Chapter 2. How to Do Research and Write Research Papers

In this chapter, we will introduce the how to do research and write research papers, including:

- The definition of research.
- The research process.
- Research methods.
- General form of a research paper.
- Technical writing methods.

1 The Definition of Research

Research is defined by the Higher Education Funding Council for England (HECFE) as "original investigation undertaken in order to gain knowledge and understanding". Three key terms in this definition have been italicised for emphasis; *original, gain and knowledge* and *understanding*. These terms are essential to the definition of research and will be discussed in turn.

1.1 Originality

Originality indicates doing something that has not been done before. You can be original in two ways. First, you can be original in the way you do research. For example, studying something that someone has done before but using a different technique or approach. There are a lot of unsolved problems in wild, and most of these problems are studied by others. They might not reach the destination or they finished some parts of these problems. In these situations, you can do research in these fields trying to solve them or improving the solutions.

Second, you can be original by producing or developing something that has not been produced before. For example, you can work on the methods of letting computing as smart as human beings. In terms of originality in the way you do research, there are some areas in which your research can be original:

- **Tools, techniques, procedures and methods.** You may apply new tools and techniques to existing problems or try new procedures and methods in contexts where they have not been applied before.

Whether these investigations prove successful or not, you will still be doing something that is original and discovering why these approaches are suitable in certain circumstances or why they are not.

- **Exploring the unknown.** Although rare, you may investigate a field that no one has thought to investigate before. Recent discoveries in scientific fields may open up new possibilities and unexplored avenues of research to pursue.
- **Exploring the unanticipated.** Although you may investigate a field of research that has been looked at many times before, you may come across unexpected results or exciting new directions as yet unexplored. Investigating these side tracks may prove fruitful, but take care that they do not lead to dead ends. You might also be able to contribute to these fields by further developing original work. Exploring a field that has already been investigated does not necessarily fail to be original. You may be able to improve on something that already exists, provide a new perspective or interpretation, or produce a unique in-depth study of the field.
- **The use of data.** You can interpret data in various ways, use them in new ways or apply them in alternative areas that have not yet been investigated.

Research is a considered activity, which aims to make an original contribution to knowledge.

2 THE RESEARCH PROCESS

One thing that the above definition of research recognised is that research must be a considered activity. In other words, your research activity should not be performed as and when you feel like it, but it should follow a recognised process. We can identify common views of the research process: *sequential, generalised, circulatory* and *evolutionary*:

Sequential. The sequential process is the simplest view of all. In this process a series of activities are performed one after another as a "fixed, linear series of stages". The process consists of seven unique, sequential steps:

1) Identify the broad area of study.
2) Select a research topic.
3) Decide on an approach.
4) Plan how you will perform the research.
5) Gather data and information.
6) Analyse and interpret these data.
7) Present the results and findings.

Although this model appears entirely sequential, some repetition and cycles may take place during this process. However, how and when this repetition takes place is not explicitly identified. Another example of a sequential research process is shown as following:

1) Review the field - perform a literature survey.
2) Build a theory - based on your understanding and interpretations of the field.
3) Test the theory C does it work?
4) Reflect and integrate C update your ideas based on your "tests" and contribute your newfound knowledge to others.

Generalised. The generalised research process is identical to the sequential process in that a defined sequence of activities is performed one after the other. However, the generalised model recognises that not all stages are applicable and some steps may require performing in different ways depending on the nature of the research. Thus, the generalised model identifies alternative routes that may be taken at different stages depending on the nature and outcomes of the research.

Circulatory. The circulatory approach recognises that any research is really only part of a continuous cycle of discovery and investigation. Quite often, research will uncover more questions than it answers and, hence, the research process can begin again by attempting to answer these newfound questions. Experiences of research might lead you to revisit or reinterpret earlier stages of your work. The circulatory interpretation also permits the research process to be joined at any point and recognises that the process is never-ending.

