UNIVERSITY OF PRETORIA
GRADUATE SCHOOL OF TECHNOLOGY MANAGEMENT

RESEARCH GUIDE FOR MASTERS AND DOCTORAL STUDENTS IN THE GRADUATE SCHOOL OF TECHNOLOGY MANAGEMENT

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List of Abbreviations

GSTM	Graduate School of Technology Management
MEM	Masters in Engineering Management
MPM	Masters in Project Management
MTIM	Masters in Technology and Innovation Management
PhD	Doctor of Philosophy

Acknowledgements

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1. Introduction

The purpose of this guide is to assist you, as a student in the Graduate School of Technology Management (GSTM) at the very start of your research career, with information which will be invaluable to your understanding of research, the planning of your project and the role of your supervisor. The guide is intended as additional material to support you in your studies of **research methodology**.

Before you begin your research project, the GSTM requires that you complete a course in research methodology. This module is now offered on-line and will form part of the programme in the early stages of your research. Research methodology is the study of research method, and covers not only research design, but the reasons for the use of different methods in different contexts. You will need this information in the planning of your research and in the writing of your dissertation, particularly the chapter on research methods, in which must describe and explain all aspects of your design, including its teleological focus, the Frascati category, the linkage to theory, the means of data acquisition and the method of data analysis. Once you have completed the course, you should be able to identify all the main attributes of the research, as summarised in Figure 1.

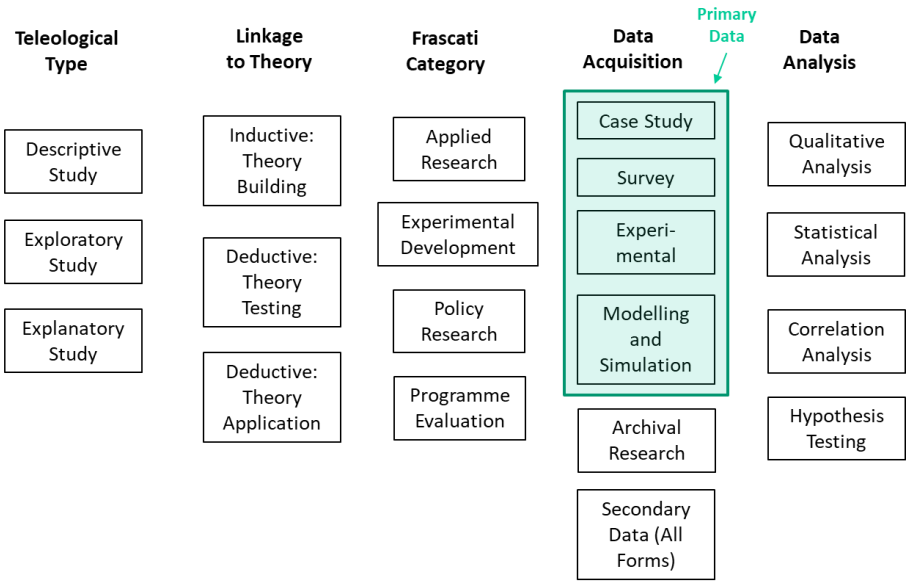


Figure 1. Summary of research attributes and categories

In Section 2, we begin with the definition of research and why the activity of research raises questions of epistemology, personal ontologies and research philosophy. This section is followed by guidance on how to choose your research topic (Section 3), how to prepare your proposal (Section 4), how to design your research (Section 5), how to plan your research project (Section 6), and finally how to structure your dissertation, mini-dissertation or thesis (Section 7).

Other useful material is attached in the appendices, and will also be made available to you through clickUP and Google Drive. Most importantly, you will receive detailed guidance and support from your supervisor.

2. The Philosophical Basis of Research

2.1 Ontology, Epistemology and Methodology

Research is an activity whose purpose is to generate new knowledge based on the collection and analysis of empirical data. The knowledge may subsequently (and hopefully will!) be applied in a variety and sometimes unpredictable number of ways. It can be used to develop new products, processes and services; to ensure the sustainable development and management of ecosystems; to develop new policies, regulations and programmes within the public sector; and to improve education and the absorption of new technologies. All of these applications should have the intention, at least, of improving our social, environmental and economic well-being; this underlying intent is referred to as the **directionality** of research (Schot and Steinmueller, 2018).

Although the objective of research is to produce new knowledge, such an outcome cannot be guaranteed. In this sense, researchers are eternal optimists; they are knowledge workers who believe in the possibility, and not the certainty, of progress. But researchers must not only accept uncertainty, they must also be self-reflective, and understand bias or prejudice. They must reject belief as a means of building knowledge, and adopt the principles of reason and analysis, which are central to philosophy of Enlightenment and what we all the 'scientific method'.

Despite our conscious efforts to follow such principles, it is inevitable that our research is influenced by our own subjective beliefs and **ontologies** (views of the world). It is therefore important that you, as a researcher, are aware of your possible bias. In undertaking your studies you need to be aware of the philosophical concepts of ontology, **epistemology** and methodology, as is illustrated in Figure 2, and how your research method may be influenced by your paradigms (Singh and Walwyn, 2017). As a means of identifying your paradigms, it is recommended that you complete the questionnaire on "Heightened Awareness of Research Protocol" (Saunders et al., 2016:45), which is also available as a spreadsheet in the GSTM Google Drive.

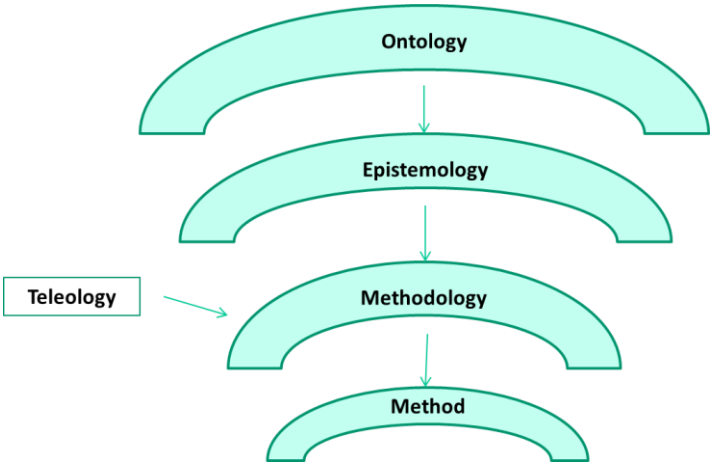


Figure 2. The hierarchy of categories for understanding knowledge and research

Epistemology is the study of knowledge and an understanding thereof is fundamental to research. There are many perspectives of epistemology, including such fundamental questions as whether truth exists or what constitutes valid knowledge, it is useful to consider the classic epistemological dichotomy between positivism and constructivism, whose main differences are summarised in Table 1. Although this bifurcation is a simplification (in reality, a whole spectrum of epistemological perspectives exists), it offers some insight into how different methodologists view the core epistemological questions, such as the nature of reality, the role of theory, the relationship between knowledge and the researcher, and the concepts of validity, reliability and repeatability.

Table 1. Comparison of epistemological paradigms

Positivist (Empirical-Analytical)	Constructivist (Interpretive Hermeneutic)
Reality is single, objective and apart from the observer	Reality is subjective and multiple
Quantitative data derived from experiment	Qualitative data derived from observation
Reliability is most important (repeatable results)	Validity is important (improved by triangulation)
Deductive	Inductive
Location is artificial; all variables held constant except the independent variable	Location is natural; not possible to control any variables
Mainly experimental, preferably with control	Type of research includes ethnographic, participant observation, case studies

Now you are almost ready to decide on your research topic, as covered in Section 3! But first, we must cover the principles of induction, deduction and the construction of knowledge.

2.2 Approaches to the Construction of Knowledge

A research project should contain elements of concrete experience, reflective observation, and the development or validation of new theory, as depicted in the research–application cycle and shown in Figure 3.

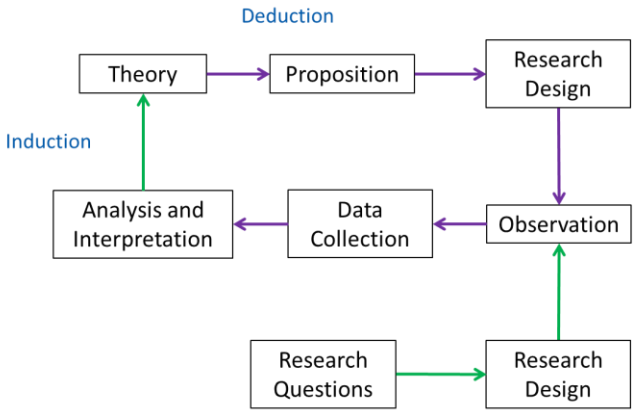


Figure 3. The construction of knowledge through research

The relationship between empirical observation and theory defines the type of research; inductive research results in the construction of theory, whereas deductive research involves theory testing and/or theory application (see **Appendix 1** for a glossary of research terms). Research which is both deductive and inductive is called mixed methods research (Creswell, 2013). Studies which develop, test, or advance management theory and practice should have well-articulated and strong theoretical foundations. All types of empirical methods, including quantitative, qualitative, or mixed methods, are acceptable. Case studies and well-considered observations of management experience, survey research, methodological studies, replications and extensions of past research are valid approaches providing the work leads to new conceptual or theoretical insights (see Section 5).

Well-conceived and successful research outcomes (knowledge or theory) will find many applications (it is said that there is nothing more useful than a good theory!). In this regard, the application or testing of existing theories, models and methods within a new context does generate new knowledge as it provides new insights. This type of project is well-suited for students registered for Masters in Technology and Innovation Management (MTIM), Masters in Project Management (MPM) and Masters in Engineering Management (MEM). Students who undertake this work should be able to demonstrate an understanding of the concepts and an ability to apply them to a specific problem; it is also essential to produce something original and useful.

In summary, there must be a clear relationship between your research and the theoretical frameworks, but this relationship can be structured in three ways, namely the application of existing theories, models and methods to a new problem; the testing of existing theories, models and methods; and the construction of new or improved theories, models and methods. The emphasis between these types is different for a Masters-level mini-dissertation and a PhD thesis, as shown schematically in Figure 4.

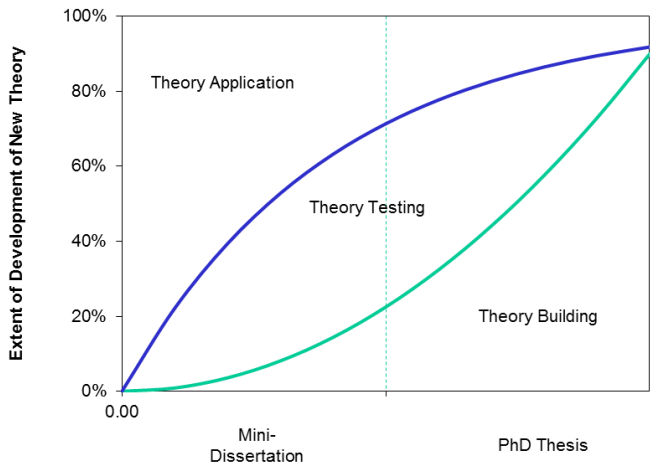


Figure 4. Typology of relationships between research/theory at varying levels of study

High quality academic research must not only have a clear link to theory; it must also follow the recognised research process, meet the required epistemic criteria and have a clearly articulated purpose (Marais, 2012).

