

3

Fundamentals of Postgraduate Research

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

- *What are the basic objectives of postgraduate research?*
- *What are the ethics and principles that a postgraduate researcher needs to adopt in order to conduct research?*
- *What is a thesis and what are the key factors in peer review and examination?*

3.1 Basic Objectives and Misconceptions

A good starting point, in understanding the difference between the objectives of postgraduate research work and the misconceptions, is to consider the parable of the two workmen, laying bricks on a construction site. In the parable, in response to a question regarding their roles, one workman replies that he is "*laying bricks*", while the other replies that he is "*building a cathedral*".

In response to a question regarding their roles in a postgraduate research program, many students will provide the analogous answer that relates to how they are laying bricks, rather than how they are building the proverbial cathedral. The key point here is to recognise that, just as bricklaying has a higher sense of purpose than laying bricks, so too does postgraduate research have a higher sense of purpose than just undertaking a research project. Ironically, few research students recognise the higher sense of purpose that is being sought through their research until long after the program has been completed.

In failing to recognise the higher sense of purpose for which a postgraduate research program is intended, many research students needlessly expend weeks or months on activities that do not contribute to their learning process or to a positive outcome within the assessment process. Worse still, many students inadequately address (or fail to address) the key issues needed to demonstrate an understanding of the research process.

The first issue that needs to be examined is the "research cathedral" that is being constructed during a postgraduate research program. In this text, the following motivational factor is put forward for postgraduate research:

- (i) *An individual should seek to undertake a Master's or Doctoral research program for the purposes of becoming a person who has a solid understanding of the mechanisms associated with the systematic and rigorous process of discovery and independent review.*

On the other hand, in practice, the dynamism that many students invoke to undertake such programs begins with a range of different motivators, including:

- (ii) *"A higher degree will be good for my career and/or I will get paid more if I have a higher degree"*
- (iii) *"I will be able to work in a project area which I find particularly interesting"*
- (iv) *"I will have the freedom to spend several years investigating an area that I find of interest"*

Ironically, the typical motivating factors (ii) - (iv) that students have for undertaking a program are not necessarily the ones which will enable them to either succeed in their desired outcomes or to "build the research cathedral". Further, the motivators listed in (iii) and (iv), which appear to be most altruistic in intention, can often lead to serious problems during the course of a research program. In order to understand why this should be the case, one needs to consider some basic tenets that are, herein, adopted for postgraduate research. These are that:

- A postgraduate research program is a means by which a student can learn how to undertake research in a systematic and unbiased manner
- The research project, and the research field, are the basis of a task which is set in order for the student to acquire research skills and to demonstrate these to independent assessors
- A successful outcome in a research program is one in which the research student has acquired the basic skills of research and has recognised how these can be more generically applied to other areas or, at a higher level, within the chosen field.

If one examines the tenets and looks at typical motivators (iii) and (iv), one can begin to see why these cause problems.

Firstly, students that are motivated by interest in a project or a field of research can sometimes have more passion for the field than for the rigours of research - hence, they focus on conducting an interesting project, rather than acquiring research skills.

Secondly, interest can introduce bias into the conduct of a research program, and when supervisors or peer reviewers attempt to correct the bias, conflicts can arise.

Thirdly, those who solely use interest as a motivator, generally discover that, once a postgraduate research program commences, the basic elements are composed of many activities that are peripheral to the conduct of the "project" and may be of "no interest". Typically, these include core activities that are central to learning the research process - for example:

- Literature reviews
- Statistical analysis
- Experimental design
- Thesis writing.

Conflicts often arise when students ascribe primary importance to the project and secondary importance to the acquisition, demonstration and mastery of research skills.

Motivator (iv) is also of concern in terms of postgraduate research because it tends to encompass words such as "freedom", which are then combined with words such as "interest". The implication is that a student, in a postgraduate research program, will be free to explore any areas provided that they are interesting. The implication is, in many ways, as naive as the ten year old child who believes that chemistry is about mixing colorful liquids and

powders in order to produce miraculous and unexpected results. The reality, however, is that in learning about the systematic process of discovery, one needs to severely restrict the pathways that are explored so that each pathway is thoroughly and carefully investigated. In other words, the interpretation that research students have of terms such as "freedom" and "interest" may be somewhat different to the realities of the research process. The realisation of the rigour and tedium, involved in some aspects of research, can therefore remove the initial dynamism that students have and, in severe cases, cause performance slumps or complete withdrawals.

Returning to the bricklaying analogy, one could say that the research cathedral, which is the ultimate objective of postgraduate research, is the ability to undertake research in a systematic manner. The research project is akin to the bricks that need to be laid to build the cathedral. Conflicts and confusion inevitably arise when students have a greater interest in laying bricks than they do in building the cathedral.

The above discussions do require some qualification and it needs to be stated that students, who are fortunate enough to have involvement in a project which they find of interest, can perform exceedingly well - provided that they are prepared to examine the higher sense of purpose; to put the project work into perspective, and their biases and preferences to one side, during the conduct of the work.

