Pearson BTEC Levels 5 Higher Nationals in Engineering (RQF)

Unit 34: Research Project

Unit Workbook 1

in a series of 1 for this unit

Learning Outcome 1

Research Project

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Planning and conducting a small research project

This Workbook addresses the task of planning and conducting a small research project. It aims to help you develop a clear sense of direction early on in the project, and to support you in organising, planning, and monitoring your project.

What it will do is point you in the right direction, enabling you to gather information and techniques in undertaking a research project. What it won't do is give you all the information on a plate. In order to answer the assignment questions fully you will need to undertake substantial investigative work of your own.

1. What is a research?

Research is a particular kind of academic task. You will usually be asked to generate a topic for yourself; to plan and execute a project investigating that topic; and to write-up what you did and what your findings were. Important stages in the process include:

- choosing a topic;
- developing a research question;
- effective planning of the research;
- being organised and methodical while conducting your research; and
- reporting the research.

2. Research Philosophy in Engineering and Technology Management

The purpose of research is to generate new knowledge, thereby enabling the development of new products, processes and services, to better understand and interact with our environment, thereby improving the quality of life in our communities and the sustainable management of ecosystems.

The purpose of research in project management, engineering management and technology management is to generate the knowledge and practical techniques which can be used to 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, 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 human resource management, innovation process management, project management, marketing, forecasting, technology roadmaps and strategic planning.

Research in relation to Engineering and Technology Management tends to be 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. It should be conducted according to the guiding principles of academic rigour and scholarship.

Within the various areas of science and in compliance with the broad principles of scientific research, a wide range of research methodologies have historically been developed and applied, including quantitative, mixed and qualitative approaches. 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 versus basic, philosophical or highly theoretical studies.

Considering that management is predominantly a behavioural science, there is also a preference for the approaches used in the social sciences rather than in the natural sciences. The dominant research designs in the natural sciences are laboratory and field experiments. These designs are less appropriate in engineering and technology management as it is difficult to obtain the highly controlled conditions required for this type of research.

A common misconception amongst engineering and technology management students is that doing research is synonymous with doing a "management investigation". This is not the case; 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. The investigator's subjectivity is acceptable when performing a management investigation, but research requires scientific objectivity. Insight and sound judgement are expected of a good management investigation, but research requires empirical proof. The outcome of a management investigation is mostly a company-confidential management report, whereas research can be published in academic peer-reviewed journals. This is illustrated in Table 1.

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
Teleological	Seeks causative relationship	Focussed on improvements and results
Methodology	Seeks novelty (insights)	Replication of proven formulae for success

Table 1 Academic Research and Management Study

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Engineering and technology management science aims at understanding the processes involved in the management of technology-based organisations. The desired research output is both new theory and novel practical techniques that can be applied by managers in their day-to-day management activities. The theories can be embodied in conceptual models (graphical, mathematical or schematic descriptions or analogies) or practical methods (procedures or techniques), and supported by observations and investigations of actual practice. As already stated, this implies an empirical approach, based on practical methods and observations supported by a sound theoretical basis (known as theory-based empirical research). A research project should therefore contain elements of concrete experience, reflective observation, abstract notions and active experimentation as depicted in the research–application cycle. The types of research designs that are preferred are therefore theory, model or method-building, testing, and application empirical research. This is illustrated in Figure 1.
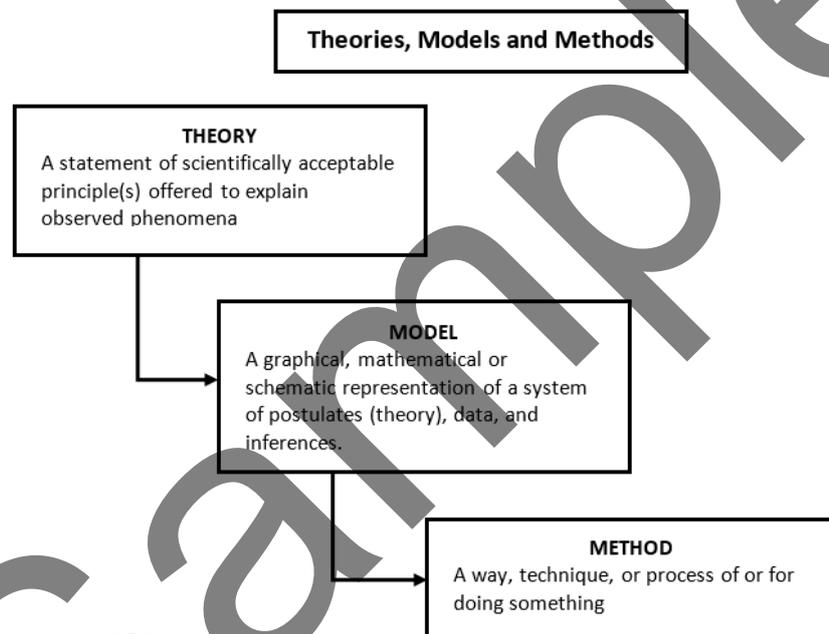