3. Choosing Your Topic

3.1 General Principles

In choosing your research topic, regardless of the level of study, there are two fundamental principles to which you need to prescribe. The first principle is that your research will be undertaken at a public research institution (a university!), will be partly supported by public funds, and in this respect, the topic needs to align with public principle and contribute to public good.

It is argued that public-funded research has in the past inadequately addressed issues of sustainability and public good, in what is called a failure of directionality (Schot and Steinmueller, 2018). If we are to ensure the longer-term survival and prosperity of our social, environmental and economic systems, all research needs to begin with a strong rationale based on its potential to the Sustainable Development Goals and the Second Deep Transition (Schot and Kanger, 2018).

The second consideration is that academic research is not synonymous with doing a "management investigation or study". There are some important differences; a management investigation consists of the application of acquired knowledge to a specific management problem in an organisation, whereas research is the generation of new knowledge which can be generalised to other environments (see Table 2).

Table 2. Comparison of academic research and management study

Aspect	Academic Research	Management Study
External validity	The results can be applied more widely than the unit of research (company or individuals)	The results are only valid to the specific company or individual
Theory	Builds new theory or tests existing theory	Applies theory but at a simplistic level
Source of background knowledge	Mostly recent peer-reviewed literature	Mostly trade articles and other management studies
Teleology	Seeks causative relationship	Focussed on improvements and results
Methodology	Seeks novelty (insights)	Replication of proven formulas for success

3.2 Research in Engineering and Technology Management

The purpose of research in project management, engineering management and technology management is to generate the knowledge and practical techniques which will improve the management of technological innovation, the implementation of new projects, the sustainability of technology-based organisations, and the outputs of national systems of innovation. Engineering and technology management links the engineering, science, and management disciplines; it provides the interface between technology and other corporate

functions such as research and development (R&D), marketing, operations management, human resource development, manufacturing and administration.

Technology management also addresses the issues involved in the planning, development, and implementation of technological capabilities which shape and accomplish the strategic and operational objectives of an organisation. It covers not only R&D management, but also the entire spectrum of managerial concerns in technology-based organisations, including issues relating to innovation process management, project management, market forecasting and development, technology roadmaps and strategic planning.

The research programme of the Graduate School of Technology Management (GSTM) is focussed on the improvement and further development of the theory, science and practice of engineering and technology management, producing material of relevance to both academics and practising managers. Further details on the specific areas of interest and research within the GSTM can be accessed from the school's web site (https://www.up.ac.za/graduate-school-of-technology-management). This information is updated on a regular basis but covers only an overview of the various research fields. In addition to these summaries, the staff of the school publish each year a list of possible research topics, which is made available to the students through clickUP.

Both Masters and Doctoral students are welcome to pick a suitable topic from the list. Before you make a final decision, however, it is advisable that you, as the student, meet with the relevant supervisor, and obtain further clarification of the project. Generally, Doctoral students are expected to develop their own topics but this is not considered to be a prerequisite for registration. Your topic will in any case evolve during the course of your research; the most important aspects are that you should feel passionate about, and take ownership of the research questions. Without this sense of commitment and passion, it is unlikely that you will be able to complete your research.

Table 3 summarises the research reports which were completed at the GSTM over the period 2013 to 2018, according to knowledge area and research approach. You will notice that the reports cover a wide range of areas.

Table 3. Profile of GSTM research reports by knowledge area and design (2013 to 2018)

Knowledge Area (KA)	Quantitative		Qualitative		Total	
	Number of Reports	Proportion of Knowledge Area	Number of Reports	Proportion of Knowledge Area	Number of Reports	Proportion of Total
Technology & Innovation Management [a]	147	82%	32	18%	179	25%
Business Strategy [b]	33	68%	16	32%	49	7%
People Management [c]	15	30%	34	70%	49	7%
Business Processes [d]	381	85%	67	15%	448	62%
Total	**575**	**79%**	**149**	**21%**	**724**	**100%**

Notes to the table:

a. Science policy, innovation management, knowledge management, manufacturing, research management and technology management.
b. Configuration management, financial management, lean engineering, marketing management, organisational strategy, systems engineering and theory of constraints.
c. Human resources, organisational behaviour, organisational culture, people management, social development and talent management.
d. Maintenance management, project management, safety and environment and risk management.

Source: Singh and Walwyn (2017)

Examples of high-quality reports will be shared with you on clickUP and it is important that you read these reports, and other works in the extant literature, in order to get a sense of how other researchers have undertaken their studies, and the quality which the GSTM will expect of your work. Examples of titles from recent studies follow:

- The impact of risk management approach on organizational culture and personal behaviour within a coal mining operation
- Influence of external funding and intellectual property protection on the success of technological ventures
- An assessment of the South African photovoltaic sector within the technological innovation system framework
- Social networks and doctoral throughput: an analysis of the South African National Research Facilities
- An evaluation of the influence of organizational project management maturity on project success in the South African construction industry
- Determination and analysis of critical failure factors in the management of biofuel projects in Mozambique
- Enterprise resource planning for supply support: A South African Air Force case study.

4. Developing Your Research Proposal

Once you have chosen your topic, you will need to develop your research proposal. The research proposal is a preliminary document that is completed before your research is undertaken. The proposal should help you to focus your thoughts on a topic, to define in broad terms the way in which you are going to approach and structure the work, and to familiarize you with the relevant literature. A standard approach to the development of this document is shown in Figure 5.

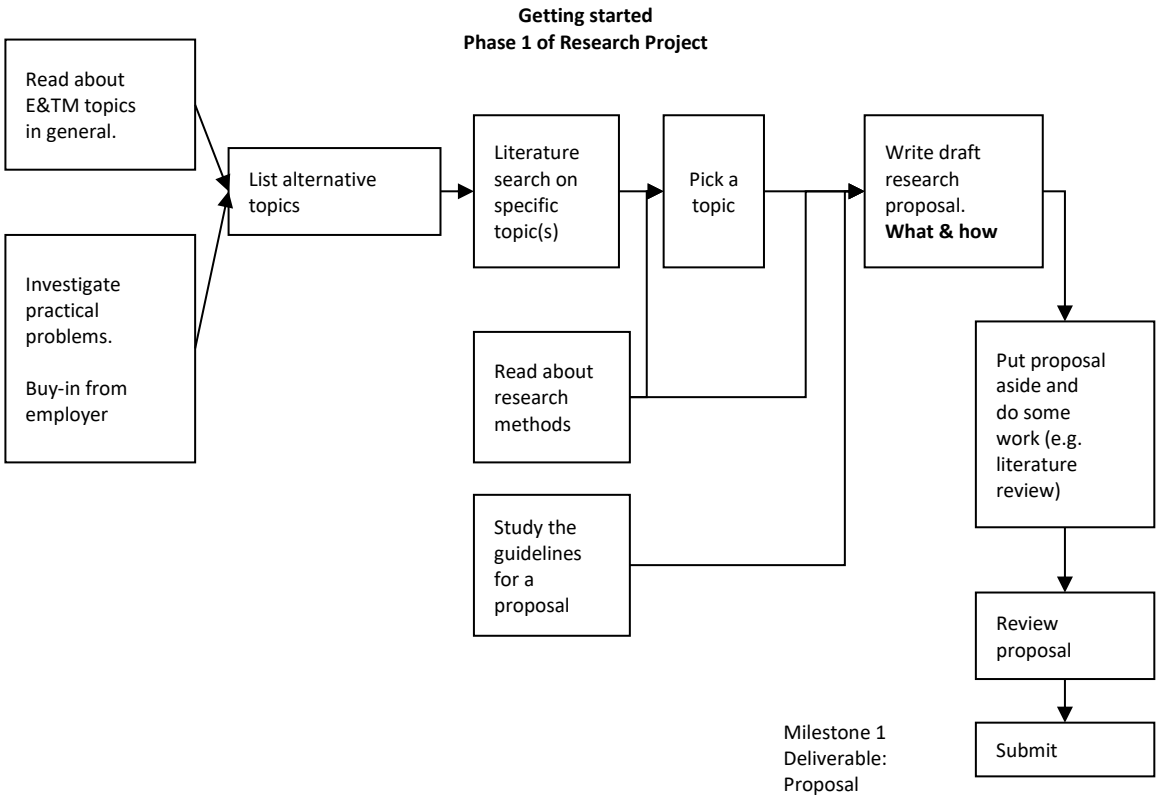


Figure 5. Flowchart for the development of your research proposal

Here are a few useful points to keep in mind when doing the preliminary search before you can write your research proposal:

- Be inclusive with your thinking and see how many different research projects you can identify.
- Try not to be overly influenced at this time. Search for something that you are really interested in.
- Keep in mind that first and foremost the whole research project should be a learning experience for you. The process of conducting the research may be just as important (or more important) than the outcomes of the research.
- Write down your ideas using the one-page format provided in **Appendix 2**. Discuss your ideas with friends, colleagues and potential supervisor.
- Ensure that the one-pager covers the essential aspects of problem (or opportunity) statement, research objectives (not more than 2), research questions (not more than 5), research propositions or hypotheses (if relevant), outline of research design and

the rationale for the research; the relationship between each aspect is shown in Figure 6.

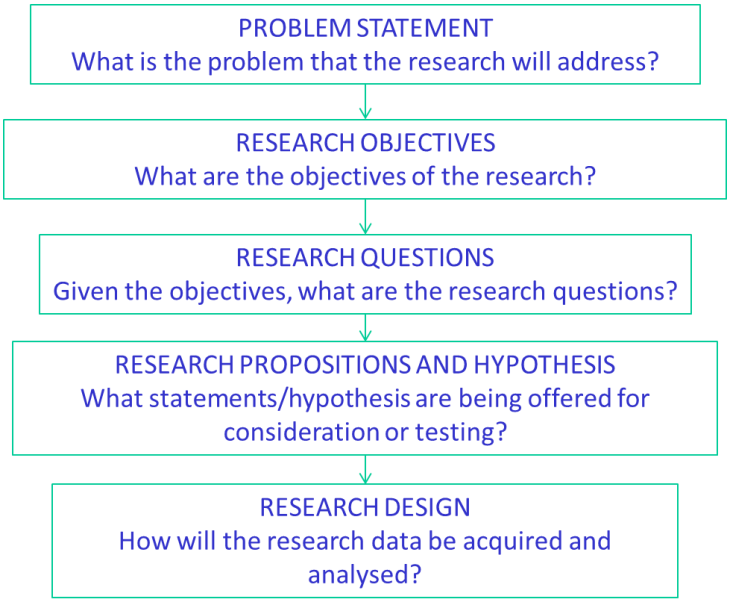


Figure 6. Framework for the development of the research idea

Here's a final check before you should start writing your proposal. Does each of these statements describe you?

