CHAPTER 1

Introduction: What are computing projects?

Aims

To introduce academic computing projects.

Learning objectives

When you have completed this chapter, you should be able to:

- discuss what research means;
- understand the research process;
- classify research and understand the different research methods that are available;
- understand what projects are and, specifically, the different types of academic projects that there are in computing.

1.1 Introduction

Pursuing an undergraduate or postgraduate project within academia is not the same as performing one within industry. As a student on a computing degree course of one kind or another you will be expected to look at things much more critically and more deeply than you would elsewhere.

In industry, for example, your line manager might ask you to develop a piece of software to solve a particular problem or improve productivity in a particular area – a database, a production control system or whatever. You could write this program satisfactorily and install it within a few months and everyone would be happy. However, although this program might be perfectly adequate and work very well in practice, academically this project would be lacking.

Why is this the case? Academic projects should provide evidence of a much deeper understanding of what you are doing. They require some form of justification and contextualisation. You are not expected to do merely what you are told to do, but you are expected to develop your own thoughts, arguments, ideas and concepts. You are expected to question things and look at things in new ways and from new angles. Merely 'turning the handle', or doing what you are told, does not lead to intellectual discovery and contributions to world thinking. As a degree student you are expected to *think*.

This 'deeper' understanding of situations, problems and events is supported by your *research* skills. These skills are vitally important within academic projects. This chapter will begin, therefore, by exploring what is meant by research before looking in more detail at computing projects themselves.

1.2 What is research?

> The good researcher is not 'one who knows the right answers' but 'one who is struggling to find out what the right questions might be'.
>
> Phillips and Pugh (1994: 48)

1.2.1 *A definition*

Research is defined by the Higher Education Funding Council for England as '*original* investigation undertaken in order to *gain knowledge* and understanding' (HEFCE 1998). There are three key terms within this definition that have been italicised for emphasis: *original*, *gain* and *knowledge*. These points are discussed in turn in the following subsections.

1.2.2 *Originality*

There is no point in repeating the work of others and discovering or producing what is already known. Originality, quite simply put, is doing something or producing something that has not been done before. While this remains a relatively simplistic idea of the term, it is important to discuss how originality relates to projects. What can *you* do that is original? What type of things can *you* produce that are original?

You can be original in two ways. First, you can be original in the way you do things – for example, doing something someone has done before but using a different technique or approach. Second, you can be original by producing or developing something that has not been produced before.

In terms of originality in the way you do things, Cryer (1996: 146) identifies a number of areas in which your project can be original:

- *Tools, techniques, procedures and methods*. You may apply new tools and techniques to alternative 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 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 many new possibilities and unexplored avenues of research that you can 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 that have not been explored. Investigating these 'side tracks' may prove fruitful but care must be taken as they may 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 that field that has not been available before.
- *The use of data.* You can interpret data in different ways, use them in new ways or apply them in alternative areas that have not yet been investigated.

In terms of your project's outcomes, Cryer (1996: 147) identifies originality from the perspective of the results themselves and, also, any original by-products of the research. Thus, original outcomes might include a new product, a new theory, a new model or a new method. Where the intended outcomes are not achieved, by-products might still represent originality – for example, an understanding of why a particular experiment failed or why a particular technique did not work in a new area.

1.2.3 Gain

Gain is, perhaps, an unfortunate term in the HEFCE definition because it does not allude to the fact that research should actually lead to a *contribution* to knowledge. It is all very well performing an exclusive piece of research and learning something new for yourself, but unless you can disseminate this knowledge to others, the results of your research are somewhat wasted. With this in mind the following discussion focuses on the term 'contribute', which gives the much clearer message that research should add to world knowledge so that it is accessible to all and not just yourself.

Figure 1.1 provides an overview of the world's body of knowledge (BOK) and how contributions can be made to it. This BOK represents world understanding, theories, concepts, models, the sciences, the arts and so on. Your own knowledge is shown subsumed within this domain by the shaded region. You can obviously learn things that others already know, shown as expansion to your own knowledge 'cloud'. Likewise, you can make contributions to world knowledge from your research, such as inventions, new theories and so on.

