Introduction

Research is discovering things that no-one knew, and creating things that never were. It is a never-ending process: discoveries and creations lead to new discoveries and new creations. As you read this, millions of people around the world are involved in research, some of it small, some of it large. Our discussion of research methodology begins with the stories of two of the most significant research projects of the last hundred years: the discovery of radium and the creation of the atomic bomb.

In 1897 a young student named Marie Curie started work on her doctoral thesis. The previous year the physicist Antoine Becquerel had detected radiation from uranium, and Curie set out to study this phenomenon of radioactivity. After studying several uranium compounds, she concluded that the amount of radiation was proportional to the amount of uranium. Something seemed strange about uranium pitchblende (the principal source of uranium), however: it produced four times more radiation than that which could be expected from the uranium content.

In trying to explain this phenomenon, Curie theorised that there must be some other, hitherto undiscovered, element causing the radiation. Her husband Pierre joined her in her research, and from tons of pitchblende they eventually isolated tiny quantities of two previously undiscovered elements, polonium and radium. In 1903 Marie Curie obtained both her doctorate and the Nobel prize for Physics (shared with Pierre Curie and Becquerel) for this work, and in 1911 she received another Nobel prize (this time for Chemistry).

The research of Marie and Pierre Curie was the basis of further research on the atom which led ultimately to the splitting of the atom in 1938. This prompted the Manhattan Project—an enormous research program to build an atomic bomb.

Two designs were pursued for the bomb: one using the uranium isotope $\text{U}_{235}$ and the other using the manmade radioactive element plutonium. Plutonium was first created by Enrico Fermi in 1942 in a reactor built in a basement at the University of Chicago in 1942. At the weapons laboratory at Los Alamos, a team under the physicist J. Robert Oppenheimer surrounded the plutonium with explosives designed to compress the plutonium into a mass capable of sustained chain reaction. At Alamogordo, on July 16, 1945, the first atomic bomb was detonated. A few weeks later, atomic bombs were dropped on Hiroshima and Nagasaki (Gro95).

These two examples demonstrate many of the fundamental features of research. Curie was a postgraduate student who had to work largely on her own with extremely
limited funds on a project designed towards acquiring knowledge for its own sake. (No-
one at that stage knew the effects of radioactive material.) The Manhattan Project, on
the other hand, was a huge project involving the United States Army, government
departments and a number of universities, with an unprecedented funding budget and
access to hundreds of the best minds of the time, all harnessed to solve a specific
problem. Despite their different natures, both projects entailed observing, theorising,
experimenting to test the theory, drawing conclusions and reporting the results—the
scientific method.

The results of these projects also opened up new questions and sparked further
research. Curie’s work, for example, started a chain of research which led not just to
the atomic bomb and nuclear power, but to the whole field of nuclear physics where
today thousands of questions are being tackled.

WHAT IS RESEARCH?

In some ways research can be seen as a process of expanding the boundaries of our
ignorance. The man who believes he knows everything reveals not only arrogance but
ignorance. True learning is often a process of discovering new aspects of our universe
that we know nothing about.

Of course, as people study the unknown (and as a result find new areas of ignorance),
they often discover useful things. Everything we now know had to be discovered by
someone at some time—without research you would be naked, homeless and penniless;
and you would certainly not be reading this book!

Research is about answering unanswered questions or creating that which does not
currently exist. It is not just information gathering. The discovery and the creation of
knowledge lies at the heart of research, or as Leedy puts it, research is ‘a systematic
quest for undiscovered knowledge’ (Lee89). Good research is ‘systematic’ in that it is
planned, organised and has a specific goal.

WHY DO RESEARCH?

Asking why people do research is in many cases the same as asking ‘Why do people ask
why?’. The pursuit of knowledge purely in order to know why is as old as humankind,
and much research is the result of this pursuit. Research can also result from specific
real-world needs—designing a low-cost house, creating a more powerful transmitter, or
even building an atomic bomb. A third, often overlooked, impetus to do research is
the pursuit of postgraduate qualifications: would the study of nuclear physics be as advanced today if Marie Curie had decided against doing a doctorate?