Another point of interest is that students who use Motivator (ii) for their dynamism (i.e., financial or career reward) can also often perform particularly well, despite the apparent lack of focus on academic excellence. Why should a mercenary approach to postgraduate research lead to potentially better outcomes than one which is fostered from a genuine interest? The answer to this question actually follows on from previous discussions - not because Motivator (ii) relates to a higher sense of purpose but because, in themselves, financial and career rewards are inadequate motivators. This leads many students, who are initially motivated by a desire for

financial or career advancement, to carefully examine the outcomes that are required in order to achieve success in their research and then to relate it to future careers. Subsequently, students tend to move away from Motivator (ii) to Motivator (i) and tend to perform well in their postgraduate research.

In concluding this section, it is appropriate to summarise the basic points that were made in Section 2.4 and to add those made here in order to provide a clear picture of the postgraduate research process. These points are brought together overleaf, so that students can compare their expectations and motivations with those presented herein. However, in subsequent sections of this chapter, the objective is to show how the basic definitions, herein, can be translated into postgraduate research practice.

Postgraduate Research Objectives:

To learn:

- How to undertake an unbiased, systematic investigation
- The mechanisms by which any biases and/or personal prejudices can be identified and eliminated from the investigation through appropriate experimentation and/or analysis
- How to evaluate the benefits and shortcomings of the investigation
- How to accurately convey the outcomes of an investigation to peers and how to interpret and respond to their feedback.

Postgraduate Research Motivator:

An individual should seek to undertake a Master's or Doctoral research program for the purposes of becoming a person who has a solid understanding of the mechanisms associated with the systematic and rigorous process of discovery and independent review.

Postgraduate Research Tenets:

- A postgraduate research program is a means by which a student can learn how to undertake research in a systematic and unbiased manner
- The research project, and the research field, are the basis of a task which is set in order for the student to acquire research skills and to demonstrate these to independent assessors
- A successful outcome in a research program is one in which the research student has acquired the basic skills of research and has recognised how these can be more generically applied to other areas or, at a higher level, within the chosen field.

Specific Doctoral Objective:

The researcher needs to demonstrate a *significant* contribution of knowledge to the field of endeavour, through a clearly-defined investigation, analysis and peer review.

Specific Master's Objective:

The researcher needs to demonstrate a *mastery* in a given field of endeavour, through a clearly-defined investigation, analysis and peer review.

3.2 Integrity of Research

It may appear to be a statement of the obvious to discuss the notion of integrity in research, but it is a subject that has to be broached in some detail because of the many misconceptions that postgraduate students may harbour.

First and foremost, one needs to consider that postgraduate research students, having progressed through primary, secondary and tertiary (undergraduate) education, have spent a minimum of one and a half decades within an environment where a principal objective is to "achieve the correct result". Hence, when experiments are conducted to test a theory which, for example, depicts a linear relationship between two quantities, then a successful outcome is generally when the student produces results that demonstrate the linear relationship. Over decades (and even centuries), many educationalists have believed that setting up an environment, where students can readily match theory with experimentation, is an effective means of demonstrating theory and, thereby, also setting quality parameters for experimentation. And, in principle, this is the case.

The problem with the school-yard approach to theory and experimentation is that it tends to reflect what happens when a well-prepared experiment is developed by a learned individual so that it can simplistically match with theory - without students being distracted by other phenomena. In other words, a skilled educator can create a one-dimensional rarefied environment in which a student can develop basic skills. In some cases, the physical world also allows us to achieve such results with minimal difficulty. However, in many instances, the relationship between theory and experimentation is considerably more complex. For example, a simple analysis of some biomedical system may predict a linear relationship between pressure and fluid flow. In practice, the relationship may also depend upon ambient temperature, viscosity and a whole range of other phenomena. Moreover, each instrument that is used to measure the required parameters inevitably causes some variation to those parameters. Hence, the simplistic school-

yard analysis may be completely inadequate to describe the multi-dimensional phenomena which take place in the physical environment.

The other aspect to the problem is that the school-yard approach to education tends to promote a range of tools that can be used to develop theories or to create models of reality. Most notably, such tools are mathematics, statistics, basic laws of physics, chemistry, etc. However, in the undergraduate environment, these tools tend to be applied in highlighted examples where they provide a clean and accurate depiction of reality - again, this serves to provide students with a basic skill set, upon which they can later build their analytical base. Again, the example set which is chosen is often the result of a highly skilled educator, seeking to create the one-dimensional learning environment.

For many postgraduate research students, one of the most traumatic discoveries occurs when they begin to develop theories and then conduct experiments, with the expectation of some correlation. Inevitably, one-dimensional theories are compared with experiments (often, conducted in another, single dimension) and students discover that correlations are difficult to find. Ingrained expectations of simple, one-dimensional relationships tend to cause research students to panic, and what then ensues is cause for concern in terms of the integrity of the research program. What can be done to correct anomalies between theory and experimentation?