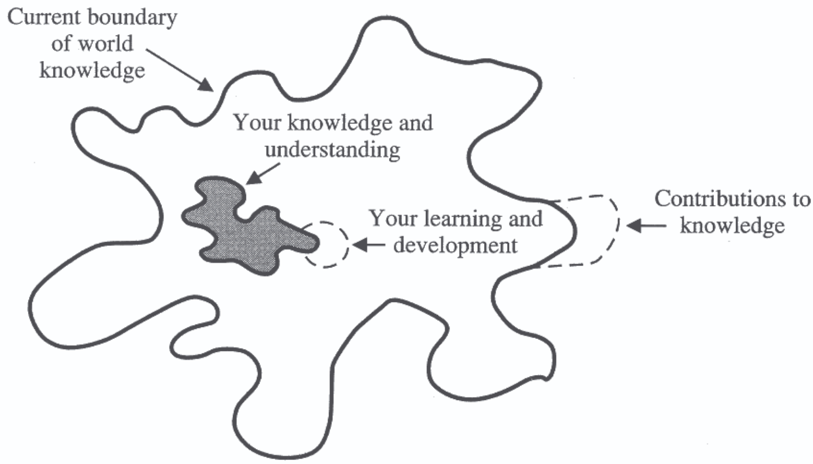

Figure 1.1 *Contributions to knowledge*

These are shown as expansions to the world's BOK by a dashed line. Thus, contribution refers to a sharing of new ideas, theories and results with the rest of the world and expanding what is already known.

1.2.4 Knowledge

In order to explain what is meant by knowledge, it will be discussed in terms of a hierarchy consisting of *data*, *information*, *knowledge* and *wisdom*. Post and Anderson (1997: 7) identify the meaning of these terms as:

- *Data*. Data are the factual elements that describe objects or events. They represent the raw numbers and raw text that you gather from your investigations. For example, as part of your research project, you may need to gather rainfall data from various sites around the country. These data, providing daily rainfall totals at fifty sites, are gathered as raw numbers that mean virtually nothing as they stand.
- *Information*. Information represents data that have been processed in order to provide you with some insight into their meaning. In other words, the data have been analysed, summarised and processed into a more understandable and useful format. In this form information can be passed to other people; for example, in books, articles, recordings, speech and so on (Orna and Stevens 1995: 36).

  Converting your rainfall data into information may lead to graphs summarising monthly totals, charts presenting seasonal fluctuations and text or tables summarising average daily rainfall at different sites. In these formats the data have some meaning and you now have some insight into what these data represent.

- *Knowledge*. Knowledge is your higher level understanding of things. While information provides you with an idea of the 'what' (i.e. what is happening in the real world), knowledge represents your understanding of the 'why'. Knowledge is your personal interpretation of what you gain from information as rules, patterns, decisions, models, ideas and so on. According to Orna and Stevens (1995: 35), knowledge represents the 'results of experience organized and stored inside each individual's own mind'.

  While your information about UK rainfall provided you with an overview of *what* was happening to weather in Britain over a period of time, knowledge represents your understanding of *why* rainfall might have changed during this period. For example, your knowledge would be your understanding of why rainfall had increased in particular parts of the country since 1900.
- *Wisdom*. Wisdom represents your ability to put your knowledge into practice. It represents your ability to apply your skills and experiences to create new knowledge and adapt to different situations.

  With respect to the rainfall example, wisdom would represent your ability to predict likely changes to rainfall and climate in the future or enable you to understand why rain falls at particular levels in an entirely different part of the world.

One more category that is worth mentioning here is *theory*. While data, information, knowledge and wisdom represent a relatively 'firm' understanding of what is going on and how things can be applied, theory represents ideas, opinions and suppositions based on your observations of the world. A theory is not necessarily true but, at the moment, it represents the best explanation of what you observe.

Although knowledge has been defined from a personal viewpoint, *world knowledge* can be defined along much the same lines. In this case world knowledge relates to world understanding, wisdom and interpretation by everybody and everything that is recorded or documented somewhere and somehow.

Collecting data and information on their own is termed 'intelligence-gathering' by Phillips and Pugh (1994: 46). These data are used to answer what Phillips and Pugh term the 'what?' questions: What is happening in the world? What don't we know? What can we find out?