Figure 1 Theories, Models and Methods

Studies must develop, test, or advance management theory and practice and should have well-articulated and strong theoretical foundations. All types of empirical methods, be they quantitative, qualitative, or combinations, are acceptable. Case studies and well-considered observations of management experience, survey research, methodological studies, replications and extensions of past research are acceptable providing the work provides new conceptual or theoretical insights.

The application of existing theories, models and methods to routine management problems is management practice and cannot be considered as research. Although the ability to apply acquired knowledge and skills is an important outcome of the education process for managers, and it is required of management students to demonstrate this ability, such project assignments will result in "Management Reports" and cannot qualify as a research project, for which there must also be some generation of new knowledge. In this regard, the application of existing theories, models and methods to a "new" problem or

situation does generate new knowledge as it provides new insights and is a type of "theory-testing" research. The instruction here is; yes, you should demonstrate your understanding of the concepts and your ability to apply them to a specific problem, but it is also essential to produce something original and useful.

In meeting this requirement, there are three possible aspects to a research project as follows:

1. Application of existing theories, models and methods to a "new" problem.
2. Testing of existing theories, models and methods.
3. Building of new or improved theories, models and methods.

3. Problem Areas

The problem areas that are appropriate for studies in Engineering and Technology Management cover a wide spectrum. They can broadly be divided in three broad categories:

1. Problems related to the Strategic Management of Technology, Innovation, Operations, Maintenance and Projects.
2. Problems related to the Operational Management of Technology, Innovation, Operations, Maintenance and Projects.
3. Problems related to Policy Issues regarding Technology, Innovation, Operations, Maintenance and Projects.

4. Choosing a topic

While some people come to their research project with a clear research question to address, many others arrive at this point with several ideas, but with no specific research question. There is often some pressure to get started fairly quickly and this can cause anxiety and even panic. It is, however, a common situation to be in. There are several ways forward:

- Talk to others: what topics are other people considering? Does this spark an interest? Don't wait until you have a fully formed research question before discussing your ideas with others, as their comments and questions may help you to refine your focus.
- Look at other writing: set aside some time to spend in the library, skimming through the titles of research papers in your field over the past five years, and reading the abstracts of those you find most interesting.
- Look through student dissertations that may be of relevance: the topics may give you inspiration, and they may have useful suggestions for further research.
- Think about your own interests: which topic have you found most interesting, and is there an element that could be developed into a research project?
- Is there a related topic of interest to you that has not been covered in your previous studies, but would fit with a theory or methodology you have been working with?
- Be extra critical: is there something in your experience so far that you have been sceptical about, or which you think needs further study?
- Read about an interesting topic and keep asking the question 'Why?': this may identify a research question you could address.
- Be inclusive with your thinking and see how many different research projects you can identify.
- Try not to be over-influenced at this time. Search for something 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 a one-page format and discuss your ideas with friends, colleagues and potential study-leaders.