- *Perhaps, keep measuring until the desired results are achieved.*
- *Perhaps, the instrument error can be blamed for the anomaly.*
- *Perhaps, the results are close enough anyway...*

In summary, a very well intentioned primary, secondary and tertiary education system often shelters students from the harsh realities of the physical world, and the void between principle and practice. Sometimes, it is only when graduates move into the

research environment that the flaws and inadequacies are exposed and, even then, there is an enormous pressure, derived from a decade and a half of conditioning, to revert back to forcing simple experiments and studies to match with simple theories.

Integrity in research requires a level of maturity in understanding the basic objectives of research and the basic limitations of proposed theories, studies and experiments. Integrity in research also involves a recognition that theory and analysis are often inadequate to accurately describe phenomena that can be measured in the real world. However, if one steps back from the specific project (or problem at hand) and endeavours to move towards the prime motivator for postgraduate research:

...to develop a solid understanding of the mechanisms associated with the systematic and rigorous process of discovery and independent review..

then one can also step back from the rather naive temptation to continue conducting research until one gets the correct answer (or, at least the answer to which one has predisposed oneself to achieving, after proposing a theory).

Again, the core problem tends to stem from postgraduate research students becoming too intimately involved in research projects, rather than endeavouring to undertake an unbiased study, without a preconceived leaning towards a particular outcome. All too often, one is confronted with theses in which basic research objectives are, for example, stated as being to:

- (i) *"Develop a methodology which..."*
- (ii) *"Demonstrate the correlation between..."*
- (iii) *"Prove that the theoretical relationship..."*
- (iv) *"Develop a model that can be verified..."*

While the specific wording of each objective appears to be perfectly reasonable, in each case, the objective has a tendency to predispose the researcher to achieving a stated project outcome, rather than to undertaking an impartial study.

An independent assessor of such research work would be entitled to pose the obvious question:

"What would have happened if the proposed objectives could not be met or if the proposed theories were found to be unsound?"

Clearly, in many stated research objectives, there is a natural assumption that those objectives will be met - the corollary being that research should continue until the objectives are met. This tends to place undue pressure on postgraduate research students and tends to diminish the integrity of many research programs.

A good method of determining how research integrity can be affected through predisposed objectives is to study previously submitted research theses. As an exercise, select a university library and examine a random sample of, say, 50 Doctoral theses, across a range of different disciplines. Read the introductory sections of each and reduce the sample to only those theses in which the objectives predisposed the research to achieving a given outcome. For the reduced sample, examine the conclusions put forward in each thesis and determine the proportion of such theses in which it was asserted that the "correct answer" had been achieved.

The disturbing trend that tends to be observed in such an experiment is that, in the context of a process of discovery, in which the boundaries of knowledge are being extended, the majority of such research students remarkably appear to have achieved the "correct answer". In all probability, given the nature of leading-edge research, one would have assumed that the most likely scenario would have been that the majority would have had "the incorrect answer". In other words, the likely reasons for achieving the "correct answer" include:

- The original hypotheses were well-founded and "correct"
- The research was essentially developmental in the first instance (and the answer to the original proposition was already known to be correct when the research commenced) and the thesis is essentially a consultant's report
- There was a tendency to skew the study or limit the boundaries of experimentation in order to verify a given idea.

The key factor here is in ensuring that the postgraduate research program does not become skewed towards achieving a given result. The postgraduate research student must adopt the role of the *impartial observer* and *humble investigator*, who is willing to learn from others, and who does not presume to know or speculate upon the outcomes of the research program until after impartial techniques have been applied to determine those outcomes.

The integrity of a research program is not just about right and wrong. It is also the means by which a research student can make a program more enjoyable, more manageable, and remove unnecessary stresses and constraints. Research students that predispose themselves to achieving particular research outcomes often stagnate in terms of human development because there is little real learning associated with such research - if one already knows the "correct answer" before undertaking the work, then there is little discovery in the research and no learning in terms of research process.

On the other hand, research students that have not predisposed themselves to particular outcomes tend to enjoy the process of research, and achieve considerable fulfilment, because it involves genuine learning. Such students can undertake experiments and studies - not with a view to matching them with theory but, rather, with a view to discovering the myriad reasons why the results

may not match with theory. In some cases, there may be more intrinsic knowledge generated by understanding the void between principle and practice than in the original principle itself.

If one moves away from the school-yard approach to "getting the correct answer", and takes the view that the process of discovery involves acquiring an in-depth understanding of why theory and practice do not match, then the quality of research is increased. Moreover, if one removes the unrealistic pressure, associated with "getting the correct answer", then one often finds that studies and experiments can be conducted with a clear and open mind. The efficiency of the research also tends to increase because there is a genuine learning and human development associated with the research. Experiments and studies tend to become more straightforward because, with each passing experiment, a genuine assessment of its worth leads one to a better understanding of the design of the next experiment, and so on.

How can one then prevent oneself from becoming predisposed and biased towards particular outcomes? The answer is often in the context of the stated objectives. Taking each of the previously cited objectives (i) - (iv), in turn, one could readily develop a more realistic phrasing that would improve the integrity of the research. Some suggested modifications to these objectives are shown in Table 3.1.