Research, however, must go beyond merely gathering data and describing what you see. It must make a contribution to *knowledge*. It looks for 'explanations, relationships, comparisons, predictions, generalisations and theories'. Research thus addresses what Phillips and Pugh term the 'why?' questions: Why do things happen the way they do? Why is the situation the way it is? and so on. While data and information on their own can only answer the 'what?', knowledge and wisdom address the 'why?'.

1.2.5 Summary

Now that the three main aspects of research have been looked at in detail, one other definition of research is presented to see if it encapsulates the essence of the term. As an example take Sharp and Howard's (1996: 7) definition of research:

> seeking through *methodical processes* to *add* to one's own body of *knowledge* and, hopefully, to that of others, by the *discovery* of *non-trivial facts* and *insights*.

Once again, the important terms within this definition have been italicised; some of them relate directly to those that have been discussed already. 'Add', for example, relates to the discussion of 'contribution', and 'discovery' appears to imply some form of 'originality'. The term 'hopefully' is, perhaps, misplaced as you would expect to make a contribution from your research. 'Non-trivial facts' and 'insights' relate to 'knowledge' and 'wisdom', not data or information.

One element that this definition contributes that the earlier definition from the HEFCE did not, is the idea of a 'methodical process'. This identifies the fact that research is not something that is done in an *ad hoc* manner but is something that is planned and pursued in a considered way. Thus, the process of performing research, which is discussed in the following section, is *methodical*.

Drawing these points together results in the following succinct definition of research, which encapsulates all the elements discussed so far – consideration, originality, contribution and knowledge:

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

1.3 The research process

1.3.1 Overview

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 should follow a recognised process. Blaxter *et al.* (1996: 7) identify four common views of the research process; these will be referred to as *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'.

An example of such a process is the systematic process model of Sharp and Howard (1996: 15). This process consists of seven unique, sequential steps:

- identify the broad area of study;
- select a research topic;
- decide on an approach;
- plan how you will perform the research;
- gather data and information;
- analyse and interpret these data;
- present the results and findings.

Although this model appears entirely sequential, Sharp and Howard (1996: 15) do admit that repetition and cycles may take place during this process. However, how and when this repetition takes place is not explicitly identified. Another, perhaps simpler, example of a sequential research process is that defined by Greenfield (1996: 7). Greenfield breaks the research process into four steps:

- review the field, i.e. perform a literature survey;
- build a theory based on your understanding and interpretations of the field;
- test the theory: does it work?;
- reflect and integrate, i.e. update your ideas based on your 'tests' and contribute your new-found knowledge to others.

- *Generalised*. The generalised research process is identical to the sequential process in that activities are performed one after the other in a defined sequence. 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. An example of such a model is that of Kane (1985: 13, cited by Blaxter *et al*. 1996: 8).
- *Circulatory*. The circulatory approach recognises that any research that you perform is really 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 new-found questions. Experiences of research might lead you to revisit or reinterpret earlier stages of your work (Blaxter *et al*. 1996: 7). The circulatory interpretation also permits the research process to be joined at any point and recognises that the process is never ending.

  An example of a circulatory process is Rudestam and Newton's

Research Wheel (1992: 5), which suggests a 'recursive cycle of steps that are repeated over time'.

- *Evolutionary*. The evolutionary concept takes the circulatory interpretation one stage 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.

Perhaps one of the more appropriate examples of the research process is that defined by Orna and Stevens (1995: 11). They define a process that is circulatory at the top level and evolutionary within the main search/investigation stage of the process. Figure 1.2 is an adapted interpretation of this model.

Figure 1.2 shows a circulatory research process that begins in the top left-hand corner with a definition of your search. Orna and Stevens (1995: 11) identify this search definition as an attempt to answer the following questions:

- What am I looking for?
- Why am I looking for it?
- How shall I set about it?
- Where shall I start looking?