Research is sometimes labelled as either pure or applied research. Pure research is held to be research performed for the single goal of gaining knowledge, hence ‘knowledge for knowledge’s sake’. Any practically useful outcomes of the research are simply a bonus. Against this is applied research, which is performed to solve a specific practical problem. Here the practically useful outcome is the goal of the research, and any outcomes of theoretical significance are simply a bonus.

Such a division seems naturally appealing to the type of person who likes to divide things into two classes. (As opposed to the other type, who doesn’t!) Certainly, Curie’s work seems very much pure research in pursuit of knowledge, while the atom bomb project seems very much applied research to fill a specific need. However, Curie’s pure research led to the applied research on the bomb, and this applied research generated many new theoretical questions. The overlap between pure and applied research is so pronounced that all research today has both pure and applied elements.

WHERE DOES RESEARCH OCCUR?

In South Africa, research is carried out at museums, universities, technikons, industry research laboratories, councils such as the Council for Scientific and Industrial Research (CSIR), the Human Sciences Research Council (HSRC) and the Medical Research Council (MRC), and various state departments. For the staff in such institutions, research is not about postgraduate study, it is a career.

The name of the Human Sciences Research Council embodies the fact that all research is scientific, and all researchers are scientists, regardless of their field of work. The research economist or social scientist is just as much a scientist as the research chemist or computer scientist.

WHAT DO RESEARCHERS USE?

Leedy (Lee89) includes the following as the basic tools of the researcher:

1) library and information resources;
2) measurement techniques;
3) statistics;
4) facility with language.
The first tool enables you to find out what is already known in the field, the second enables you to experiment with and test new theories (hypotheses) on the basis of data collected, the third enables you to evaluate your results, and the fourth enables you to report these results to the scientific community. This last step adds to the available information and so becomes the start of a new cycle.

In many fields, computer software and mathematics are vital additional tools.

**USING THIS BOOK**

This book is in five parts, each dealing with a major element of the research process.

1) Getting started
2) Data and designs
3) Statistics in research
4) Research writing
5) Broader issues in research

**Part 1: Getting started**

Part 1 deals with how to get started in research. First, we describe various types of research. We next present a ‘research recipe’ giving the basic steps in the research process. We discuss the first two steps: finding a topic and preparing a statement of the research problem. We then describe sources of information and how to access them, emphasising the usefulness of library resources and the Internet. Finally, we outline the processes of enrolling for postgraduate study and obtaining funding.

**Part 2: Data and designs**

Part 2 deals with the design of research and the collection of data. We first describe the experimental method and the role of variables. We then explain the role and use of sampling in research. We look next at the use of instruments to collect data, and how the reliability and validity of instruments can be tested. Finally, we focus on the particular problems of laboratory work, modelling and simulation, and collecting data from people.

**Part 3: Statistics in research**

Part 3 deals with the analysis of data. We begin by describing how to organise, summarise and depict data. A section on regression follows, in which we describe how to fit curves to measured data. We then introduce the normal probability distribution,
and show how this is used in statistical estimation. In the remainder of the part we describe several statistical tests used to determine if data conforms to certain patterns.

Part 4: Research writing

Part 4 deals with scientific writing. We begin with some suggestions on style, and then discuss the production of reports. Thereafter we describe techniques used to reference other people’s work, and conclude the part by outlining specific formats for theses, dissertations and other research reports.

Part 5: Broader issues in research

Part 5 deals with a number of more general research issues. We begin by discussing ethical issues in research, and the question of what constitutes intellectual honesty. Next we look at the history and philosophy of scientific research. Finally we look to the future by discussing the role of research in South Africa’s reconstruction and development.

We conclude the book with some case studies showing research in practice.