Remember that a research study can:

- replicate an existing study in a different setting;
- explore an under-researched area;
- extend a previous study;
- review the knowledge thus far in a specific field;
- develop or test out a methodology or method;
- address a research question in isolation, or within a wider programme of work; or
- apply a theoretical idea to a real-world problem.

This list is not exhaustive, and you need to check whether your sponsor has a preference for particular kinds of research study.

Discuss your proposed topic with supervisors, heads of department, or academic staff who you think might be appropriate to supervise the project. Provided they feel that they know enough about the subject to supervise it, and provided that it can be interpreted as falling within your sphere of activity these people are generally open to suggestions.

You should think realistically about the practical implications of your choice, in terms of:

- the time requirement;
- necessary travelling;
- access to equipment or room space;
- access to the population of interest; and
- possible costs.

For example, a project on coal mining in the North East of England may require you to visit Newcastle's Record Office, or to interview coal miners from the region. Is this something that you are prepared and able to do? If the practical considerations associated with your research ideas are unrealistic, you need to consider whether you are willing to modify or reconsider your project.

Below is a possible, but far from complete, list of subjects that may be appropriate for a research project:

1) Decision Analysis
2) Development Management
3) Engineering Economics
4) Engineering Logistics
5) Engineering Management
6) Entrepreneurship
7) Financial Management
8) General Management

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9) Information Management
10) Innovation Management
   a) Understanding the Dynamics of Technological Change (Substitution, Diffusion, Products and Processes Evolution, Performance Trajectories)
   b) Assessment of Technological Threats and Opportunities (Emerging Technologies Assessment, Technology Forecasting, Technological Landscape Scanning and Monitoring, Competitive Intelligence)
   c) Impact Assessment of Technologies
   d) Innovation Strategies and Methodologies
   e) Appropriate Technology and Appropriate Best Practice
   f) Technology Audits
   g) Technology Transfer Mechanisms
   h) Adoption, Uptake and Diffusion of Technology
   i) Incubation of Technology-based Companies (SMMEs)
   j) National Innovation System and Policy
   k) National Technology Policy Initiatives
   l) Impact of Technology on Competitiveness and Quality of Life
   m) Related Research Areas (Strategic Management of Technology, Research and Development Management, Entrepreneurship, Commercialisation, Manufacturing, Economic Analysis, Intellectual Property Protection, Marketing, Political and Environmental Assessments)
11) Law of Contract
12) Maintenance Management
13) Marketing Management
14) New Ventures & Entrepreneurship Operations Management
15) People Management
16) Production and Operations Management Project Contract Management
17) Project Cost Management
18) Project Financial Management
19) Project Human Resource Management Project Management
20) Project Quality Management
21) Project Risk Management
22) Project Systems Engineering
23) Quality Management
24) R&D Management
25) Safety, Health & Environment Management Strategic Management
26) Systems Engineering
27) Technology Management

5. Research Methodology

The preferred research design for studies in Engineering and Technology Management is theory, model or method-building, testing, and application empirical research.

Related research designs that can also be considered are statistical modelling and computer simulation studies, surveys, case studies, implementation (process) evaluation, field/natural experimental design, and experimental and quasi-experimental outcome studies. Although these could be complete studies in their

own right, it may be preferable that they be used as data-gathering and data-analysis techniques for theory, model or method-building, testing and application studies. Stand-alone literature reviews are generally not acceptable. Theory and research reviews should be an integral part of all studies, irrespective of the particular research designs used.

6. Nature of Subject Literature

Subject literature is mainly those contained in textbooks, articles in scientific journals, published conference proceedings and master's or PhD dissertations and theses, but the serious researcher must search beyond these.