Following on from this stage you begin your *evolutionary* investigation of the chosen research area. This investigation will take place within the current boundaries of world knowledge as you search through, digest and evaluate material that is available. This search/investigation is not clear cut and will

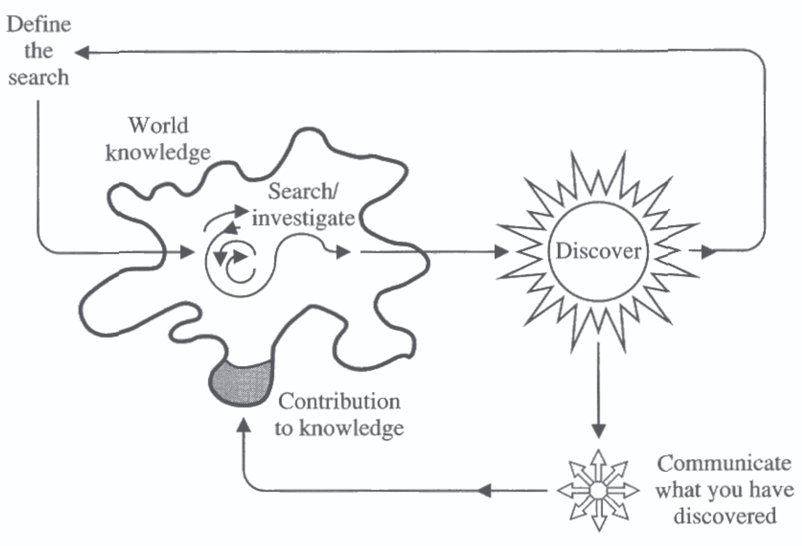

Figure 1.2 *The real research process*
Source: Adapted and reproduced with kind permission from Orna and Stevens (1995).

evolve over time. It will take time for your ideas to mature, you may find yourself pursuing dead ends, and you might create more questions than answers. Eventually, however, your diligence will hopefully pay off and you will discover something of value.

This discovery must then be disseminated to others through your reports, presentations, articles and discussions. There is no point in keeping discoveries to yourself as to do so ignores a fundamental purpose of the research process – that of disseminating your new-found ideas and results to others. Through this communication you are able to make a contribution to world knowledge and understanding, shown by the shaded area in Figure 1.2.

However, although you may have discovered something of value, and contributed this 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.

1.3.2 ***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 or problem you are studying and, importantly, what you already know and believe.

  The knowledge that you can obtain from what you are studying is referred to as *epistemology* (Cornford and Smithson 1996: 39). You can either draw general conclusions from what you observe and from what you are studying and apply them to other things (*positivism*), or you can only induce knowledge unique to yourself and the particular situation under study (*anti-positivism*).
- *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.

To solve complex problems you might need to follow a complex chain of inductive and deductive reasoning. Knowledge, which was discussed earlier, is what you derive from inductive reasoning. In other words, you build your ideas, models, theories and understanding based on your inductive reasoning about the world. Wisdom, on the other hand, is evident from your abilities of deductive reasoning – applying what you know to other situations and problems you have not yet encountered.

There is more to intellectual discovery than inductive and deductive reasoning alone. If you are having difficulty solving a problem, two interesting methods of intellectual discovery listed by Greenfield (1996: 5) that might help are:

> The method of **Pappus**: assume the problem is solved and calculate backwards.
> The method of **Terullus**: assume a solution is impossible and try to prove why.

In addition, Greenfield also suggests trying techniques such as:

- *Random guesses*. A similar technique to brainstorming, whereby you can try to solve a problem by generating a number of potential solutions at random. Hopefully one of them will make sense and work.
- *Analogy*. Is the problem similar to anything else that already has a solution or explanation?
- *Inversion*. Try to look at things from the opposite angle. For example, instead of asking 'which computer language should I use?' ask 'why shouldn't I use Pascal?'.
- *Partition*. Break the problem or situation down into smaller, more manageable and understandable parts.

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?'.

1.4 Classifying research

1.4.1 Introduction

Research can be classified from three different perspectives: its *field*, its *approach* and its *nature*. These three categories are adapted from the four categories discussed by Sharp and Howard (1996: 11) and Herbert (1990: 1). These authors identify an additional category called *purpose*. However, as the purpose of research is arguably to contribute to knowledge, the way that research achieves this contribution has been identified here subsumed within its *nature*.

