplines may satisfy none entirely. For this reason, the writer needs to make hard decisions about the specific interests and disciplinary targets at which the thesis is aimed. The third issue is that, in a larger sense, the thesis is intended to be a timeless work, to which reference can be made by other researchers, whose fields of interest may be either directly or only peripherally related to the theme of the thesis.

The issue of the expert reviewer is difficult to address in the context of a thesis, unless one is able to identify the type of individual that will assess the work and the particular disciplinary traits of that individual. However, one of the reasons that a literature review is so critical for research students is that it enables them to recognise the key researchers, their specialist disciplines, and the levels of work that are published in the international arena. Hence, without pre-empting the specific individual, that will be used to assess the thesis, a research student must be able to use the literature review to formularise a profile of the type of person for whom the thesis will be written. This profile needs to include the core discipline from which the individual will emerge; the typical opinions and biases of such an individual, and so on. The profiling needs to be carried out before any thesis writing commences and, preferably, as soon as the research student has completed an initial literature review, and has identified the styles,

preferences and research expectation levels of the key researchers in the field.

The literature review will yield an overview of the types of individuals that publish in a particular field and are likely to be assessors for the thesis.

> ***Rule 4:***
>
> *Make a clear profile of the reviewer/reader and his/her field of expertise before commencing the writing of a thesis*

Once the profile of a typical assessor (i.e., reader) has been established, a number of factors need to be considered in terms of the level at which the work needs to be pitched. As a starting point, a balance needs to be struck between the level of background theory that needs to be presented and the amount of the thesis that needs to be dedicated to the "new" work which is to be presented. Even on the assumption that the reader is an expert in the field, the purpose of providing the background information is to enable the research student to demonstrate, to a reader, his/her level and depth of understanding of the subject that led to the conduct of the research program. Moreover, without a comprehensive and balanced coverage, a thesis can degenerate into a school assignment rather than a professional work. On the other hand, too much emphasis on the background, and insufficient emphasis on the current research, can make the thesis appear to be more like a text book than a research dissertation.

A useful way of addressing this dichotomy is to think of the thesis as a historical mechanism by which the research student's progressive learning of the material, and extension of knowledge, can be conveyed to the reader in a systematic manner. In other words, the thesis provides background material to the extent that it demonstrates the thought processes that went into the development of research directions, the conduct of the research and so on. Hence, the

background material should not be authored in such a way as to teach the reader about the subject but, rather, to demonstrate how the student has learnt the subject. Another complementary perspective on the issue is to consider the writing style in terms of enabling another novice, who commenced with the same level of knowledge as the research student, to follow the same thought processes and reproduce the current research work. In adopting either of these approaches, an expert reader can assess whether or not a research student has followed a systematic path of investigation.

> ***Rule 5:***
>
> *The thesis is written from the perspective that, in order to assess the work, an expert reader will need to follow the historical thought processes of a novice learner in mastering a subject and extending knowledge through that mastery.*

The second issue that needs to be addressed in terms of writing a thesis for a target audience is that of the "timeless" document. A good way to do this is to consider that the research work was conducted at some distant time in the past, and to make no assumptions about what still remains after the passage of time. In other words, the writer should place himself/herself into the role of one who is reading the work, say, a century after it has been written. Each sentence can then be considered in terms of its timeliness. Consider the following example which will very quickly date the work:

> ***Example 9.8 - Text That Will Quickly Date a Thesis***
>
> *The algorithms, developed in this research program, are capable of executing on the fastest available Xylog XS workstation in under 4 milliseconds...*

The same idea can be presented in a more timeless fashion by considering how the document will be viewed in the future. This is shown in Example 9.9.

> ***Example 9.9 - Ensuring That Text Remains Timeless***
>
> *The algorithms, developed in this research program, were executed on a computer system (i.e., a Xylog XS workstation) that was commercially available and considered relatively fast at the time the performance tests were undertaken . Given this level of technology, the algorithms could be executed in under 4 milliseconds. It was anticipated that this execution time would decline as the computing technology improved...*

Note how Example 9.9 makes the assumption that the world will change over time, while Example 9.8 makes the naive assumption that it will remain static. In a timeless document, it is sometimes necessary to explain the context of occurrences, equipment and events, on the assumption that these will no longer be understood by readers at some time in the future. Clearly, there can be no absolute rules about timeless phrasing because, taken to its limits, the preparation of dissertations would become unwieldy because every item would be explained - in the above examples, the writer could go to the extreme and explain what a computer system was, and so on. However, some reflection upon the reader of the future is important if the research dissertation is to have long term value - particularly because many theses are permanently stored as historical documents in university libraries.