	<i>Predisposing Objective</i>	<i>Impartial Observer's Objective</i>
(i)	<i>"Develop a methodology which..."</i>	<i>"To investigate whether or not the development of a methodology could..."</i>
(ii)	<i>"Demonstrate the correlation between..."</i>	<i>"To determine whether or not a correlation existed between..."</i>
(iii)	<i>"Prove that the theoretical relationship..."</i>	<i>"To study the theoretical relationship..."</i>
(iv)	<i>"Develop a model that can be verified..."</i>	<i>To determine the limitations of a model that...</i>

Table 3.1 - Converting Predisposing Objectives into Objectives that can be Adopted by an Impartial Observer

3.3 Impartiality of Research

In Section 3.2, a range of issues associated with the integrity of research were raised and the concept of the postgraduate research student as a "*humble investigator*" and "*impartial observer*" was put forward. One might assume that a research program which has integrity also displays impartiality but this is not always the case. There is a distinction between the two factors and it is important that both are clearly brought forward within the research undertaken by a student.

A research program can have a great deal of integrity in the sense that all the presented work is, in the mind of the researcher, a genuinely accurate depiction of events. However, is the work also impartial? This depends not only upon the depiction of events but also the manner in which these events are depicted. For example, a piece of work that is 100% accurate but which only portrays half of the total universe of discourse, leaving the reader to jump to a convenient (possibly incorrect) conclusion about the remaining elements, is a biased piece of work. Similarly, a piece of work that represents the best aspects of one researcher's results against the worst aspects of another is a biased piece of work.

In a postgraduate research program, it is not only important to be impartial in the conduct of the program but, also, to make a positive effort to demonstrate the impartiality of the research to peers and assessors. In Section 3.2, it was noted that a good starting point for ensuring the integrity of the research is to carefully screen research objectives so that they do not create an environment that is predisposed to achieving particular outcomes. This is also important in terms of ensuring that what follows, from the research outcomes, is an impartial treatment of the work.

One has to be particularly careful to ensure that a piece of research does not become a marketing document that is used, however artfully, to persuade a reader to adopt a particular point of view - through careful omission of important information. In many cases, it takes a concerted effort, on the part of a postgraduate

researcher, to refrain from "selling" the benefits of a piece of research. Again, it is important for the researcher to realise that it is not the outcomes of the research that are being "sold" but, rather, the researcher's ability to objectively assess his/her own work and to impartially compare it against that of other researchers.

Some key factors that are required in order to achieve impartiality in the presentation of research are:

- (i) When discussing one's own work, ensure that the negative attributes are highlighted to the same extent as the positive attributes - a balanced view must always be presented and the final interpretation should be left to peer review or to an assessor
- (ii) When comparing one's research work against that of other researchers, ensure that the worst aspects of one's own work are compared against the best possible interpretation of others' work
- (iii) Always endeavour to place the research work into context - ensure that it is clearly stated that the work is only one element in a larger environment. Ensure that the proportional contribution of the work to the larger environment is highlighted.

3.4 Accuracy in the Depiction of Reality

It is often said that there are lies, damned lies, and then there are statistics. Despite their foundation in the accurate depiction of reality, figures have a remarkable ability to metamorphose into a range of different forms that can be used to support any number of different, and even contradictory, arguments.

Many research programs involve studies or experiments that are multi-dimensional in nature. In other words, a researcher often needs to study the relationship between a number of different parameters, on the assumption that the other dimensions of a problem are either constant, within the range of study, or else of no consequence. Sometimes, such assumptions are justified and sometimes the assumptions are later proven to be invalid. Sometimes, it is simply not practical to examine all the dimensions of a particular problem and intuitive assumptions are made about the influence of a range of different factors.

The key factor here is that in order to provide an accurate depiction of reality, it is particularly important to avoid the pretence of completeness or certainty, when it is apparent that experiments are inadequate to support a dogmatic premise. The act of omission is equally a distortion of reality - particularly when a researcher does not clearly state that other dimensions of a problem were either ignored, presumed inconsequential, etc. Again, it needs to be clearly demonstrated that the humble investigator and impartial observer is capable of recognising the limitations of the experiments or studies that have been conducted. It is then a matter for the peer reviewer or assessor to interpret the validity of the outcomes based upon the complete set of information supplied by the researcher.

All too often, however, statistics are used in research theses as a marketing tool, rather than as a mechanism for systematic or scientific analysis. This is another symptom of the school-yard approach to experimentation, where the objective is to derive "the correct answer" rather than to perform a systematic investigation and accept and interpret whatever answer emerges.