7. Developing a research question

Once your topic has been accepted and / or decided upon, you need to begin the process of refining the topic and turning it into something that is focused enough to guide your project. Try describing it as a research problem that sets out:

- the issue that you are going to be investigating;
- your argument or thesis (what you want to prove, disprove, or explore); and
- the limits of your research (i.e. what you are not going to be investigating).

It is important that you establish a research problem at, or close to the start of, your project. It is one of the key tools you have, to ensure that your project keeps going in the right direction. Every task you undertake should begin with you checking your research problem and asking, "will this help me address this problem?".

You should be willing to revise your research problem as you find out more about your topic. You may, for example, discover that the data you were hoping to analyse is not available, or you may encounter a new piece of information or a new concept while undertaking a literature search, that makes you rethink the basis of your research problem. You should always talk to your supervisor before you make any substantial revision to your plans, and explain why you think you need to make the change.

Here are some examples:

Research problem	Commentary
'Public transport in Scotland'	This sets out your research field but does not frame a research problem because it is too general. You do not have time to study everything about a topic, so you should focus on an aspect that you are interested in.
'Examination of the influence of public transport links on new housing development in Western Scotland'	This is a much better research problem as it establishes an argument (existence of public transport may have some influence on new housing development). However, it is still quite general and could be improved by further focus.
'Investigation of the relationship between public transport links and the development of new areas of housing in Western Scotland: a comparison of local plans and building development since 1990'	This is better still. It shows the limits of the project. You will be investigating a complex subject (public transport in Scotland), but will be focusing on only one aspect of it (possible influence on new housing development). You will make this large subject manageable by focusing on a limited period of time (1990 onwards), and limited sources.

8. Research Management Process

In assist in working in a systematic and orderly way, the research project should be divided into the following phases:

1. Research Proposal
2. Research Plan
3. Research Execution
4. Dissertation/thesis/report
5. Dissemination of research results

Each phase has a set of actions, an output, a review baseline, and a milestone as indicated in Figure 2.
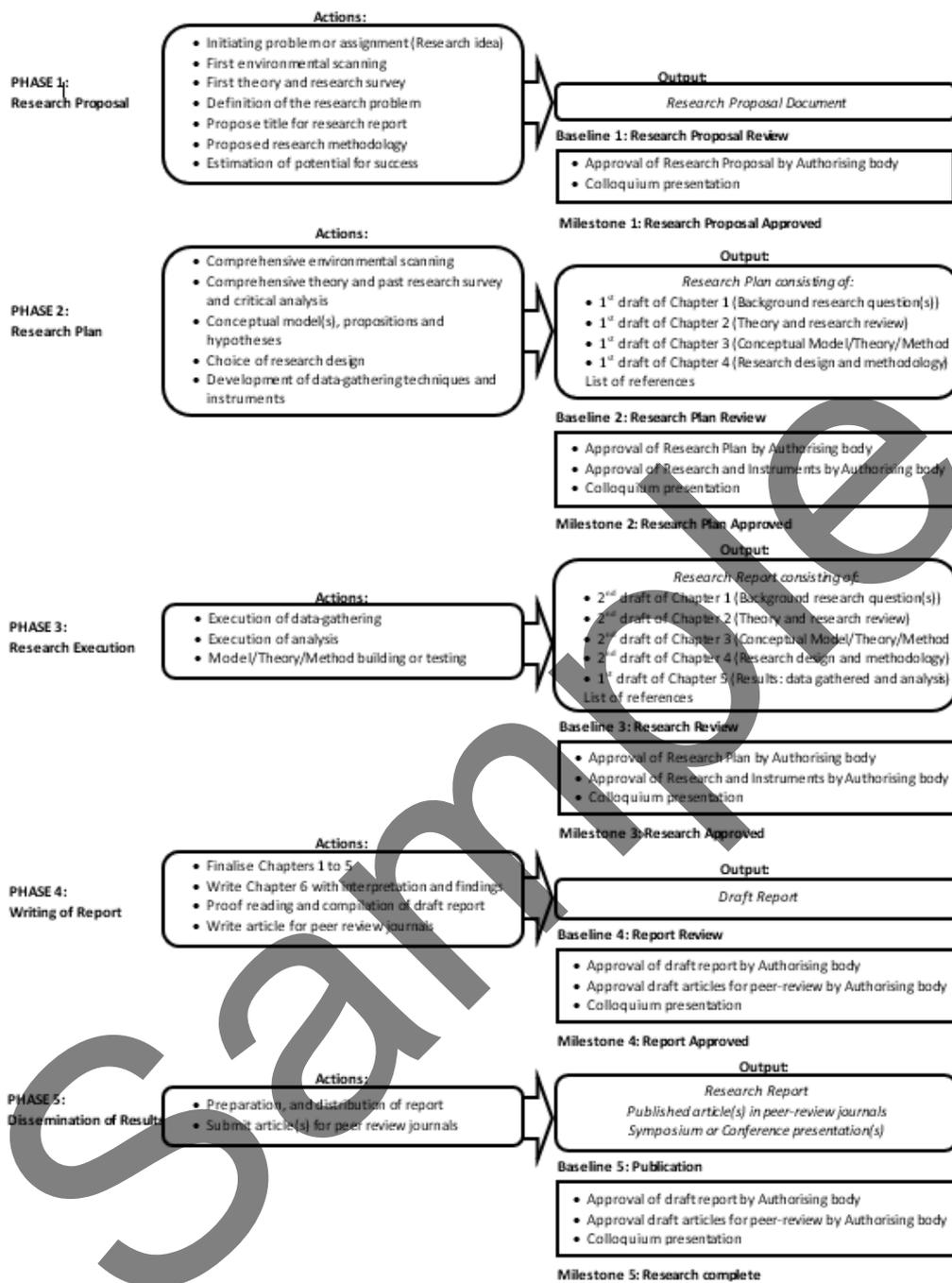
PHASE 1:
Research Proposal