> ***Rule 6:***
>
> *The thesis is written from the perspective that it may be read at some distant time in the future as a historical work. The level of included explanations should be such that the reader of the future can interpret the significance of events, policies, technologies, etc. of the day.*

9.4 Creating a Lasting Impression for the Examiner

A thesis, composed solely according to a predefined set of rules, can be a particularly uninteresting document in the sense that it has a somewhat mechanical structure which remains essentially similar regardless of the field of research. Moreover, many theses have a decidedly unloved appearance because they have been grudgingly composed as an afterthought to a research program - they satisfy only the barest minimum standards of writing style and originality.

A significant problem with many theses is that research students use other people's theses as a benchmark for their own work. In practice, of course, a thesis is an amateur's document which could be far better rewritten by the same author after he/she had gained experience from writing the original. As a starting point, it is therefore far better to seek a higher benchmark for authoring one's own thesis, even though one may never reach that benchmark. A good alternative source of inspiration for developing a high-quality writing style is the study of landmark biographies, history texts, political works, and so on. Such texts, which have been expertly authored, can provide outstanding examples of how to:

- Provide balanced literature reviews (particularly historical texts)
- Maintain a simple theme throughout the course of a long and complex text
- Formulate defensive arguments
- Frame current research events into an appropriate historical context
- Develop a timeless writing style
- Provide even-handed and subtle arguments that are ultimately more persuasive than hard-edged personal opinions

- Develop an ability to write in a manner that allows the reader to form his/her own conclusions.

> ***Rule 7:***
>
> *Do not use other people's theses as a benchmark, as a thesis is generally an amateur writer's work - always go to a higher professional source as the benchmark for writing style - even if the higher source is in a different field of endeavour.*

Ironically, those that most need to read historical, political and biographical texts are those that undertake postgraduate research in engineering, medicine and the sciences. These individuals tend to be well adapted to presenting sequences of facts but very poor at presenting sustained well-developed arguments that can convince a reader of the merits of a particular approach. Moreover, given that research students in such disciplines tend to have had less exposure to texts in the field of history, politics, etc., their experience with high quality writing is minimal. Ultimately, this causes them to depend upon a series of mathematical or chemical equations, statistics and technical statements to defend their ideas. The problem is that these devices, in themselves, are inadequate to present a balanced view of a research program over the course of a lengthy dissertation - inevitably, arguments interspersed between equations and data tend to become muddled and sometimes self-contradicting. These are symptoms of a poor communications ability. Moreover, these sorts of communications problems can only be resolved by people reading outside their own sphere of technical expertise - this forces people to focus on the arguments and writing styles rather than the technical details.

Another side-effect of being "poorly read" prior to writing a dissertation is that a thesis tends to develop a "minimalist" feel - as though the student did the absolute minimum that was necessary in order to satisfy examination requirements. The technical aspects can

all be present; the data can all be appropriately supportive and, yet, the thesis does not convey a sense of passion for the field of research - a sense that the researcher was prepared to do more than just undertake a series of mechanical research procedures. This is a common problem in scientific and engineering theses, particularly because the field of study is generally narrow.

The higher one's level of confidence in one's field and writing style, the more likely one is to inject personal touches that convey a higher sense of regard for the work that has been undertaken. In many cases, this confidence level can only be achieved by extensive reading in a broader field than the one which is the subject of the thesis. Consider an example of how even the dry technical thesis, previously cited in Example 9.5, can be improved through a broadened reading base:

Example 9.10 - A Higher Sense of Purpose for a Dry Thesis

"Progress is impossible without change, and those who cannot change their minds cannot change anything"

- George Bernard Shaw

In this thesis, the challenges of change, as they pertain to the technologies for storage and retrieval of information, are investigated, with a view to comparing a range of traditional technologies with emerging technologies.

This thesis is the documentation for a Doctoral research program that was undertaken at the New England University in Vermont, USA, between the years of 1999 and 2002. This Doctoral research program was part of a larger program of research, undertaken in collaboration with a semiconductor manufacturer (Motorola) over the same period. The overall research program was composed of five postgraduate researchers, and its objective was to investigate the potential applications of light-based semiconductor memory devices for computers. The specific purpose of this Doctoral research was, however, to investigate the relationship between an applied stimulus energy and the emission of light, in a range of different materials.

The objective of conducting this research was to determine whether or not a range of high-speed, low-cost data storage devices could be developed for the computer industry...

The incorporation of relevant thoughts which, although not central to any of the proposed arguments, enhance the reading quality by instilling a higher sense of purpose to the work, also leave an impression with the examiner as to the author's passion for the field of study.

Following on from the above discussions, is becomes evident that research dissertations can be divided into different classes - that is:

- Those that seek to provide the minimum possible level of documentation necessary to achieve a research qualification

- Those that seek to provide a higher sense of purpose for the research and to place a narrow field of research into a broader (and, perhaps, more meaningful) context.

The issue of whether or not a thesis is intended to be a purely technical document, or whether it should seek to lift the discussion beyond the narrow technical issues, is debatable. However, it goes without saying that those who seek to generate a thesis with a higher sense of purpose also tend to be those that inject a higher sense of care and responsibility into the technical issues that are central to the research.