In order to maintain an accurate depiction of reality, some key factors that need to be considered in the presentation of research include the identification and highlighting of:

- (i) *The most negative (worst-case) interpretation of the results that were derived from the research - then juxtaposing this against the most positive (best-case) interpretation that could be construed from the results*
- (ii) *Experimental/study dimensions that were not included in the research - then providing an analysis of why these were not included and what possible influences they may have had if they were*
- (iii) *Potential sources of error and possible flaws in the experimental/study procedure that could invalidate the results - then explaining how susceptible the presented research outcomes are to such sources.*

It does need to be noted that research students do not necessarily consciously seek to undertake research work which lacks integrity, impartiality or accuracy. Indeed, many are genuinely convinced that their research work has all three of these attributes - the problem is that this conviction is more related to naivety in the conduct of research than to a wilful attempt to misrepresent. Much of the naivety is associated with the fear of presenting "the incorrect answer" and having a peer reviewer or examiner subsequently fail a piece of work. The reality, of course, is that this naivety, combined with a determination to present "the correct answer" tends to produce a piece of research which is poorly conducted and analysed and, in the worst-case, an inaccurate representation (or misrepresentation) of reality. It therefore needs to be restated, in summary, that there is one simple solution to the problems addressed here, and in Sections 3.2 and 3.3 - if one is prepared to step back from the research project and become *the humble investigator, the impartial observer* and the *devil's advocate*, then integrity, impartiality and accuracy should automatically follow.

3.5 Publication and Peer Review

In terms of postgraduate research, the process of publishing one's work serves a number of different purposes in the sense that it:

- Enables researchers to compare, at an international level, the status and standards of their research
- Makes a researcher or group of researchers known to others in the field and identifies them (or their researching organisation) with a particular sphere of research
- Makes new knowledge available to other researchers
- Contributes to measures of "research outputs" for universities and other research organisations.

Over and above these benefits is the fact that, in an academic sense, publication is normally associated with some form of peer review. In other words, a paper which is submitted to an international refereed journal, or to a conference (for publication in proceedings) is normally screened by peers who can comment upon the work. Hence, publication provides a useful forum for independent discussion of research and contribution to that research.

Postgraduate research students generally need to demonstrate that their work is not only satisfactory to their direct and local supervisors but, also, that it has been undertaken at a suitable international level. Further, peers who are local to the researcher (or are supervisors of that researcher) may inadvertently provide a biased view of the work because of their relationship with the researcher. In some cases, local peers may not be recognised as leaders in the particular field of research and, therefore, may be less suited to review the work than other experts who are internationally recognised as leaders.

Each discipline of study tends to have forums which have defacto recognition as arbiters of the quality of research. Generally, this is brought about by the fact that a journal or conference is refereed by a panel of experts that have already demonstrated leadership in a field of research - for example, their papers may have high levels of citation or they may be recognised as the seminal authors in their field (and the base upon which other researchers may have established their work). A particular discipline may have several different forums, all of which have equal standing in terms of their ability to screen the quality of published research. For example, a field of medicine may have a particular journal which is recognised as one in which the review process is rigorous and the referees are eminent in their field. The same field of research may also give rise to a conference in which, it is recognised, that the quality of screening and presented work is agreed, by international experts, to be of a particularly high standard.

A postgraduate research student therefore needs to submit research work for publication in order to subject the work to the highest level of scrutiny that is available. The feedback that is derived from expert referees, associated with a journal or conference, can then be used to improve a postgraduate research program or to change its direction in line with the observations of an independent expert panel.

In this text, the submission of work for external review, through publication, is considered to be a key factor in postgraduate research and the process requires considerable planning and analysis. For this reason, Chapter 8 of this text expands on the subject of publication and peer review in some detail.

3.6 The Thesis

A thesis, or dissertation, is perhaps the most visible embodiment of a postgraduate research program and it is generally one of the most time consuming aspects of such a program. In order to understand what a thesis or dissertation should be, it is important to reflect upon what a thesis should not be - that is:

- A thesis is not a book
- A thesis is not a consultant's report
- A thesis is not a document written by an expert.

In summary, however, a thesis is:

A document written by a humble investigator and impartial observer as an accurate, timeless historical record of a series of events that took place over a particular period.

One may well ask how such a description varies from what may be contained in a book, consultant's report or an expert document. In simple terms, all three of these entities tend to be written from the viewpoint of an expert (or claimed expert) whose purpose is to provide a particular perspective on a subject. In general, in all three cases, the expert is deemed to be imparting knowledge to those who read the document in question. All three entities can contain personal opinions, unsubstantiated claims, unreferenced and unqualified assertions, and so on. In each case, it is a matter for the reader to make some assessment of the validity of the presented ideas. In each case there is a significant probability that a reader may incorrectly reject or accept presented ideas.

In a thesis, on the other hand, the author is a humble student who endeavours, through:

- The strength of reasoned arguments
- The opinions of learned peers

- Well-sourced references
- Supporting scientific evidence
- Statistics

to convince a learned reader of the validity of a course of action and its outcomes. In a thesis, the author humbly endeavours to convey the fact that there has been a preparedness to:

- Value the opinions of peers and colleagues
- Learn from peers and colleagues
- Review the work of peers and colleagues by comparing and contrasting the views of those peers without prejudice or favour
- Put aside personal opinions and biases in favour of strong scientific evidence or reasoning.