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

Output:
Research Proposal Document

Baseline 1: Research Proposal Review
- Approval of Research Proposal by Authorising body
- 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 1 (Background research question(s))
- 1st draft of Chapter 2 (Theory and research review)
- 1st draft of Chapter 3 (Conceptual Model/Theory/Method
- 1st draft of Chapter 4 (Research design and methodology)
List of references

Baseline 2: Research Plan Review
- Approval of Research Plan by Authorising body
- Approval of Research and Instruments by Authorising body
- Colloquium presentation

Milestone 2: Research Plan Approved

PHASE 3:
Research Execution

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

Output:
Research Report consisting of:
- 2nd draft of Chapter 1 (Background research question(s))
- 2nd draft of Chapter 2 (Theory and research review)
- 2nd draft of Chapter 3 (Conceptual Model/Theory/Method
- 2nd draft of Chapter 4 (Research design and methodology)
- 1st draft of Chapter 5 (Results: data gathered and analysis)
List of references

Baseline 3: Research Review
- Approval of Research Plan by Authorising body
- Approval of Research and Instruments by Authorising body
- Colloquium presentation

Milestone 3: Research Approved

PHASE 4:
Writing of Report

Actions:
- Finalise Chapters 1 to 5
- Write Chapter 6 with interpretation and findings
- Proof reading and compilation of draft report
- Write article for peer review journals

Output:
Draft Report

Baseline 4: Report Review
- Approval of draft report by Authorising body
- Approval draft articles for peer-review by Authorising body
- Colloquium presentation

Milestone 4: Report Approved

PHASE 5:
Dissemination of Results

Actions:
- Preparation and distribution of report
- Submit article(s) for peer review journals

Output:
Research Report
Published article(s) in peer-review journals
Symposium or Conference presentation(s)

Baseline 5: Publication
- Approval of draft report by Authorising body
- Approval draft articles for peer-review by Authorising body
- Colloquium presentation

Milestone 5: Research complete

Figure 2 Research Flowchart

8.1   Writing a research proposal

A research proposal is a more detailed description of the project you are going to undertake. Sometimes you will be required to submit a research proposal at an early stage, but it is worth preparing one even if it is not a formal requirement. It should build on the thinking that you have done in defining your research

problem; on the discussions that you have had with your supervisor; and on early reading that you have done on the topic. A comprehensive research proposal will make you think through exactly what it is that you are going to do, and will help you when you start to write up the project.