- I am familiar with the theories and past research that has been conducted in areas related to my research project.
- I have a clear understanding of the steps that I will use in conducting my research.
- I feel that I have the ability to get through each of the steps necessary to complete my research project.
- I know that I am motivated and have the drive to get through all of the steps in the research project.
- I have found a study leader that is prepared to guide me through my research project.

Now you're ready to write your research proposal. Here are some ideas to help with the task:

- Read through someone else's research proposal.
- Do a comprehensive theory and research review. The rationale behind the theory and research review is to make sure that this research is needed and the methodology is appropriate for the question that is being asked. General sources such as textbooks, course notes and overviews are more appropriate at this stage. You should consult at least the following number of literature sources: MEM/MPM/MTIM @ 30; and PhD @ 50.

(Practical advice for literature: When you read something that is important to your study, capture the relevant article or section in your filing system, either as paper copies or in electronic format. Keep your copies organized according to categories and sections. Most

importantly, record the bibliographic citation so that you can easily reference the material in your bibliography. Then, when you decide to sit down and actually write the theory and research review, retrieve your copied records, arrange them into logical and sequential order, and begin your writing. MS Word has a function that can be activated to record references as you write. The list of references can then be compiled later. The library also offers a course in EndNote to students.)

- A good proposal should begin with a statement of the problem/background information, then move on to a review of theory and past research, and conclude with a defining of the research methodology. Of course, it should be written in a future tense since it is a proposal.
- Focus your research very specifically. Don't try to have your research cover too broad an area.
- Include a title on your proposal. Preparing a good title means: having the most important words appear toward the beginning of your title, limiting the use of ambiguous or confusing words, breaking your title up into a title and subtitle when you have too many words, and including key words that will help researchers in the future find your work.
- It's important that your research proposal be organized around a set of questions that will guide your research. When selecting these guiding questions try to write them so that they frame your research and put it into perspective with other research. These questions must serve to establish the link between your research and other research that has preceded you. Your research questions should clearly show the relationship of your research to your field of study. Don't be carried away at this point and make your questions too narrow. You must start with broad relational questions.

  A good question: "Are the technology management challenges faced by high-tech start-up firms in Pretoria similar to those faced by start-up firms in general?"

  A poor question: "What are the technology management challenges faced by high-tech start-up firms in Pretoria?" (too vague and unspecified)
  A poor question: "What are the technology management challenges faced by firm XYZ?" (not generalizable and too vague)

The length of research proposals should be at least 40 typed pages for PhD candidates and 15 to 20 typed pages for MEM/MPM/MTIM students. Use formal South African English and the scientific style of writing (e.g. “It is proposed…” not “I propose …”), and follow the format as listed in **Appendix 3**.

For guidelines on paragraphs, numbering, etc. consult the relevant templates on the GSTM Google Drive. All references must be listed as shown in **Appendix 5**.

5. Constructing Your Research Design

Once you have completed the research proposal, and it has been approved by the GSTM research committee, in the case of Doctoral students, or your supervisor, in the case of Masters students, you will need to develop your detailed research method, covering how the research questions will be answered and why you have chosen a particular approach from the smorgasbord of available methods.

Such research approaches include quantitative, qualitative and mixed methods (Mouton, 2001). Most of these can be, and indeed have been, used within the field of engineering and technology management. However, the latter field is typically an applied science, dealing with the highly practical problems of managing technology-based organisations in a competitive global market. As a result, there is a preference for certain types of research designs; for example, there is a bias towards applied or empirical research vs. basic, philosophical or highly theoretical studies

As already mentioned, research projects for MTIM, MEM and MPM students can be either inductive or deductive empirical studies (Mouton, 2001:176), and adopt either a mixed methods approach (preferable), a quantitative or a qualitative design (Singh and Walwyn, 2017). In deciding in your research approach, you will need to review what approaches have been used by previous scholars interested in similar questions and working within the same area as yourself. The extant literature is invaluable in this regard. Your decision should also be guided by the general principles of the dominant methods of quantitative and qualitative research, as compared and summarised in Table 4.

Table 4. Comparison of quantitative and qualitative approaches

	Qualitative Research (QUAL)	Quantitative Research (QUANT)
Objective	To develop an initial understanding of underlying reasons and motivations; to provide insights, generating ideas and/or hypotheses for later quantitative research	To quantify data and generalize results from a sample to the population of interest; to measure the incidence of various views and opinions in a chosen sample
Sample	Usually a small number of non-representative cases with purposive sampling	Usually a large number of cases representing the population of interest with randomly selected respondents
Data Collection	Unstructured or semi-structured techniques e.g. individual depth interviews or group discussions	Structured techniques such as online questionnaires, face-to-face or telephone interviews
Data Analysis	Content analysis and non-statistical; descriptive and interpretive	Statistical data is usually in the form of tabulations (tabs); findings must describe level of significance and error
Outcome	Exploratory and/or investigative; findings are not conclusive and cannot be used to make generalizations about the population of interest	May be used to recommend a final course of action if the results are significant; sometimes followed by qualitative research which is used to explore main findings in more detail

Within these broader approaches, one can use research designs based on statistical modelling and computer simulation studies (Mouton, 2001:163), case studies (Yin, 2009), surveys (Mouton, 2001:152), programme evaluation (Mouton, 2001:158), field/natural experimental design (Mouton, 2001:157) and experimental/quasi-experimental. outcome studies (Mouton, 2001:160). Stand-alone literature reviews (Mouton, 2001:179) or non-empirical theoretical will not be supported. Theory and research reviews should be an integral part of all studies, irrespective of the particular research designs used.

In many cases you may use different means of data collection and analysis for each research question. In such cases, and indeed for all research projects containing more than one research question, it is useful to compile a consistency matrix which shows for each question the relevant literature and the collection/analysis design to be used. An example of such a matrix is shown in Table 5.

Table 5. Example of consistency matrix for projects with multiple research questions

Research Question	Literature	Data Collection	Data Analysis
What was the cost of the programme over its first four rounds?	Programme Report 2015	Archival or secondary data	Time series/QUANT
What was the consequence of this investment?	Walwyn and Brent (2015)	Archival or secondary data	Time series analysis/QUANT
What is the cost/benefit ratio?	(Walwyn et al., 2015)		Regression analysis/QUANT
What is the perception of this value?	(Walwyn and Nkolele, 2018)	Survey with semi-structured questionnaire	Content analysis to uncover perceptions

6. Research Management Process

6.1 PhD Research Management Process

To enable students to work in a systematic and orderly way, the research project is divided into the following five phases:

Phase 1 : Research Proposal
Phase 2 : Research Plan
Phase 3 : Research Execution
Phase 4 : Dissertation/thesis/report
Phase 5 : Examination and Dissemination

Each phase has a set of actions, an output, a review baseline and a milestone as shown in **Appendix 4.1**. At the conclusion of each phase the output documentation is submitted to the Study Leader or the Research Committee for review and approval. A typical schedule of milestones for a PhD research project is also shown in **Appendix 4.1**. Review Committee's pro-forma Review Reports can be found on the PhD clickUP site.

6.2 Masters Research Management Process

The Masters research management process for a two-year research project is shown in Figure 7. The detailed schedule and description can be found **Appendix 4.2** and also in the study guide.

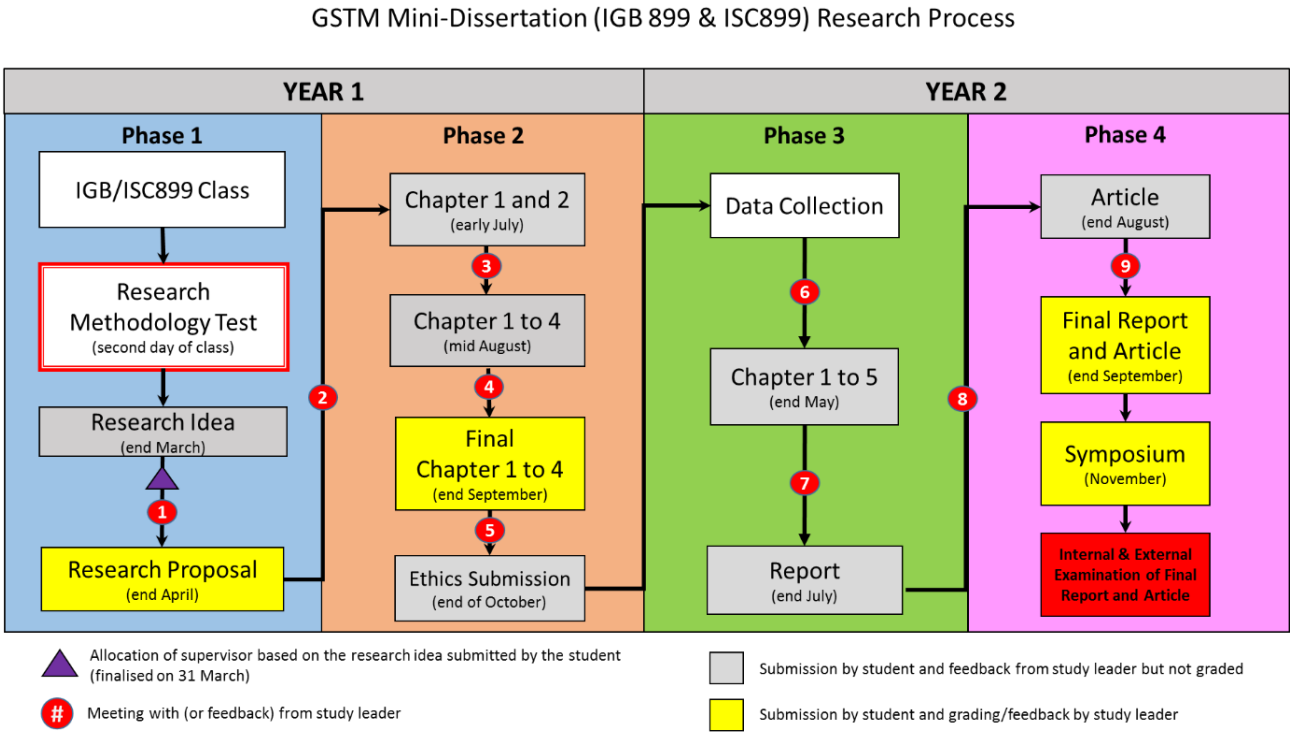


Figure 7. Milestones of a Masters level research project

7. Structure of Dissertations/Theses/Reports

The dissertation/thesis/report is the final embodiment of your research project. It is a reconstruction and documentation of the logic of your research.