- *Field*. The field of research is 'little more than a labelling device that enables groups of researchers with similar interests to be identified' (Sharp and Howard 1996). For example, in computing you might identify research fields in areas such as information systems, artificial intelligence, software engineering and so on.
- *Approach*. Approach represents the research methods that are employed as part of the research process – for example, case study, experiment, survey and so on. These methods are discussed in more detail in the following section.
- *Nature*. The type of contribution that research makes to knowledge depends upon its nature. Sharp and Howard (1996: 13) identify three levels that can be used to classify the nature of research:

  - Level 1: pure theoretical development;
  - Level 2: research that reviews and assesses pure theory and evaluates its potential for practical application;
  - Level 3: applied research that has some practical application or outcome.

The nature of research can also be identified according to the following common classifications which are adapted from Sharp and Howard (1996: 13), Herbert (1990: 1) and Saunders *et al*. (1997: 78–79):

- Pure theory: developing theories to explain things without necessarily linking them to practice. This can be based on your own inductive reasoning which leads you to make conclusions and theories about the world as you see it.
- Descriptive studies: reviewing and evaluating existing theory and knowledge in a field or describing particular situations or events. This might include testing existing theories, describing the state of the art, or looking for limits in previous generalisations.
- Exploratory studies: exploring a situation or a problem. These studies are useful for finding out 'what is happening; to seek new insights; to ask questions and to assess phenomena in a new light' (Robson 1993: 42, cited by Saunders *et al*. 1997: 78–79). Exploratory studies can be performed through literature searches, open questionnaires and interviews. These studies can start out by exploring particularly broad areas, concepts and ideas before focusing in and narrowing down to specifics as the research progresses. The process is thus an iterative and flexible one that seeks new information and ideas.
- Explanatory studies: explaining or clarifying something or some phenomena and identifying the relationships between things.

- Causal studies: assessing the effects that one or more variables have on another. The independent variables are those that might be having an influence on the dependent variable in which you are interested. In these studies you would manipulate the independent variables and monitor changes to the dependent variable. For example, does the size of software product (independent variable) affect how difficult it is to maintain (dependent variable which is measured in some way)?
  In these studies it is important to ensure that extraneous factors do not influence your results. For example, software size appears to be influencing maintainability but, in fact, maintainability might be due to a range of other factors you were unaware of and did not control.
- Resolving a problem with a novel solution and/or improving something in one way or another.
- Developing or constructing something novel.

1.4.2 Research methods

While techniques for sampling, data gathering, interviewing and so on are beyond the intended scope of this book, it is useful to take a brief look at some of the more widely recognised research methods that are available. Whether you use these methods at all, or decide to combine them in one way or another, will clearly depend on the nature of your project. Four of the most common research methods that you might use are *action research*, *experiment*, *case study* and *survey*.

Action research

Action research involves 'the carefully documented (and monitored) study of an attempt by you ... to actively solve a problem and/or change a situation' (Herbert 1990: 29). It involves working on a specific problem or project with a subject or, more usually, an organisation and evaluating the results. This method is used to gain 'a greater understanding and improvement of practice *over a period of time*' (Bell 1993: 8). 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 – that is, evaluating it as part of your academic project.

Experiment

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. According to Saunders *et al.* (1997: 75), experiments typically involve:

- defining a theoretical hypothesis;
- selecting samples from known populations;

- allocating samples to different experimental conditions;
- introducing planned changes to one or more variables;
- measuring a small number of variables;
- controlling all other variables.

Case study

A case study is 'an in-depth exploration of one situation' (Cornford and Smithson 1996: 49). 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 and so on, or indirectly by studying company reports or company documentation. For more information on case study research you can refer to texts such as Yin (1989) and Easton (1992), which are entire books devoted to this issue.

Survey

This 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' (Saunders *et al.* 1997: 76). As part of a survey you might have to identify samples, select sample sizes, design questionnaires and define interviews as appropriate. Fowler (1995) and Czaja and Blair (1996) are two texts that cover this topic in detail.