Before you start writing your research proposal, go through this checklist. Can you agree with each of the statements in the list?

- 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.

You could try outlining your project under the following headings:

Topic:	this project will study...
Question/problem:	to find out...
Significance:	so that more will be known about...
Primary resources:	the main data will be...
Secondary sources:	additional data comes from...
Methods:	the research will be conducted as follows...
Justification:	the method is most appropriate because...
Limitations:	there are some matters that this methodology may not help me to explain. These might include...

You may find that some of these headings are difficult to fill in right at the start of your project. However, you can use the gaps to help identify where you need to begin work. If, for example, you are unsure about the limitations of your methodology you should talk to your supervisor and read a bit more about that methodology before you start.

Here are some other ideas to help with the task of writing the research proposal;

- 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. The more general sources such as textbooks, course notes and overviews are more appropriate at this stage.
  Practical advice: 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.

- 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.

- 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 Liverpool 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 Liverpool?" (too narrow).
  A poor question: "What are the technology management challenges faced by firm XYZ?" (not generalisable).

- Choose your methodology wisely. A well-designed quantitative research study can often be accomplished in very clear and direct ways. A similar study of a qualitative nature usually requires considerably more time and a tremendous burden to create new paths for analysis where previously no path had existed. Sometimes a combined methodology makes the most sense. You can combine a qualitative preliminary study (to define your population more clearly, to develop your instrumentation more specifically or to establish hypotheses for investigation) with a quantitative main study to yield a research project that works well.

The research proposal which is submitted prior to admission, must contain at least the following information:

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.

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. (refer to the framework illustrated in Fig.xxxx)

3.5 Indicate the relative weight of the following types of research that you propose to undertake:

3.5.1   Theory building research.

3.5.2   Theory testing research.

3.5.3   Theory application research.

3.6 Indicate the importance of the problem – why should this particular problem be addressed?

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 What will the contribution(s) of the research results be? Describe the contributions towards scientific knowledge and what other values the research will have.

4.3 Who will benefit from the research?

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 (where appropriate).

6.1 Submission to the Ethics Committee (if appropriate).

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:

Preliminaries

Chapter 1: Introduction / Background

Chapter 2: Theory and research review / Theoretical background

Chapter 3: Theoretical framework / Concept model or method

Chapter 4: Research design and methodology

Chapter 5: Results: Data gathered and analysis

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

9.1 List all the references that have been referred to, in a prescribed format.

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

10 Personal Information

Give the following information:

- Name and relevant reference
- 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.

8.2   Creating a research plan

A research project is an extended project that asks you to manage your time and undertake a variety of tasks. It is essential, therefore, that you allocate enough time to each task you have to complete.

It is useful to work out how many weeks you have until you need to submit your completed project findings, and draw a chart showing these weeks. Block out the weeks when you know you will be unable to work, and mark in other main commitments you have that will take time during this period. Then allocate research tasks to the remaining time.

January

Christmas	Write a proposal	Literature Review	Complete Literature review and conduct pilot study	Main data collection

February

Complete data collection	Analyse data	Analyse data	Write dissertation plan, then begin first draft

March

Complete first draft	Discuss draft with supervisor	Second draft	Proofing/checking

It is very important to be realistic about how long each task is likely to take. Some focused thought at the beginning, then at the planning stage of each phase, could save hours later on. Write down the resources needed for each stage. It could be time in the library; the resource of your working hours; or the use of equipment or room space that needs to be booked in advance.

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