The dissertation/thesis/report should start with the research problem, followed by the research design, the evidence and the conclusions. The reader should never be in doubt as to where you are in this process. You should indicate this clearly in introductory and closing paragraphs in each chapter. Here are some guidelines for the structure of the dissertation/thesis/report[1]:

Preliminaries
The dissertation/thesis/report should start with a *Title Page, Acknowledgements, Summary/Abstract, Table of Contents and List of tables/List of figures*.

Chapter 1: Introduction/Background
Chapter 1 should contain background information regarding the *technological*, *industrial and organisational setting* for the study. It should describe and give a thorough overview of the historical development and current state of the industry, organisation/s and technology under investigation. It should present the reasons for selecting the particular problem - the rationale for the study - as well as a statement of the research problem (and/or research objectives or research question/s). You should identify the key attributes of the desired theory and derived models or methods that is required to solve the research problem. Your objective could read: "To [develop a new] or [test the] or [apply the] theory for …". Your goal could be to show that the theory you have developed, tested or applied is *valid and useful* for solving the research problem (or answering the research question/s). See Mouton (2001:122) for detailed instructions on writing this chapter. Sub-headings for this chapter could be:

1.1 Introduction
1.2 Historical development and current state of the <*industry, organisation/s and technology under investigation*>
1.3 Research problem
1.4 Rationale for the study
1.5 Research objectives and/or research question/s
1.6 Key attributes of the desired theory and derived models or methods

Chapter 2: Theory and Research Review/Theoretical Background
Chapter 2 should contain a comprehensive review and critical analysis of the theory and past research that represents the most authoritative scholarship in those fields related to the research problem. This should be a wide-ranging survey of the broad area of interest, including work in related fields. You should indicate what research has been done and what

[1] Note that the structure described in this section is for the traditional "PhD by Monograph" approach. In a *PhD by Monograph*, the PhD student writes a comprehensive piece of research in a book form. The other approach known as "PhD by Publications" on the other hand does not follow the same structure. In *PhD by Publications*, multiple articles are written and joined together to constitute the PhD thesis. The structure of each journal paper depends on the journal chosen by the student and the study leader.

theories currently exist and if any of them can or have been applied to the research problem. Don't just list or describe what you have read, give a critical analysis of the theory and past research. You have to show whether a 'gap' exists for a new or improved theory that is specifically tailored to the research problem.

It is very important to revisit your literature review before you submit your final dissertation/thesis/report to check that there have not been new publications in your field of study. One of the most common criticisms from external examiners is: "The student ignored the following recent publications in this field".

See Mouton (2001:123) for detailed instructions on writing this chapter. Sub-headings for this chapter could be:

2.1 Theory and research review
2.2 Current theories
2.3 Need for a new or improved theory (optional for theory-building research)

Text references must give the author's surname, year of publication and page reference (see **Appendix 5** for further details). For example;

"Landman (1998:12) points out that without a thorough literature study, on which adequate time has been spent, the research work in question can only be considered superficial and naive."

OR

"Without a thorough literature study, on which adequate time has been spent, the research work in question can only be considered superficial and naive (Landman 1998:12)."

The reference number refers to Landman's work as shown in the list of references at the end of the dissertation/thesis/report (see last item in this section).

Chapter 3: Theoretical Framework/Conceptual Model or Method

In chapter 3 you will present the current and proposed theory and derived models or methods that are directly relevant to your research problem. The theory should be embodied in conceptual models (graphical, mathematical or schematic descriptions or analogies) or practical methods (procedures or techniques).

For a theory-testing or -application study, you will present the models or methods you wish to test or apply. The relevant current theories should be extracted from Chapter 2, integrated and presented again in summarised form.

For a theory-building study, you will use either deductive or inductive reasoning. When using deductive reasoning, the deduction of new theoretical propositions must be substantiated by references to real-world observations (Chapter 1) and past scholarship (Chapter 2). You have to describe how you developed your new or improved model or method based on the new theoretical proposition. You have to describe your model or method in detail and show that

what you are proposing is new. Remember that applying a known model to a new application is also "new".

Theories should be subjected to empirical testing to evaluate their validity. The deduction of research hypothesis (expectations based on theory) can serve as a useful methodological guide. When observational facts support a hypothesis, the probability of its being true is increased, but if any contradicting facts are uncovered, the hypothesis must be rejected. The hypotheses will also be useful when doing the research design. This is a powerful methodology for theory testing and should be used whenever appropriate. Hypotheses could be omitted when using only inductive reasoning (see Section 2.2), which is often the case in surveys, case studies, exploratory, and application studies. Sub-headings for this chapter could be:

3.1 Theories, models or methods to be used for this study.
3.2 Hypotheses (optional).

Chapter 4: Research Design

Chapter 4 should contain your discussion of the research design and methodology followed in your study in order to investigate the problem as formulated above. Once you have specified your theory, model or method, you have to show that it is valid (true) and/or useful. This you do by applying it to real-world case/s – this is the empirical testing or application phase. This is where working with hypotheses could be helpful, as they will determine the type of data required to test them. Describe the data-gathering and data-analysis techniques and instruments you intend using. See Mouton (2001:123) for detailed instructions on writing this chapter. Sub-headings for this chapter could be:

4.1 Research strategy
4.2 Research methodology
4.3 Research instruments

Chapter 5: Results: Data Gathered and Analysis

Chapter 5 should contain the presentation of the data or information collected and analysed in the study. The detail of the data gathering process is described. This chapter also includes the testing of hypotheses by showing that the observed facts support the hypotheses or not. The description of your result should be systematic by highlighting the most relevant observations to the topic under investigation. See Mouton (2001:124) for detailed instructions on writing this chapter. Sub-headings for this chapter could be:

5.1 Data gathering process
5.2 Data or information gathered
5.3 Data analysis
5.4 Hypotheses testing

Chapter 6: Discussion

In Chapter 6 the results presented in the previous chapter is interpreted and evaluated in a discursive style. You need to draw together different aspects of your findings and respond to

the research questions in the introduction chapter and findings from the previous research surveyed. This discussion should not only discuss the findings but also why they show this, using evidence and/or theory from previous research to justify the findings. When using retroductive reasoning, this chapter will include the inference of new hypotheses based on the observed facts. Sub-headings for this chapter could be:

6.1 Explanation of results
6.2 References to previous research
6.3 New hypotheses, theories, models or methods

Chapter 7: Conclusions and Recommendations
In chapter 7, the main conclusions of the study are summarised, discussed and interpreted, and where appropriate recommendations are made for further research and practice or policy. You have to show that current theory or your proposed theory and derived models or methods are supported by the research. This is also where you could use inductive reasoning to formulate new theory.

The most important conclusion is that you have achieved the stated objective: "To [apply/test/develop] theory/model/method for …". You have to convince the reader that you have made an important and unique contribution to the "state-of-the-art". An honest appraisal of what you have accomplished is however also appropriate. Without diminishing the value of what you have done, you should state any shortcomings and areas for further research. This should be contained in the recommendations. See Mouton (2001:124) for detailed instructions on writing this chapter. Sub-headings for this chapter could be:

7.1 Summary of results
7.2 Implications for and/or contributions to theory and practise
7.3 Recommendations
7.4 Suggestions for future research

References and Appendices
List all the references by number in the order they were referenced. Adhere to the prescribed format (see **Appendix 5**). See Mouton (2001:125) for detailed instructions on writing this part.

General Regulations **G.58** and **G.59**[2] must be adhered to in the technical editing of the thesis/dissertation/report. Additional regulations that apply in the Department of Engineering and Technology Management are given in **Appendix 6**.

[2] https://www.up.ac.za/media/shared/Legacy/sitefiles/file/publications/2013/general_regulations_and_rules2013.pdf

8. Colloquium, Symposium and Conference Presentations

Key requirements of scientific research are that it must be **public** and **reproducible** (by others). Therefore, an exposure of how the scientific research is structured and executed is of crucial importance, so that others are able to agree or disagree that the observed and/or measured event/s have (or have not) occurred (Page and Meyer, 1999:200). It is therefore expected of researchers to present their research at colloquia, symposia and conferences.

8.1 Colloquia Presentations

The GSTM organises colloquia on a regular basis to give students the opportunity to present their research to academics and fellow students. It also forms part of the Research Management Process described in Section 6 of this Guide. Doctoral students are required to make a colloquium presentation whenever a milestone has been reached.

The purpose of a PhD colloquium presentation is twofold:

1. to give a progress report on completed work, and
2. to present your planning for the continuation of the research project and discuss any problems you are experiencing.

The relative weight of the two parts will change as the project progresses - initially it will consist of only part 2), but after the completion of the project it will consist of only part 1).

MEM/MPM/MTIM students make only one symposium presentation on completion of their research projects. Students MUST submit their presentations to their study leaders, who must approve that it complies with the requirements as set herein, before they do their colloquium presentations.

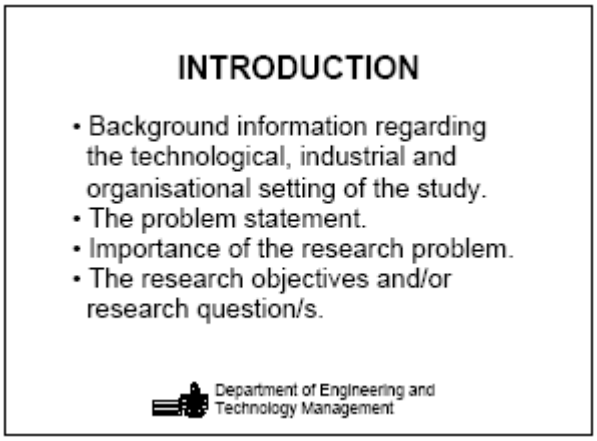
The basic structure of a research presentation is the same as for a dissertation, thesis, research report or a research article. Typically, the presentation should start with the research problem, followed by the research methodology, the findings and the conclusions. The template of PowerPoint slides for the structure of a research presentation at a Masters Symposium is provided on clickUP. Here are some guidelines (and examples of PowerPoint slides) for the structure of a research presentation at a PhD Colloquium:

Topic and author/s

The presentation should start with the title of the presentation and name/s and field of study of the author/s.