Evolutionary. The evolutionary concept takes the circulatory interpretation one step further and recognises that research must evolve and change over time, not necessarily following a defined circulatory pattern or repeating the same forms of analysis and interpretation that were performed before. The outcomes of each evolution impact on later ones to a greater or lesser extent.

However, although you may have discovered something of value and contributed it to world knowledge, the research process might be only just beginning. These discoveries might lead to new questions, new avenues of research and so on. Thus, the research cycle is entered once again as you redefine your search and continue your voyage of discovery.

2.1 Intellectual Discovery

While the research process can be represented by a model of one kind or another, your own reasoning processes and intellectual discoveries are often much more complex and personal. When you are looking for questions to answer and answers to those questions, you will often follow a complex process of *inductive* and *deductive reasoning*.

Inductive reasoning. You start with your observations of the world and come to general conclusions about it. In other words, you build models and theories based on your interpretation of the world. Clearly, this interpretation will depend on the data and information you can draw from the world, the subject/problem you are studying and, importantly, what you already know and believe.

Deductive reasoning. You start with your knowledge and understanding of the world and predict likely observations within it, even though you might not have encountered them before. Deductive reasoning is affected by your theory of reality, your own personal understanding of the world and your underlying assumptions about what you are investigating. This is referred to as ontology. Different people might deduce different things as their understanding differs from your own and they see things in different ways.

It is also worth considering where you are heading with your research before you spend several months pursuing it. For example, quite often research students will get an idea for their investigation and pursue it enthusiastically. However, when they finally obtain the "answer" they realise that it was of little value in the first place. Try to think of where you are going, assume you have obtained the answer already, and ask yourself "so what use is this to me?"

3 RESEARCH METHODS

There are two classes of research methods - *quantitative* and *qualitative*. Quantitative research methods are associated with measuring things on numeric scales. In the natural sciences one is usually concerned with testing hypotheses and "repeatability of the experiments and the testing of hypotheses are vital to the reliability of the results".

Qualitative methods, on the other hand, have their origins in the social sciences. These methods are "primarily concerned with increasing understanding of a substantive area, rather than producing an explanation for it". Qualitative methods are more common within the field of information science and involve methods such as case studies and surveys. These methods, along with a number of others, are discussed in the following section.

3.1 Research Method

Four of the most common research methods that you might use (either individually or combined) are *action research, experiment, case study* and *survey*:

Action Research involves "the carefully documented (and monitored) study of an attempt by you. . . to actively solve a problem and/or change a situation". Sometimes referred to as participant observation, it involves working on a specific problem or project with a subject or, more usually, an organisation and evaluating the results. With action research you must ensure that you do not become too obsessed with completing the action itself and neglect the real reason for doing it C i.e., evaluating it as part of your academic project.

Experiment involves an investigation of causal relationships using tests controlled by yourself. Quite often quasi-experimental research will have to be performed due to problems of insufficient access to samples, ethical issues and so on. Normally experiments typically involve:

1) defining a theoretical hypothesis;
2) selecting samples from known populations;
3) allocating samples to different experimental conditions;
4) introducing planned changes to one or more variables;
5) measuring a small number of variables;
6) controlling all other variables.

Case Study is "an in-depth exploration of one situation". It involves the investigation of a particular situation, problem, company or group of companies. This investigation can be performed directly, for example, by interviews, observation, etc.; or indirectly by studying company reports or company documentation. You should not merely report on the outcome of the case study investigation, but also attempt to "generalise from the specific details of the examined setting, attempting to characterise the situation for which the studied organisation is typical".

Case studies usually generate a large amount of subjective data C data that you must sift, analyse and interpret in order to produce meaningful, accurate and fair conclusions. You should also be aware of your own influence on the case study if it is performed directly. For example, when you interviewed

staff within a local company, did they tell you what they felt you wanted to hear rather than the facts of the situation? Is there any means of triangulating your data C i.e., obtaining the data from two or three different sources to confirm the truth in what you are told (and thus eliminating the possible influence you might be having on the data capture)?