Research methods can also be classified according to their 'time frame'. In other words, does the study that has been performed result in a snapshot of what you have observed or do your data provide an insight into events over a *period of time*? A snapshot of a situation or event is referred to as a *cross-sectional* study. A long-term picture, on the other hand, in which data are gathered continually over a period of time, is called a *longitudinal* study. Which kind of study you use will depend on the nature of your research and what you hope to achieve. For more information on these kinds of study refer to texts such as Saunders *et al.* (1997: 77) and Cornford and Smithson (1996: 48).

1.4.3 *What is good research?*

You should now have an idea of what research is about and how to classify it, but what is meant by *good* research? Phillips and Pugh (1994: 47) identify three characteristics of good research:

- *Open minds*. You should work with an 'open system of thought'. Be open minded to the questions posed. 'Conventional wisdom and accepted doctrine … may turn out to be inadequate.'
- *Critical analysis*. Examine data critically. Are these figures correct? Have they been affected in some way? What do these data *really* mean? Are alternative data available? Can these data be interpreted differently?

- *Generalisations*. Researchers generalise and specify limits on the generalisations they identify. Generalisation allows research to be interpreted and applied to a wide variety of situations. However, researchers must know the limitations of these generalisations. Generalisations stem from your own wisdom and evolve from your deductive reasoning, which leads you to develop ideas about things you have not encountered before, with certain caveats.

Failure to apply these characteristics perpetuates the status quo – everything remains unchallenged and stays the same. Without an open mind to things, without a critical eye and without an ability to generalise your understanding to different things, you will not make a contribution to knowledge. This is, after all, the main aim of your research.

1.5 What are projects?

1.5.1 Introduction

Although you should now understand what is meant by research and the research process, it is still necessary to identify what is meant by projects, computing projects in particular, and how research fits within this context. This section begins by discussing what is meant by projects in a more general sense first.

A project has been defined as 'something which has a beginning and an end' (Barnes 1989, cited by Turner 1993: 4). Unfortunately, this rather broad definition does not encapsulate the underlying purpose of projects, which is to bring about some form of beneficial change. This change takes you from a current existing situation to a desired situation sometime in the future. This can be represented by the *Meliorist model* shown in Figure 1.3. In this figure a project is represented by a set of actions that you perform. A project thus enables you to move from one situation to another. Your movement towards the desired situation might stem from a dissatisfaction with your current situation, a lure towards a situation which appears more satisfactory, or some combination of the two.

The desirable situation in this case represents some form of contribution to knowledge – perhaps representing the development of a new tool, technique, discovery and so on. The term 'contribution' in this context necessarily implies the uniqueness of the project and the novelty of its outcomes.

$$\textbf{Existing situation} \xrightarrow[\{\text{a project}\}]{\{\text{set of actions}\}} \textbf{Desired situation}$$

Figure 1.3 *The Meliorist model*

While project managers are concerned with other aspects of projects, such as their complexity, constraints, organisational aspects and so on, as an individual you will only be concerned with the change that your project brings about – that is, the contribution that it will make. This simplistic interpretation of projects will do for now.

So far projects have been identified as having a beginning and an end: bringing about a beneficial change by making some kind of contribution. Looking more specifically at computing projects in particular, you need to see what kind of contributions these projects can make.

Computing projects come in all different shapes and sizes as the field they are drawn from is immense. However, these days it is more widely recognised, within academic institutions, that computing projects need to do more than, for example, develop a piece of software. The project that you pursue must involve an element of research, it must justify its context, and evaluate and discuss its results. Merely developing a tool or algorithm with no evaluation or contextualisation may well be acceptable in industry, where commercial solutions are required. However, within the academic world, this is not the case and, depending on the nature of your project, it will have to contain an element of research to a greater or lesser extent.

The computing project that you embark upon gives *you* an opportunity to make your *own* contribution. There is little point in doing a project that merely regurgitates the work of others. Your own thoughts, ideas and developments *are* important, and these are the things that people reading your report are interested in. It is through your project that you will develop, not only your own skills, but also the ideas and work of others. The level of contribution made by undergraduate and postgraduate projects is looked at in more detail in Section 4.1.

The following section introduces the different kinds of project that you are likely to encounter within the field of computing. In each of these cases it has been identified how these projects make some kind of academic contribution. They do not merely follow a simplistic project process to develop a product at the end of the day.