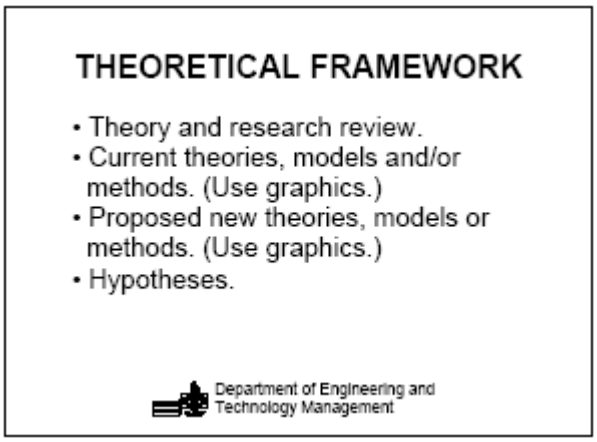
Introduction

Present the background information regarding the technological, industrial and organisational setting of the study. Give the reasons for selecting the particular problem, as well as a statement of the research problem and/or research objectives and/or research question/s.



Theoretical framework

Present a (short) review of the relevant scientific literature. Describe the current theories, models and methods that are relevant to the research problem. For a theory, model or method -building study, the deduction of new theoretical propositions, models or methods should be presented, as well as any research hypotheses.



Research Methodology

Describe the research strategy/design and methodology followed in the study, including the methods used for data collection and analysis. Discuss the testing of hypotheses and the derivation of new theoretical propositions, models or methods when using retroductive reasoning.

Conclusion

The main conclusions of the study should be summarised, interpreted and discussed. Where appropriate, recommendations should be made for further research or practice or policy.

8.2 Symposium and Conference Presentations

Students are encouraged to present their research at local and overseas symposia and conferences. Conference organisers usually require presenters to submit a paper (or an abstract) for publication in the proceedings. They have their own unique prescriptions for the format of the papers they will accept for publication.

The basic structure of a conference presentation is the same as for a colloquium presentation, but would normally deal only with completed research.

8.3 Presenting Skills

Presenters should prepare thoroughly for their presentations. Time utilisation is of the utmost importance as the time allowed is usually very limited. Typically speakers have 20 minutes for presentations at colloquia, symposia and conferences and 10 minutes for questions and discussions. Audio-visual aids should be used to best effect. The use of MS PowerPoint presentations have become the standard.

The following are useful guidelines to presenters:

- Speak to the audience and not to the screen. Never turn your back to the audience. Have written notes or read from the computer display in front of you, but don't turn around to read what's on the screen.
- Project your voice by speaking to the furthest person in the hall and not to those closest to you.
- Don't read only what's on the screen or expect of the audience to do so. (If that is your intention, then why do the presentation? Just hand them a hard copy to read!). The purpose of the images on the screen is to provide the audience with a visual reference to what you are saying. It also allows you to show graphical images such as photographs, diagrams, flow-charts, etc. It is also useful as "speaker's notes" to remind you what to say next.
- When pointing to something on the screen, use an aid such as the arrow cursor of the computer (this works well in PowerPoint) or a laser pointer or a rod to point on the screen. Don't stand in front of the projected image and point with your hands!
- Be very careful not to clutter the images with too much detail. Use large fonts (recommended are Ariel regular, 28 pt or larger for PowerPoint presentations) and high contrast (dark colours on light background or vice versa).
- Practise presenting your presentation and time yourself. You will always take somewhat longer when you present it in front of an audience, so allow for this. A good rule-of-thumb is that you cannot get through more than one slide per minute at most! More complicated slides like diagrams that need a lot of explaining will take much longer.
- Pay attention to voice intonation (do not speak in a monotonic way) and non-verbal communication (body language; do not stand as a salt pillar, do not jump around).

References

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Walwyn, D. R., Huddy, S. M. & Rybicki, E. P. 2015. Techno-economic analysis of horseradish peroxidase production using a transient expression system in Nicotiana benthamiana. *Applied Biochemistry and Biotechnology,* 175(2)**,** pp 841-854.

Walwyn, D. R. & Nkolele, A. T. 2018. An evaluation of South Africa's public–private partnership for the localisation of vaccine research, manufacture and distribution. *Health Research Policy and Systems,* 16(1)**,** pp 30.

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Appendix 1: Glossary of Research Terms

Assumption
A fact or statement assumed to be valid or true or represent an objective view of reality.

Axiology
Study of values, value judgements, ethics and aesthetics

Axiom
A statement accepted as true or a self-evident truth

Concept
Abstract or generic idea generalized from particular instances

Conceptual
Relating to, or consisting of concepts

Conceptual Model
Analytical framework which is used to understand a certain phenomenon or system

Conjecture
A proposition before it has been proved or disproved.

Deduction
Development of argument from the general to the specific

Empirical
Originating in or based on observation or experience

Epistemology
Philosophical study of the nature and scope of knowledge (e.g. traditional vs. scientific)

Fiction
A fiction is either a deliberate or an unintentional fantasy, which is not based on scientific or evidence-based knowledge.

Hypothesis
A tentative assumption made in order to draw out and test its logical or empirical consequences. A hypothesis is an unverified scientific conjecture which contains speculations, and which amplifies an incomplete empirical result, or provisionally explains some fact. If a hypothesis serves as a methodological guide when a new research project is undertaken, it is known as a research hypothesis. A hypothesis is usually stated as a testable expectation, logically derived from a proposition, theory or observation.

Induction
Development of argument from the specific to the general (or theoretical)

Method
A way, technique, or process of or for doing something

Methodology
Systematic and theoretical analysis of the methods applied to a field of study (research methodology is the study of the methods used in research).

Methodological study
Study aimed at developing a new method, process or technique.

Model
A graphical, mathematical or schematic description or analogy of a system of postulates, data, and inferences. Models are representations of reality.

Model-building study
Study aimed at developing a new model and theory to explain a particular phenomenon. (Mouton, 2001:176-178).

Ontology
Philosophical study of the categories of being (reality) and the relationships between them (ontology of NSI or knowledge)

Paradigm
When a certain theory (or a system of hypotheses, or a world-view) pervades entire fields of research or an entire scientific era, it is known as a paradigm. Such a view then delineates the propositions used for explaining individual phenomena.

Postulate
To claim as true, existent, or necessary.

Proposition
Something offered for consideration or acceptance usually stated in sentence form near the outset.

Research
Investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws (Merriam-Webster Collegiate Dictionary).

Research is original investigation undertaken to gain knowledge and/or enhance understanding. Research specifically includes the creation and development of the intellectual infrastructure of subjects and disciplines (e.g. through dictionaries, scholarly editions, catalogues and contributions to major research databases); the invention or generation of ideas, images, performances and artefacts where these manifestly embody new or substantially developed insights; the use of existing knowledge to produce new or substantially improved materials, devices, products, policies or processes. It specifically excludes routine testing and analysis of materials, components, instruments and processes,

as distinct from the development of new analytical techniques; the development of teaching materials and teaching practices that do not embody substantial original enquiry (National Research Foundation).

Research Ethics
Application of fundamental ethical principles to the conduct of scientific research.

Research Methodology
The study of how research is done based on the underlying philosophical and theoretical assumptions; also used to describe (perhaps incorrectly) the design, structure and the associated logic (how and why) of a research project.

Research Design or Approach
A high level description of the various steps that are generally adopted by a researcher in studying a research problem.

Research Method
The specific process or steps followed by researchers in undertaking research (experimental design, data collection, etc.).

Supposition
A belief held without proof or certain knowledge; an assumption or hypothesis.

Teleology
Notion of root cause or objectives; it is an account of a given activity's or object's purpose; a definition of an object or activity based on its purpose (e.g. a car is a form of transport)

Theory
A plausible or scientifically acceptable general principle or body of principles offered to explain phenomena. Theories endeavour to explain facts in a unified representation of models and hypotheses. To put it briefly, a theory is a scientific statement based on empirical findings. Since empirical results are seldom final, theories are of a provisional nature.

Theorem
An idea, proposition, or statement accepted or proposed as a demonstrable truth often as a part of a general theory

Verification
The action whereby a proposition is tested experimentally.

Appendix 2: Research Idea

Proposal Title:

Initials and Surname		**Student Number**	
E-mail		**Contact Number**	
Date		**Degree (MPM, MEM, etc.)**	
Study Leader		**Signature of Study Leader**	

Research Problem (see Section 7):

Research Objectives (not more than 2):

Research Questions (not more than 5):

Relevance of the Research:

Relevant Theory (see Appendix 2):

Key Subject Literature References (see Appendix 3):

Proposed Research Methodology and Design (see Section 4):

Field of Study (be as explicit as possible):

Appendix 3: Template for Research Proposal (Doctoral)

(Note that all Masters students will be provided with a proposal template which includes all the headings as listed below.)

Title

The proposed title should be one sentence, free from all elaboration and superfluous detail, which gives a clear, complete and formal description of the research project. To ensure that the proposed topic/title in not a duplicate of previous or current research, a search should be carried out on the Research Report database of the National Research Foundation.

Table of Contents

Give a listing of the section headings with page numbers.

1. Introduction and background

1.1 Describe and give an introductory overview of the technological, industrial and/or organisational context of the study.
1.2 Indicate the proposed topic of the research – what is the broad issue to be investigated?
1.3 Give reasons for selecting the particular problem - the rationale for the study.

2. Theory and research review

2.1 Give a preliminary overview of the relevant theories properly referenced. What research has already been done on this topic or in this field, and what important findings have been made thus far?
2.2 Describe and give a critical analysis the main theories, models and methods that currently exist.
2.3 Indicate whether a need exists for a new or improved theory and identify the key attributes of the desired theory and derived models or methods.

3. Problem Statement and Research Objective/s

3.1 Formulate the proposed problem statement in one paragraph, free from all elaboration and superfluous detail.
3.2 Give clear, complete and formal descriptions of the research question/s.
3.3 Describe the research objectives – what will be achieved?
3.4 Give clear, complete and formal descriptions of the research proposition/s or hypotheses. (See the framework as shown in Figure 6).
3.5 Indicate the relative weight of the following types of research that you propose to undertake between the normal categories of theory building research; theory testing research, and theory application research.

3.6 Indicate the importance of the problem – why should this particular problem be addressed? What is the rationale of the study?
3.7 Describe the limitations of the study and the assumptions on which the research will be based.

4. Expected Contributions

4.1 Describe the expected nature of the results.
4.2 Who will benefit from the research?
4.3 What will the contribution(s) of the research results be? What is the rationale of the study? How does it link to important social or economic issues and problems? Describe the contributions towards scientific knowledge and what other values the research will have.

5. Research Strategy

5.1 Present the proposed approach and strategy for performing the research.
5.2 Describe the method of study or research design and methodology to be followed.
5.3 Indicate the proposed research instrument/s (questionnaire, case study, interview) and methods of data collection and analysis. Give some justification of why the methods are proposed.
5.4 Give a proposed project plan and schedule for performing the research.

6. Ethics Committee Approval

6.1 All research, excluding mini-dissertations, must be submitted to the Ethics Committee of the Faculty for approval. See the application procedure on clickUP for an updated version of this process.
6.2 All students registering for mini-dissertations need to apply for ethical clearance at the department (GSTM) first. They will be advised by the Ethics Committee of GSTM whether or not application at Faculty is necessary. Application procedure is available on clickUP; **Appendix 7** describes the GSTM ethics application process.