A thesis is neither better nor worse than a book, consultant's report or expert document - it is simply a different forum for expression, with a different fundamental purpose. Of course, there are also many books, consultant's reports, etc. which have all the attributes of a well-written thesis but, at the core of each of these, is the relationship between the reader and the author.

One reader may read and completely concur with the thoughts expressed in a book on, say, politics, which has been developed by an author with a particular perspective. Another reader may well read the same text and completely disagree with the expressed sentiments. Although it would be extremely naive to suggest that all thesis readers will concur on the sentiments expressed in a thesis, the objective of the author is to seek, through powerful and impartial arguments, a broad consensus of opinion on the process and outcomes of the research. This is a particularly difficult task, because it is generally left in the hands of a novice author (the postgraduate

student) who has little experience with the preparation of lengthy documents.

It is also important to note that a thesis is a document written by an amateur. In many cases, this means that the presentation and the presented work may be imperfect or mediocre or "just passable". It is therefore necessary to recognise that, while reading theses from other researchers can give an insight into the standards required of a thesis, it can also lead to postgraduate students lowering their own standards in line with work they have read.

Even though, as it has already been stated, text books and theses have different purposes, there are many text books which can be used to exemplify the very best attributes that are required from a thesis. For example, a text book that represents a life-time's research for a historian, may provide a far superior model for a research literature review than an amateurishly written thesis. A mathematical text, written by an expert in the field, may provide a far better model for the presentation of mathematical proofs than an array of student theses.

It is also important to note that, in preparing to write a dissertation the length of a traditional Master's or Doctoral thesis, a postgraduate student generally needs to be well read in order to produce such a document to a high standard. For example, a student, undertaking a Doctoral program in physics, may benefit from reading a political or historical treatise written by a talented author. Why should this be the case? Simply, because it is often easier for one to recognise the important attributes of a piece of work when one moves outside one's own sphere of research. Hence, the physics student, in the above example, may read a book in the field of physics, and be more concerned about the technical aspects of the work than in the intrinsic qualities of the writing, or the tactics used to present arguments, that make the book an expert's work. Expanding one's horizons to a completely different field may therefore serve to highlight the intrinsic qualities of other authors' skills, rather than the technicalities and semantics of the presented information.

In this text, however, the principal focus is upon tactics that can be employed in the systematic preparation of a thesis and the documentation of a research program. In summary, the key factors that are addressed, herein, are as follows:

- (i) The development of a central theme for the research thesis. The development of a thesis structure that emphasises the research process and the central theme
- (ii) The incorporation and analysis of other researchers' views - through literature review
- (iii) The concise depiction of the physical aspects of the research program
- (iv) The detailed explanation of the impartial techniques that are used to test the boundaries of the proposed ideas within the research program
- (v) The presentation of the research outcomes
- (vi) The analysis of the manner in which the research outcomes contribute knowledge relative to the broader environment
- (vii) The critical appraisal of the research program.

Importantly, one of the emphases in this text is how the seven basic elements, listed above, can be seamlessly combined into a document which is also concise and well balanced in terms of the image presented to the reader.

3.7 The Examiner

The final arbiters in postgraduate research programs are examiners that are used to assess written theses and/or verbal defences of the research work and the research process. If one is to be entirely pragmatic about the conduct of the research program, then one has to accept that, in terms of achieving a formal outcome, it is the examiners for which the research program needs to be conducted. In other words, the success or failure of a thesis or verbal defence ultimately depends upon a combination of the subjective and objective opinions of the examiners.

The postgraduate research student is always faced with the uncomfortable dichotomy of research. On the one hand, the research program should have an altruistic objective and motivation, independent of the final examination process. On the other hand, the research student, being a humble investigator, needs to recognise that the work needs to be independently assessed by examiners and that those examiners will (either consciously or subconsciously) be subject to biases that may influence their assessment. To some extent, the problem can be resolved by the student always taking the view that an examiner will assess the work with a bias towards some opposing viewpoint - hence, the thesis and verbal defence should always be prepared with the devil's advocate in mind. However, there are other issues about examiners and peer reviewers that need to be understood if one is to achieve positive outcomes from a postgraduate research program.

Firstly, the research student needs to get to "know" the examiners at a very early stage within a research program - not necessarily the specific examiners that will be called forth but, rather, the types of examiners that will be called forth. How can this be achieved while still retaining an impartial investigation? Simply, by having a clear understanding of:

- The arena in which the research is conducted
- The experts that work within that arena

- The opinions and biases that experts within that arena maintain.

The examiners, of course, should ideally represent the body of expert knowledge that exists in a particular field - together with the biases and idiosyncrasies often associated with the history of a body of knowledge.

Why should the biases and opinions of experts influence a postgraduate research program?

- Because the postgraduate research student is neither a consultant nor an expert
- Because the opinions and biases of expert peers must be respected by a student who is a humble investigator
- Because one of the fundamental objectives of postgraduate research is to learn from expert peers and to respect their work until hard scientific evidence or independent studies prove otherwise.

In other words, given that the objective of a postgraduate research program is to learn how to learn from others, it would be presumptuous to ignore or ridicule the opinions of expert peers.