Survey is usually undertaken through the use of questionnaires or interviews. It allows "the collection of a large amount of data from a sizable population in a highly economical way". As part of a survey you might have to identify samples and sample sizes, design questionnaires and define interviews as appropriate.

4 General Form of A Research Paper and Technical Writing Methods.

An objective of organizing a research paper is to allow people to read your work selectively. Different readers have various aims to read you paper, and the first thing they do when reading your paper is the same, which is to determine whether your paper is the one they are looking for. For example, the methods, a specific result, the interpretation, or just the summary. To this end, we need to clarify the general form of a research paper [1].

4.1 Title

The title of a research paper should be informative. A good research paper title should:

- Condenses the paper's content in a few words
- Captures the readers' attention
- Differentiates the paper from other papers of the same subject area

Here are three basic tips when writing a title:

1) **Keep it simple, brief, and attractive.** The primary function of a title is to provide a precise summary of the papers content. So keep the title brief and clear. Use active verbs instead of complex noun-based phrases, and avoid unnecessary details. Moreover, a good title for a research paper is typically around 10 to 12 words long. A lengthy title may seem unfocused and take the readers attention away from an important point.
2) **Use appropriate descriptive words.** A good research paper title should contain key words used in the manuscript and should define the nature of the study. Think about terms people would use to search for your study and include them in your title.
3) **Avoid abbreviations and jargon.** Known abbreviations such as IT, CPU, and so on can be used in the title. However, other lesser-known or specific abbreviations and jargon that would not be immediately familiar to the readers should be left out.

4.2 Abstract

The abstract should be two hundred words or less. An abstract is a concise single paragraph summary of completed work or work in progress. In a minute or less a reader can learn the rationale behind the study, general approach to the problem, pertinent results, and important conclusions or new questions.

Write your summary after the rest of the paper is completed. After all, how can you summarize something that is not yet written? Economy of words is important throughout any paper, but especially in an abstract. However, use complete sentences and do not sacrifice readability for brevity. You can keep it concise by wording sentences so that they serve more than one purpose. For example, "In order to learn the role of protein synthesis in early development of the sea urchin, newly fertilized embryos were pulse-labeled with tritiated leucine, to provide a time course of changes in synthetic rate, as measured by total counts per minute (cpm)." This sentence provides the overall question, methods, and type of analysis, all in one sentence. The writer can now go directly to summarizing the results.

Summarize the study, including the following elements in any abstract. Try to keep the first two items to no more than one sentence each.

- Purpose of the study, including hypothesis, overall question, and objective.
- Models organism or system and brief description of the experiments.
- Results, including specific data - if the results are quantitative in nature, report quantitative data; results of any statistical analysis should be reported.
- Important conclusions or questions that follow from the experiment(s).

For the style, there are some suggestions as following:

- Single paragraph, and concise
- As a summary of work done, it is always written in past tense
- An abstract should stand on its own, and not refer to any other part of the paper such as a figure or table
- Focus on summarizing results - limit background information to a sentence or two, if absolutely necessary
- What you report in an abstract must be consistent with what you reported in the paper
- Correct spelling, clarity of sentences and phrases, and proper reporting of quantities (proper units, significant figures) are just as important in an abstract as they are anywhere else

4.3 Introduction

Your introduction should not exceed two pages (IEEE transaction format). The purpose of an introduction is to acquaint the reader with the rationale behind the work, with the intention of defending it. It places your work in a theoretical context, and enables the reader to understand and appreciate your objectives. We list some useful approaches when writing an effective introduction.