7. Proposed Table of Contents of Thesis/Dissertation/Report

Give a proposed chapter plan and a preliminary outline of the chapter divisions. The following is the basic structure for all theses/dissertations/reports:

Preliminaries
Chapter 1: Introduction/Background
Chapter 2: Theory and research review/Theoretical background
Chapter 3: Theoretical framework/Conceptual model or method
Chapter 4: Research design and methodology
Chapter 5: Results: Data gathered and initial analysis
Chapter 6: Discussion of results
Chapter 6: Conclusions and recommendations
List of references and appendices

8. Conclusion

A concluding statement on the feasibility of completing the study as proposed.

9. References and preliminary bibliography

8.1 List all the references that have been referred to, in the prescribed format (see **Appendix 5**).

8.2 Give a preliminary bibliography listing the most important and recent specialist literature that has been consulted.

9. Personal information

Give the following information:

- Name and student number
- Postal address
- E-mail address and telephone number(s)
- Your complete academic record(s) as well as work history.
- A list of your previous research results, e.g. research reports, masters dissertation, publications, articles, conference papers, etc.

Appendix 4: Research Flowchart

The milestones or pathway of research projects in the GSTM depend on the degree being taken. Doctoral studies (covered in Appendix 2.1) take longer than Masters level programmes (between 3 and 5 years) and typically follow a five-phase programme, as shown in Figure 8 and **Appendix 4.1**. Masters level research projects take 2 to 3 years and follow a well-defined series of milestones, as shown in Figure 7.

Appendix 4.1: Doctoral Studies

PHASE 1: RESEARCH PROPOSAL

Actions:
- Initiating problem or assignment (Research idea)
- First environmental scanning
- First theory and research survey
- Definition of the research problem
- Propose title for dissertation/thesis/report
- Proposed research methodology
- Estimation of potential for success

Output: *Research Proposal Document*

Baseline 1: Research Proposal Review
- Approval of *Research Proposal* by Research Committee of Department
- Colloquium presentation

Milestone 1: Research Proposal Approved

PHASE 2: RESEARCH PLAN

Actions:
- Comprehensive environmental scanning
- Comprehensive theory and past research survey and critical analysis
- Conceptual model/s, propositions and hypotheses
- Choice of research design
- Development of data-gathering techniques and instruments

Output: *Research Plan* consisting of:
1st Draft of Chapter I (Background, Research Question/s)
1st Draft of Chapter II (Theory and research review)
1st Draft of Chapter III (Conceptual Model [or Theory or Method])
1st Draft of Chapter IV (Research design and methodology)
List of references and appendices

Baseline 2: Research Plan Review
- Approval of *Research Plan* by Research Committee of Department

- Approval of *Research* and *Instruments* (e.g. questionnaires) by Faculty Committee for Research Ethics and Integrity3
- Colloquium presentation

Milestone 2: Research Plan Approved

PHASE 3: RESEARCH EXECUTION

Actions:
- Execution of data-gathering
- Execution of analysis
- Model (or Theory or Method) building or testing

Output: *Research Report* consisting of:
2nd Draft of Chapter I
2nd Draft of Chapter II
2nd Draft of Chapter III
2nd Draft of Chapter IV
1st Draft of Chapter V (Results: Data gathered and analysis)
List of references and appendices

Baseline 3: Research Review
- Approval of Research Report by Research Committee of Department
- Colloquium presentation

Milestone 3: Research approved

PHASE 4: WRITING OF DISSERTATION/THESIS/REPORT

Actions:
- Finalise Chapters I to V
- Write Chapter VI with interpretation and findings
- Proof reading and compilation of draft dissertation/thesis/report
- Write article/s for peer-reviewed international journals

Output: *Draft dissertation/thesis/report*

Baseline 4: Dissertation/thesis/report Review
- Approval of draft dissertation/thesis/report by Research Committee of Department
- Approval of draft article/s for peer-reviewed international journals
- Colloquium presentation

Milestone 4: Dissertation/thesis/report Approved

[3] All research involving interaction with people must be submitted to the Ethics Committee of the Faculty for approval. The application form for approval is available on the faculty website at http://www.up.ac.za/ebit/r_ethics.html. See also Appendix 14.

PHASE 5: EXAMINATION AND DISSEMINATION OF RESEARCH RESULTS

Actions:

- Preparation, bind and distribute examination copies of dissertation/thesis/report
- Submit article/s to peer-reviewed international journals

Output: *Dissertation/thesis/report*
Published article/s in peer-reviewed international journals
Symposium or Conference presentation/s

Baseline 5: Examination

- Internal and external examination

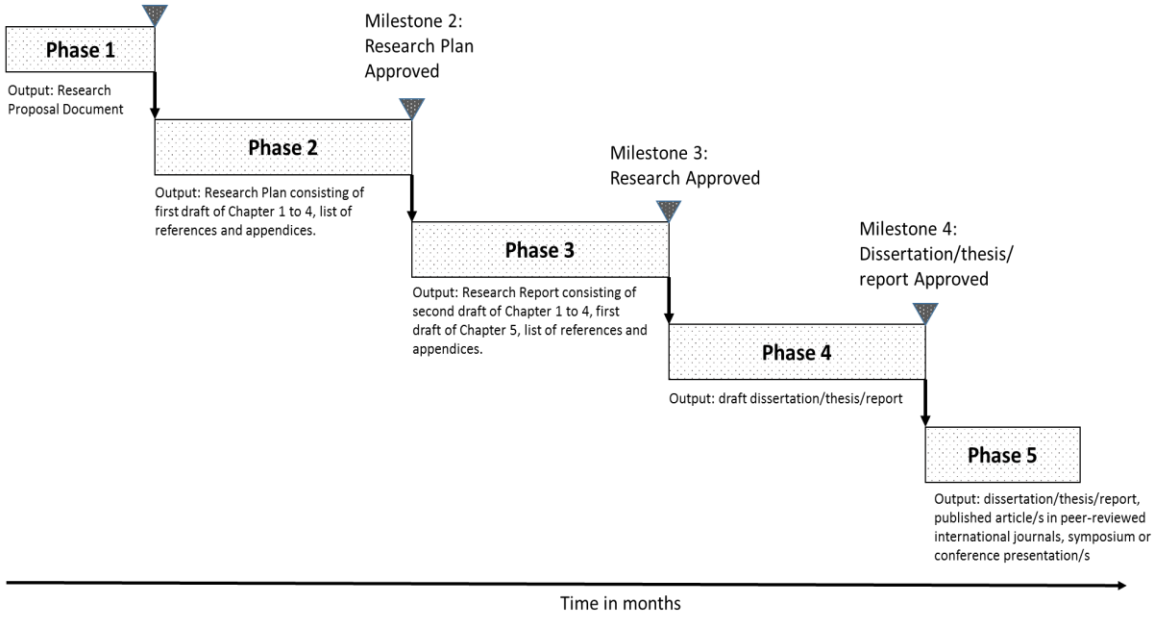
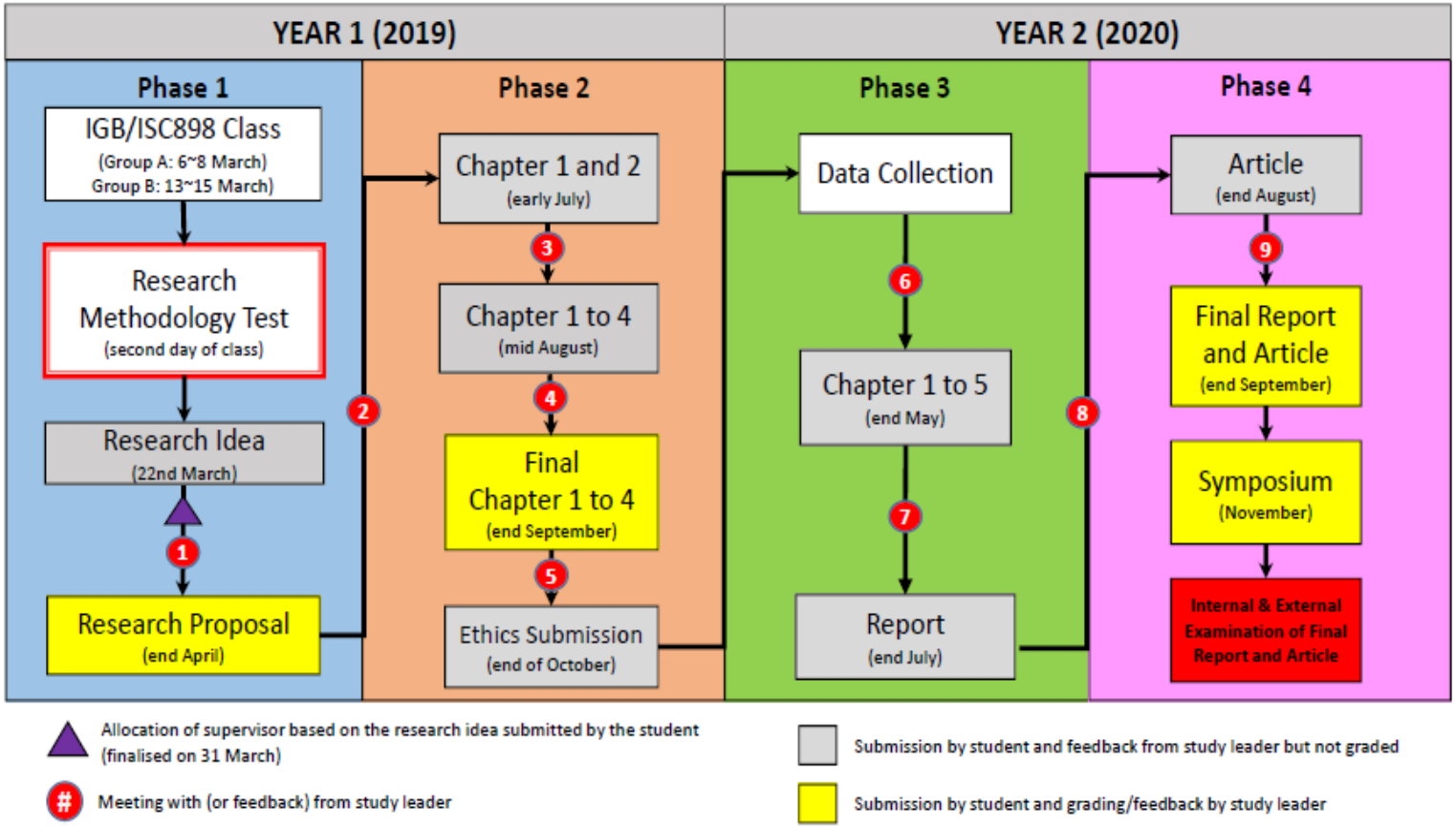


Figure 8. Phases of a PhD programme

Appendix 4.2: Masters Studies

GSTM Mini-Dissertation (IGB 898 & ISC898) Research Process Year 2019/2020 (Nov symposium)



Appendix 5: GSTM Harvard Referencing Method

Academic writing requires that sources be acknowledged explicitly. Indeed, all the main tenets of your argument in your dissertation must be supported either by credible sources or new evidence from primary data. References should be given whenever statements are made that originates from another person's work or publications, even if rephrased. If such references are omitted the impression is created that they are the writers own work, thus amounting to **plagiarism** which can have serious consequences for your academic career and eventually for your professional career. Plagiarism is a serious offence; it is unacceptable to simply give a list of (unreferenced) sources at the end of the document. Material that was read but that is not specifically referred to, can be given in a bibliography.