The examiners, on the other hand, have every right to use their biases and opinions in order to act as devil's advocates and to probe the details and argumental or thematic weaknesses of a research project. This leaves the research student with the task of:

- Learning where biases exist
- Learning why the biases exist
- Determining how to present balanced arguments for and against those biases without introducing personal biases into the process.

An examiner may have more than just personal biases associated with the review of a postgraduate's work. Typically, an examiner may work within one narrow aspect of a broader field of study. A research student may work within another narrow aspect of the same broader field. The communication link between the student's field and the examiner's field may be weak. Sometimes, an examiner may have a natural leaning toward his/her own field of study and the student's field may appear to be less important. This sort of field biasing tends to create results that confuse the research student. Often, an examiner will criticise a student's work as being weak when, in fact, the student's work is good in one area but not in the specific field of interest of the examiner.

Hence, in undertaking postgraduate research, one not only needs to become familiar with the processes and rigours of the process of discovery but also the idiosyncrasies of the review process. A detailed literature review is critical if the student is to understand the range of viewpoints and biases that will be held within the sphere of interest. Ultimately, however, the student must adopt the worst-case scenario approach and assume that the examiners' arguments will be diametrically opposed to the approach adopted by the student. This means that literally every sentence, within a thesis or verbal defence, needs to be analysed in terms of the counter arguments that can be put forward. It also means that a student has to exercise extreme caution in the wording of a thesis or verbal defence. Table 3.2 shows how careful one needs to be in order to avoid having expressions used in common speech being countered during the course of an examination.

A simpler way in which to view the examiner is in terms of other experts in the field. After having completed a literature review, extract two published authors with opposing views. Consider how a thesis or verbal defence would have to be worded in order to individually satisfy each of the two authors - then consider how the thesis would have to be written in order to simultaneously satisfy the two authors. This is the approach that needs to be adopted in the very early phases of the research program in order to

understand how to navigate a course between an unbiased research program and the personal biases of particular peers.

Another dichotomy in the research process is the manner in which the examiner needs to be treated by the student. On the one hand, the examiner is considered to be an expert. On the other hand, in order to convince the examiner that the student has completed the research program to a high standard, it is the student's role to explain theories and concepts to the examiner as though he/she was a novice. This means that arguments need to be carefully developed - not because an examiner will not understand complex arguments but because a student needs to involve the examiner in his/her learning process.

One of the most common myths in postgraduate research is that, in order to impress examiners, one needs to make theses and journal papers extremely complex so that no-one can understand them. In fact, the reverse is true and many examiners are particularly impressed when a student is able to explain a complex concept or mathematical theorem in a straightforward manner. Contrary to popular student opinion, therefore, the esteem in which the student's abilities are held, by the examiner, is sometimes inversely proportional to the complexity of the arguments that the student uses to support his/her case.

	Argument	Counter Argument
(i)	<i>"All the research suggests..."</i>	<i>You could not possibly have studied ALL research</i>
(ii)	<i>"Until this research program commenced no research had ever been undertaken in this field..."</i>	<i>In order to prove this you would have to have seen ALL research</i>
(iii)	<i>"It is this author's opinion..."</i>	<i>You are not an expert - what do other learned people think</i>
(i)	<i>"The evidence uncovered during the course of this research suggested..."</i>	<i>Justifiable statement</i>
(ii)	<i>"A literature review undertaken during the early phases of this research program covered a range of key journals in the field, cited herein, and these did not contain reference to any similar research..."</i> <i>"Jones (1967) stated that no research in this field had been undertaken up until that time..."</i>	<i>Balanced statement of status</i> <i>Impartial assessment of status</i>
(iii)	<i>"Thwaites and Simpson (1999) expressed the view that..."</i>	<i>Impartial supporting statement</i>

Table 3.2 - Alternative Approaches to Expressing Sentences in Order to Avoid an Examiner's Counter Arguments

3.8 The Examination Process

Having established the potential characteristics of an examiner, the mechanics of the examination process take on somewhat less significance. It is also important to note that the requirements of a verbal defence, as part of an examination process, can vary markedly from university to university and it is therefore difficult to generalise on the traits of such a process. Nevertheless, there are a few key factors that need to be addressed in terms of the examination process as it pertains to a thesis - some of these points also translate to the verbal defence of a research program.

The first point that needs to be made concerns the remoteness of an examiner. Generally, thesis examiners for postgraduate research programs, particularly at Doctoral level, are appointed externally to the university in which the program is conducted. Often, these are assessed outside the country of origin. A university normally contacts and appoints potential thesis examiners on behalf of the research supervisors. The interactions, regarding a thesis, are therefore between a university's governing research body and the external examiner - the supervisors may not be involved in the process at all after they have provided a list of potential examiners to the university.