- Describe the importance (significance) of the study - why was this worth doing in the first place? Provide a broad context.
- Defend the model - why did you use this particular organism or system? What are its advantages? You might comment on its suitability from a theoretical point of view as well as indicate practical reasons for using it.
- Provide a rationale. State your specific hypothesis(es) or objective(s), and describe the reasoning that led you to select them.
- Very briefly describe the experimental design and how it accomplished the stated objectives.

4.4 Materials and Methods

There is no specific page limit, but a key concept is to keep this section as concise as you possibly can. People will want to read this material selectively. The reader may only be interested in one formula or part of a procedure. Materials and methods may be reported under separate subheadings within this section or can be incorporated together.

This part should be the easiest section to write, but many students misunderstand the purpose. The objective is to document all specialized materials and general procedures, so that another individual may use some or all of the methods in another study or judge the scientific merit of your work. It is not to be a step by step description of everything you did, nor is a methods section a set of instructions. In particular, it is not supposed to tell a story. By the way, your notebook should contain all of the information that you need for this section.

4.4.1 Materials

- Describe materials separately only if the study is so complicated that it saves space this way.
- Include specialized chemicals, biological materials, and any equipment or supplies that are not commonly found in laboratories.
- Do not include commonly found supplies such as test tubes, pipet tips, beakers, etc., or standard lab equipment such as centrifuges, spectrophotometers, pipettors, etc.
- If use of a specific type of equipment, a specific enzyme, or a culture from a particular supplier is critical to the success of the experiment, then it and the source should be singled out, otherwise no.
- Materials may be reported in a separate paragraph or else they may be identified along with your procedures.
- In biosciences we frequently work with solutions - refer to them by name and describe completely, including concentrations of all reagents, and pH of aqueous solutions, solvent if non-aqueous.

4.4.2 Methods

- See the examples in the writing portfolio package
- Report the methodology (not details of each procedure that employed the same methodology)
- Describe the methodology completely, including such specifics as temperatures, incubation times, etc.
- To be concise, present methods under headings devoted to specific procedures or groups of procedures
- Generalize - report how procedures were done, not how they were specifically performed on a particular day. For example, report “samples were diluted to a final concentration of 2 mg/ml protein;” do not report that “135 microliter of sample one was diluted with 330 microliter of buffer to make the protein concentration 2 mg/ml.” Always think about what would be relevant to an investigator at another institution, working on his/her own project.
- If well documented procedures were used, report the procedure by name, perhaps with reference, and that’s all. For example, the Bradford assay is well known. You need not report the procedure in full - just that you used a Bradford assay to estimate protein concentration, and identify what you used as a standard. The same is true for the SDS-PAGE method, and many other well known procedures in biology and biochemistry.

4.5 Results

The page length of this section is set by the amount and types of data to be reported. Continue to be concise, using figures and tables, if appropriate, to present results most effectively. The purpose of a results section is to present and illustrate your findings. Make this section a completely objective report of the results, and save all interpretation for the discussion.

4.5.1 Content:

- Summarize your findings in text and illustrate them, if appropriate, with figures and tables.
- In text, describe each of your results, pointing the reader to observations that are most relevant.
- Provide a context, such as by describing the question that was addressed by making a particular observation.
- Describe results of control experiments and include observations that are not presented in a formal figure or table, if appropriate.
- Analyze your data, then prepare the analyzed (converted) data in the form of a figure (graph), table, or in text form.

4.5.2 Figures and Tables

- Either place figures and tables within the text of the result, or include them in the back of the report (following Literature Cited) - do one or the other
- If you place figures and tables at the end of the report, make sure they are clearly distinguished from any attached appendix materials, such as raw data
- Regardless of placement, each figure must be numbered consecutively and complete with caption (caption goes under the figure)
- Regardless of placement, each table must be titled, numbered consecutively and complete with heading (title with description goes above the table)
- Each figure and table must be sufficiently complete that it could stand on its own, separate from text

REFERENCES

[1] Rice. Experimental biosciences. http://www.ruf.rice.edu/ bioslabs/tools/report/reportform.html, 2015.