All referencing in your research report must be formatted according to the GSTM Harvard Referencing Method. There are two tools available which will assist you with the Referencing; EndNote and Mendeley. Further details follow.

Endnote

Should you wish to use the **Endnote** software to assist you with the Harvard Referencing Technique, you must download the software and install it on your computer from http://up-za.libguides.com/EndNote. Read the instructions carefully and then allow sufficient time to ensure that you are familiar with all the key features of the software. The University of Pretoria has a comprehensive license which allows all students to install a free version of the software on their devices.

EndNote uses pre-coded output styles to format the references (both in-text citations and also the reference list). You must use the "Harvard GSTM' output style which will be made available to you through clickUP and can also be downloaded from Google Drive in the folder containing all the research templates. It is a good idea to keep your EndNote files in the cloud so that they can be accessed from a multiple of sites.

Mendeley

Should you wish to use Mendeley to assist you with referencing and citations, please download the installation application from https://www.mendeley.com/download-mendeley-desktop/. Currently there is not GSTM Harvard referencing style available in Mendeley, but a number of alternative Harvard styles are, e.g. Anglia Ruskin. Use a style in agreement with your supervisor as another one can be easily reselected. This software is preferred by some of the supervisors and by users of Apple devices. You will need to be guided in its use should you decide to opt for this approach to your referencing.

The following methods is prescribed for references to source material(s).

1. REFERENCES USED IN THE TEXT

References in the text should be by author(s) (only surnames) with the date of publication, colon and page number in brackets, e.g.

Kash (1989:9) states that …
... were shown to be important issues (Tidd, Bessant & Pavitt 1997:21).

The second and following references to the same source only indicate the first author's surname, followed by et al, e.g.

Tidd et al (1997:37) recommend that...

When referring to one author quoted by another author, use the following format:

Abell (in Burgelman, Maidique & Wheelwright (2001:6)) stated that...
or Abell, as quoted by Burgelman, Maidique & Wheelwright (2001:6) stated...

2. REFERENCES USED IN TABLES AND FIGURES

References to sources, which relate to information contained in a table or figure, must appear immediately below the table or figure (preceded by "Source(s):"). (Cf. Table 1 as an example.)

Table 1 – The gross domestic product of the Republic of South Africa, 1990 - 1993

Year	Gross Domestic Product (R million)
1991	244 549
1992	238 711
1993	242 001

Source: Central Statistical Service (1994:21).

3. FOOTNOTES

Footnotes can be used to clarify words or items in the text, figures or tables, but must NOT be used as a way of referencing. If any footnotes are required, Arabic numerals are used with one bracket as a superscript. Footnotes3) referring to words or figures in the text must appear at the bottom of the page. However, footnotes that relate to a table or figure must appear immediately below the table or figure. (Cf. Table 1 as an example.)

4. LIST OF REFERENCES

References must be provided at the end of the *dissertation/thesis/report/article* in the form of one consolidated and alphabetical list of all the sources referred to throughout the document.

The required layout of items in a reference is as follows:

Reference to a book

Author's Surname, Initials. Year of publication. Title. Edition (if not the first). Place of publication: Publisher.

e.g. Burgelman, R.A., Maidique, M.A. & Wheelwright, E.C. 2001. *Strategic Management of Technology and Innovation*. 3rd ed. New York: McGraw-Hill/Irwin.

Reference to a contribution in a book

Contributing author's Surname, Initials. Year of publication. Title of contribution. Followed by In: Initials. Surname, of author or editor of publication followed by ed. or eds. if relevant. Title of book. Place of publication: Publisher, Page number(s) of contribution.

e.g. Buys, A.J. & Ndrika, V.I.O. 2005. Assessment of the Impact of Intermediate Agricultural Processing Technologies on a Rural Community in South Africa. In: L. Morel-Guimares, T.M. Khalil and Y.A. Hosni, eds. *Management of Technology: Key Success Factors for Innovation and Sustainable Development*, Amsterdam: Elsevier, 153-163.

Reference to an article in a journal

Author's Surname, Initials. Year of publication. Title of article. Title of journal, Volume number and (part number), Page numbers of contribution.

e.g. Buys, A.J. and Malebo, L.M.M. 2004. Managing Rapid Diffusion: The Case of Cellular Communications in South Africa. *South African Journal of Industrial Engineering*, vol. 15, no. 2, pp.67-78.

Reference to a conference paper

Contributing author's Surname, Initials. Year of publication. Title of contribution. Followed by In: Initials. Surname, of editor of proceedings (if applicable) followed by ed. Title of conference proceedings including date and place of conference. Place of publication: Publisher, Page numbers of contribution.

e.g. Mbewana, P. and Buys, A.J. 2005. Key Success Factors for Incubation in South Africa. In: T.M. Khalil, ed. *14th International Conference on Management of Technology*. 22-26 May 2005 Vienna. Available from: International Association for the Management of Technology, [CD-ROM] Track 7, Paper 92.

Reference to a dissertation/thesis

Author's Surname, Initials. Year of publication. Title of dissertation/thesis. Designation, (and type). Name of institution to which submitted.

e.g. Le Grange, L.I. 2000. *Maintenance Technology Transfer in the South African Aviation Industry.* Dissertation, (M.Eng.). University of Pretoria.

Reference to web pages/sites

Author's /Editor's Surname, Initials. Year. Title [online]. (Edition). Place of publication, Publisher (if ascertainable). Available from: URL [Accessed Date].

e.g. Oerlemans, L.A.G., Pretorius, M.W., Buys A.J. & Rooks, G. 2004. *Industrial Innovation in South Africa 1998-2000.* Pretoria: University of Pretoria. Available from: http://www.sais2001.up.ac.za [Accessed 4 November 2004].

Appendix 6: Technical Editing

1. Language and General Requirements

The thesis/dissertation/report must be in either English or Afrikaans. The final thesis/dissertation/report copy must have a ready-for-publication appearance. It must have standardised features and be attractively reproduced. Introductory material, text, and appendices must all be clearly and consistently prepared and must all meet the specifications stated below.

2. Paper size and Layout

Only good quality A4-size (210mm x 297mm) white paper must be used. Manuscripts must be typed in only one column to the page. Use one side only. All text pages must be laid out in "portrait" orientation. As an exception pages containing only an exhibit (table or figure) may be in "landscape" orientation, if so required.

Top, bottom, and right margins must be 25mm. The left margin must be 30mm, to allow for binding.

3. Fonts, Point Sizes, Spacing and Equipment.

Text should be printed in Arial, Times Roman or similar fonts with point size not less than 10 and not more than 12 (used in this document). An exception to this are the chapter headings, which should be in 14 point. One and a half spacing should be used (as shown in this paragraph), except where conventional usage calls for single spacing; e.g. footnotes, indented quotations, tables, etc.

A letter quality printer (laser, impact, or ink jet) or an electric typewriter is required for printing the final manuscript.

4. Bold, Italics, Underlines, and Justification.

Headings should be bold if possible, otherwise underlined (but not both). Book and journal titles should be italicised if possible, otherwise underlined. Text should be left and right justified against the margins (as shown in this document). Text must not be indented under headings.

5. Corrections.

No corrections with correction fluid or any other method are allowed on the manuscript. Use black ink whenever it is necessary to letter mathematical symbols or other copy by hand.

6. Tables and Figures.

Tables and figures are exhibits and numbered sequentially. They should be placed as close after their first mention as possible. The table number or figure number as well as heading of each exhibit must appear centred directly beneath the exhibit as in the following example:

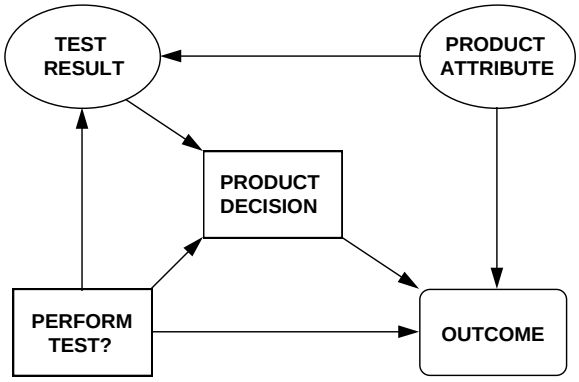


Figure 7: Influence diagram of test problem

Although placement of exhibits directly in the text is preferred, it is also acceptable to place exhibits on separate pages, immediately following the page of first mention. Line drawings and photographs should be reduced to proper size. Ensure that all text, symbols and information in exhibits are clearly legible in the final manuscript. Avoid text or symbols smaller than 10 points.

7. Equation Numbers, Symbols and Abbreviations.

When numbering equations, enclose numbers in parentheses and place flush with right-hand margin of the column. Equations themselves should be centred. See sample below. Use only standard symbols and abbreviations in text and exhibits.

$$\sigma_x^2 = \frac{1}{n}\left\{\sum_{i=1}^{n} X_i^2 - n\overline{X}^2\right\} \qquad \text{…….. (12)}$$

8. Headings

The thesis/dissertation/report must be divided into chapters, and further into paragraphs and subparagraphs (if so required). Do not use more than 4 levels of indenture. Each chapter must start on a new page. A blank line should be used to separate headings from text above and below them. Blank lines must be used to separate paragraphs. New paragraphs are not indented, but start flush with the margin. In the event of a subparagraph that is numbered but does not require a heading, the text should start immediately next to the number and not on the next line.

9. Word and Text Divisions

Words must be divided correctly at the end of a line and may not be divided from one page to the next. Use a standard dictionary to determine word division. If word-processing is used, it must divide words and text correctly: you may find it advisable to avoid all word division.

Avoid short lines that end a paragraph at the top of a page, and any heading or subheading at the bottom of a page that is not followed by text.

10. References

List all references by number at the end of the thesis/dissertation/report in alphabetical order, as shown below. Text references should use the author's name, date of publication and page number. For example, "According to Smith (1991:8) ....." or "The use of influence diagrams (Howard and Matheson 1984:22) .....".