1.5.2 **Computing project types**

As a guideline, projects in computing tend to fall into one of the following five categories:

- *Research-based project*: 'many good dissertations do no more than review systematically, and impose some structure on, a field of interest' (Sharp and Howard 1996: 25). A research-based project involves a thorough investigation of a particular area, improving your understanding of that area, identifying strengths and weaknesses within the field and acknowledging areas suitable for further development and investigation. This kind of project will involve some form of literature search and review and would be suitable for undergraduate or taught Masters courses.

- *Development project*: this category includes the development not only of software and hardware systems, but also of process models, methods and algorithms. It may well require you to include evaluation, requirements documentation, designs, analyses and fully documented test results, along with user manuals or guides.

  Depending on the nature of your course the focus for a development project may vary. For example, for software engineering courses, more emphasis may be placed on the development and evaluation of a piece of software following particular process models that generate interim evaluatory documentation. Information systems courses may require you to focus more on the development of broader systems using 4GLs, CASE tools and/or database systems. In this case human–computer interaction (HCI), customer issues and requirements capture problems may be more your focus.

  Whichever kind of development project you tackle it is unlikely that the development of a product would be acceptable on its own. You would normally be expected to include a critical evaluation of the product as well as the development process used. Critical evaluation emphasises the distinction between the academic quality of your work and technical ability alone.
- *Evaluation project*: this category encompasses all projects that involve some form of evaluation as their main focus. A project of this nature might involve an evaluation of several approaches to a particular problem, an evaluation of two or more programming languages (applied in different contexts or to different problems), an evaluation of an implementation process within a particular industry, an evaluation of different user interfaces, an evaluation of a particular concept, and so on. Projects in this category may well include case studies as a vehicle for evaluating the issue under consideration.
- *Industry-based project*: this is simply an industry-based project that involves solving a problem within either an organisation or another university department. Care must be taken with these kinds of projects to ensure that they are not 'hijacked' by the sponsor. In other words, your project must not be forced in a direction that the company wishes it to go which is not necessarily suitable for your academic work or your course. You will probably find that an action research method is employed in this kind of project.
- *Problem solving*: this can involve the development of a new technique to solve a problem or might involve improving the efficiency of existing approaches. It might also involve the application of an existing problem solving technique to a new area. In these cases, some form of evaluation

would be expected; for example, did your new approach work well or did you discover reasons why it was unsuitable for problems of this nature?

These categories are not mutually exclusive and you may find that your project draws on approaches that are identified in more than one of them. In addition, the nature of your project will have an effect on the methods you will use to tackle it. The research methods that you might employ within your project were discussed earlier.

1.5.3 ***Programming in computing projects***

It is not necessarily the case that, because you are on a computing course of one kind or another, you will automatically be expected to write a program. Computing is a broad field and encompasses many topics, including information systems, software engineering, knowledge engineering, HCI, data communications, networks, computer systems architecture and so on. Not all of these fields involve programming and to write a program for the sake of it is clearly ill advised.

Sometimes programming is the main emphasis of your project; for example, if you are on a software engineering course. At other times you may need to write a program as a 'vehicle' for testing and demonstrating one thing or another; for example, to test out some ideas, demonstrate a technique or algorithm, or evaluate some HCI concepts.

Whatever the case, as a computing student you will naturally be expected to produce code that is of an acceptable *quality*. Although you may not be expected to produce a fully documented piece of software with test plans, designs, evaluation and so on, any code that you do produce should be satisfactory for your aims. Your supervisor should be able to advise you on the breadth and depth of any software that you produce as part of your project, so make sure that you liaise with him or her closely.

1.6 **Summary**

- Research is defined as 'a considered activity which aims to make an original contribution to knowledge'.
- The research process can be either *sequential*, *generalised*, *circulatory* or *evolutionary*.
- Research can be classified according to its *field*, *approach* and *nature*. Approaches to research include *case studies*, *experiments*, *surveys* and *action research*.
- Computing projects tend to fall into one of the following five

categories: *research based*, *development projects*, *evaluation projects*, *industry based* or *problem solving*.

1.7 Exercises

1. Try to formulate your own definition of research and ask yourself what research means to you.

2. Classify your own computing project into one of the categories identified in Section 1.5.2.