Given that potential examiners have to be identified, approached, have their qualifications assessed by the university, etc., it may be several months between the time an examiner is first contacted and the time that the thesis arrives for assessment. In such a period of time, the examiner may have put aside all recollections of discussions on the topic and, upon receipt of the thesis, may need to have a basic overview restated. It is therefore particularly useful for a postgraduate research student to write the thesis with such an examination environment in mind. Hence, assuming that an examiner has no knowledge of:

- Where the research was conducted
- Why the research was conducted

- When the research was conducted
- What the basic objectives of the research were
- What other collaborating organisations were involved in the research
- Whether or not the postgraduate research program was an independent project or part of some larger research program involving other staff
- What the research student's role in the overall program was

then it is particularly important that the research student make these points clear at the outset of the thesis.

All too often, theses are written on the assumption that the examiner has an intimate knowledge of the work that was conducted - opening statements often begin poorly with complex technical jargon related to the project, rather than important basic information on the research program. In general, however, the postgraduate thesis examination process does not support this sort of reasoning. Further, it can be particularly frustrating for examiners to assess work when they have no concept of the environment and time-frames in which it is conducted. The student can have an important role in making the examination process more pleasant and meaningful for the examiner thereby, potentially, improving the examiner's understanding of the work and aligning his/her thought processes with those of the student. Consider the following two examples:

Example 3.1 - Commencing a Thesis with Technical Detail

"The application of adaptive filtering approaches based upon the Kalman approach can have potentially positive benefits for the removal of..."

Example 3.2 - Introducing a Research Environment and Context

"This thesis documents a Doctoral research program, undertaken at the New England University, between the years of 1996 and 1999. The research work, presented herein, was part of a larger program of research involving six researchers. The objective of the overall research program was to investigate the optimisation of imaging techniques that could be applied within a range of medical environments. This Doctoral research was a subset of that overall program and the specific objective here was to study the application of adaptive filtering approaches..."

Note the way in which Example 3.2 moves to address a range of basic issues that may not have been covered in interactions between the university and the examiner. While the Example 3.1 is an immediate launch into technical detail, Example 3.2 begins with a simple and reassuring coverage of key factors that the examiner must understand in order to make a meaningful assessment of the work.

Another point that needs to be made in regard to the examination process, as it pertains to theses, is that theses are generally difficult documents to read because they tend to be written by amateurs and because they are highly technical in nature. Moreover, few examiners have sufficient time available to read an entire thesis from cover to cover within a single session. Typically, an examiner may read one or two chapters in a day or in a week. If a postgraduate student considers that the examiner will also be preoccupied with other matters between reading sessions then what

becomes apparent is that the writing style of the thesis has to account for the reading style of the examiner. In other words, the student needs to consider the addition of brief prompts that will remind the examiner of important points that were made in previous chapters - on the assumption that the examiner may not immediately recall such details because of the time lapse between reading chapters.

It is also particularly poor practice, and extremely frustrating for examiners, for students to constantly cross-reference backwards and forwards in a thesis. Again, if one assumes that the examination process will involve pauses between chapters, then brief summaries, seamlessly integrated into the text, are considerably more pleasant to read than repeated cross-references to previous or upcoming sections. To a large extent, excessive cross-referencing is a hallmark of a poor thesis structure and a poor communications ability on the part of the postgraduate research student.

In understanding the examination process, whether it be verbal or thesis based, it is also necessary for a postgraduate student to understand his/her own communications limitations. Unless students have had considerable exposure to professional public speaking (in their technical field) or to the writing of large volumes of text, then they tend to find that getting their thought processes into alignment with those of examiners is quite difficult. One of the key factors that gives rise to this is that research students often endeavour to present complicated arguments in order to impress examiners and, ultimately, discover that either they don't understand the concepts themselves or, worse still, don't even believe in their own arguments.

In order to understand the difficulty of aligning the examiner's thought process with the student's thought process, consider any number of fictional novels, and the manner in which a theme is presented. In general, regardless of the inherent complexity, it is possible to summarise the basic theme of a novel within one or two sentences. An entire novel of 500 pages, or more, may do little more than convey the details of that central theme. Many research students overestimate their writing abilities and believe that they can

convey a broad range of complex ideas to a thesis examiner or panel member in a verbal defence. This is a particularly serious mistake that can lead to disastrous outcomes in terms of the examination process.

An entire thesis or verbal defence must, therefore, like a novel, be in support of a simply-stated central theme and all the arguments therein must support that central theme. Once the breadth of the theme increases, or its complexity increases, then the quality of the arguments and the defence must inevitably diminish.

In summary, combining what has been covered in Sections 3.6 - 3.8 and, indeed, throughout this chapter, the key factors that need to be addressed in moving a postgraduate research program towards the examination process are:

- (i) Understanding the fundamental purpose of postgraduate research
- (ii) Setting motivators that align with the true purpose of postgraduate research
- (iii) Understanding the role of peer review and independent assessment
- (iv) Understanding potential examiners and understanding their attributes
- (v) Developing a simply-stated central theme for the research that can be solidly defended
- (vi) Understanding one's own communications abilities and ensuring that one does not exceed one's capacity for communications when developing a central theme for research
- (vii) Understanding the physical limitations and dimensions of the examination process and adjusting presentations of research to align communications between the examiner and the student.