Howard, R.A. and Matheson, J.E., 1984. Influence Diagrams. In: Howard, R.A. and Matheson J.E. (eds.), The Principles and Applications of Decision Analysis. Strategic Decisions Group: Menlo Park, California.

Smith, J.P., 1991. The Rise of Engineering Management. Printers Press: Pretoria.

11. Order and Content

This paragraph describes the required order and content of the thesis/dissertation/report.

11.1 Preliminary Pages

a. Title page - a sample page is attached. Follow the format exactly; use upper case letters as shown. The title of the thesis/dissertation/report should be a meaningful description of the content of the manuscript. Use word substitutes for formulas, Greek letters, etc. Avoid long titles.

b. Abstracts - one in English and one in Afrikaans (starting on separate pages), according to the format attached. In the case of an English thesis/dissertation/report, the English abstract should be placed first and for an Afrikaans thesis/dissertation/report, the Afrikaans one. The abstract should be carefully prepared to give a succinct account of the research. It should include a statement of the problem, procedure and methods, results and conclusions. The abstract must follow the style used for the rest of the manuscript.

c. Acknowledgements, if any.

d. Table of Contents, with page references.

e. List of Tables, with titles and page references.

f. List of Illustrations, with titles and page references.

11.2 Text

a. Introduction

b. Main body

11.3 References

a. Bibliography or list of references.

12. Pagination

Each page of the manuscript, including all blank pages, and pages with tables, figures, computer program printouts should be assigned a number. Consistent placement of pagination (preferably centre at the bottom of the page), at least 12mm from the paper's edge, should be used throughout the manuscript. The following pagination plan must be used:

- For the preliminary pages, use small Roman numerals (i, ii, iii, iv, etc.). The title page does not have a number but counts as page i; the following page is ii.

- For the remainder of the manuscript - continuous pagination for text, illustrations, references and appendices - use Arabic numbers (1, 2, 3, etc.)

Appendix 7: Ethics Approval Process (GSTM)

The ethics approval process follows the steps as outlined in Figure 9.

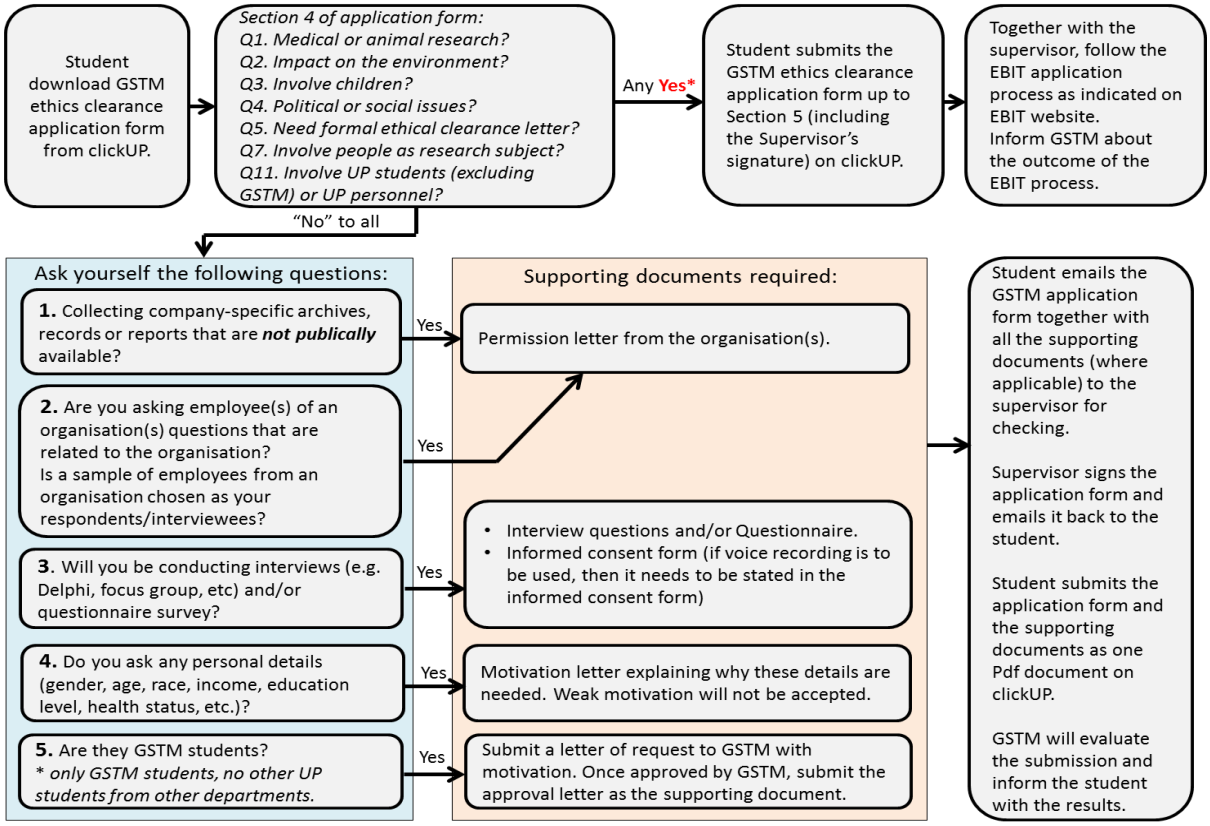


Figure 9. Steps of GSTM ethics approval process

Appendix 8: References and Literature Sources

1. Policy, procedures and regulations

Study Guide for MEM/MPM/MTIM Mini-Dissertation (IGB 899/ISC 899). Department of Engineering and Technology Management, University of Pretoria.

University of Pretoria Code of Ethics for Research. Available from: https://www.up.ac.za/media/shared/9/HumPdf%20docs/Postgrad%20Research%20Docs/university-of-pretoria-code-of-ethics-for-research-rt-429-99.zp53279.pdf

University of Pretoria Survey Policy. Available from: https://www.up.ac.za/media/shared/9/HumPdf%20docs/Postgrad%20Research%20Docs/survey-policy-fnal-doc-jan-2011.zp53277.pdf

General Regulation and Rules. 2018. Available from: https://www.up.ac.za/media/shared/360/Faculty%20Brochures%202015%202016/2018/fact-finder_rules-and-regulations-2018-pdf-11-11.12.2017.zp137172.pdf.

2. Research methodology

Botha, W.M. and Du Toit, P.H. 1999. *Guidelines for the Preparation of Written Assignments*. Pretoria: University of Pretoria. Available from: http://www.up.ac.za/asservices/ais/assign.pdf.

Bryman, A., Bell, E., Hirschsohn, P., dos Santos, A., du Toit, J. and Masenge, A. 2014. *Research Methodology: Business and Management Contexts.* 5th ed. Cape Town: Oxford University Press Southern Africa.

Cooper, D.R. and Schindler, P.S. 2014. *Business Research Methods.* 12th ed. New York: McGraw-Hill/Irwin.

Easterby-Smith, M. Thorpe, R., Jackson, P.R. and Jaspersen, L.J. 2018. *Management & Business Research*, 6th ed. California: Sage Publications.

Monette, D.R., Sullivan, T.J., De Jong, C.R. and Hilton, T.P. 2014. *Applied Social Research. Tool for the Human Sciences*. 9th ed. Belmont: Cengage Learning

Mouton, J. 2001. *How to succeed in your Master's & Doctoral Studies. A South African Guide and Resource Book.* Pretoria: Van Schaik Publishers.

Leedy, P.D. and Ormond, J.E. 2016. *Practical Research Planning and Design.* 11th ed. London: Pearson.

Saunders, M., Lewis, P. and Thornhill, A. 2016. *Research Methods for Business Students*, 7th ed. Essex: Pearson.

3. Survey research

Fowler Jr. F.J. *Survey Research Methods*. 2014. 5th ed. Applied Social Research Methods Series, Volume 1, Thousand Oaks: SAGE Publications.

Groves, R.M, Fowler, F.J., Couper, M.P., Lepkowski, J.M., Singer, E. and Tourangeau, R. 2009. *Survey Methodology*. 2nd ed. New Jersey: John Wiley & Sons, Inc.

Marsden, P.V. and Wright, J.D. 2010. *Handbook of Survey Research*. 2nd ed. Bingley: Emerald Group Publishing Limited.

Scheaffer, R.L., Mendenhall, W., Ott, R.L. and Gerow, K.G. 2012. *Elementary Survey Sampling*. 7th ed. Boston: Cengage Learning.

4. Case study research

Harrison, M.I. 2001. *Diagnosing Organizations*. 3rd ed. Applied Social Research Methods Series, Volume 8, Thousand Oaks: SAGE Publications.

Yin, R.K. 2018. *Case Study Research and Applications. Design and Methods.* 6th ed. Los Angeles: SAGE Publications.

5. Policy research

Majchrzak, A. and Markus, M.L. 2014. *Methods for Policy Research. Taking Socially Responsible Action*. 2nd ed. Applied Social Research Methods Series, Volume 3. Thousand Oaks: SAGE Publications.

Springer, J.F., Haas, P.J. and Porowski, A. 2017. *Applied Policy Research. Concepts and Cases*. 2nd ed. New York: Routledge.

6. Simulation

García, J.M. 2017. *Theory and Practical Exercises of System Dynamics*. Massachusetts: MIT Sloan School of Management.

Gilbert, N. and Troitzsch, K.G. 2005. *Simulation for the Social Scientist*. 2nd ed. Berkshire: Open University Press.

Whicker, M.L., and Sigelman, L. 2001. *Computer Simulation Applications.* Applied Social Research Methods Series, Volume 5. Thousand Oaks: SAGE Publications.

7. Qualitative research

Cassell, C., Cunliffe, A.L. and Grandy, G. 2018*. The SAGE Handbook of Qualitative Business and Management Research Methods*. Thousand Oaks: SAGE Publications.

Guest, G., Namey, E.E. and Mitchell, M.L. 2013. *Collecting Qualitative Data. A Field Manual for Applied Research*. Thousand Oaks: SAGE Publications.

Maxwell, J.A. 2013. *Qualitative Research Design. An Interactive Approach*. 3rd ed. Applied Social Research Methods Series, Volume 41. Thousand Oaks: SAGE Publications.

5. Statistical analysis

Arsham, H. Statistical Thinking for Managerial Decisions. Fully-online course at: https://home.ubalt.edu/ntsbarsh/Business-stat/opre504.htm

Field, A. 2017. *Discovering Statistics Using IBM SPSS Statistics*. 5th ed. India: SAGE Publications.

Tabachnick, B.G. and Fidell, L.S. 2013. *Using Multivariate Statistics.* 6th ed. Pearson.

Tacq, J. 1997. *Multivariate Analysis Techniques in Social Sciences Research: From Problem to Analysis*. London: Sage Publications.

6. Additional resources and references

Additional resources and references on UP regulations, research methodology, literature management, writing, ethics and formatting are available on the following website: http://up-za.libguides.com/c.php?g=485435

